Driver IC for single phase Brushless Motor

KA44170A
Datasheet

Nuvoton is providing document only for reference purposes of KA44170A driver IC based system design. Nuvoton assumes no responsibility for errors or omissions.
All data and specifications are subject to change without notice.

For additional information or question, please contact Nuvoton Technology Corporation Japan
www.nuvoton.co.jp

■ IMPORTANT NOTICE

Regarding the specifications of this product, it is considered that you have agreed to the quality level and disclaimer described below.

Support for industry standards and quality standards

Functional safety standards for automobiles ISO26262	**No**
AEC-Q100	**No**
Market failure rate	**50Fit**

Disclaimer

1. When the application system is designed using this IC, please design the system at your own risk. Please read, consider, and apply appropriate usage notes and description in this standard.

2. When designing your application system, please take into the consideration of break down and failure mode occurrence and possibility in semiconductor products. Measures on the systems such as, but not limited to, redundant design, mitigating the spread of fire, or preventing glitch, are recommended in order to prevent physical injury, fire, social damages, etc. in using the Nuvoton Technology Japan Corporation (hereinafter referred to as NTCJ) products.

3. When using this IC, for each actual application systems, verify the systems and the all functionality of this IC as intended in application systems and the safety including the long-term reliability at your own risk

4. Please use this IC in compliance with all applicable laws, regulations and safety-related requirements that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. NTCJ shall not be held responsible for any damage incurred as a result of this IC being used not in compliance with the applicable laws, regulations and safety-related requirements.

5. This IC does not have any security functions using cryptographic algorithms, such as authentication, encryption, tampering detection.

6. Unless this IC is indicated by NTCJ to be used in applications as meeting the requirements of a particular industry standard (e.g., ISO 9001, IATF 16949, ISO 26262, etc.), this IC is neither designed nor intended for use in such environments for that applications. NTCJ shall not be held responsible for not meeting the requirements of a particular industry standard.

7. Using IC that have been indicated as compliant with industry functional safety standards does not warrant that the application meets the requirements of industry functional safety standards. NTCJ shall not be held responsible for the application compliance with requirements of the particular industry functional safety standard.

8. Unless this IC is indicated by NTCJ to be used in applications as meeting the requirements of a particular quality standard (e.g., AECQ-100, etc.), this IC is neither designed nor intended for use in such the environments for that applications. NTCJ shall not be held responsible for not meeting the requirements of a particular quality standard.

9. In case of damages, costs, losses, and/or liabilities incurred by NTCJ arising from customer's non-compliance with above from 1 to 8, customer will indemnify NTCJ against every damages, costs, losses and responsibility.

FEATURES

- Supply voltage range：5.0V ~ 30 V
- Built in Auto phase control with Soft Switching function
- Wide range operation (12V/24V)
- Speed Control by direct PWM input
- Motor lock protection and built-in Auto-recovery Adjustable by a external capacitance
- Output pin for FG pulse (open drain)
- Output pin for lock detection (open drain)
- Various protection functions
  - ・Under Voltage Lock Out (UVLO),
  - ・Thermal protection
  - ・GND short protection
  - ・Current limit Protection Adjustable by a external resistor
- Selectable for Startup mode (50%duty or PWM input duty)
- Output ON Resistance：Upper + Lower 1.25Ω(typ) （22% less than our similar product KA44169A）
- Built in STBY control
- Package : TSSOP 14L (4.4x5.0x0.9mm3, Lead Pitch 0.65mm)

DESCRIPTION

KA44170A is a high efficiency single phase motor driver IC with built-in Soft Switching function for low noise operation.

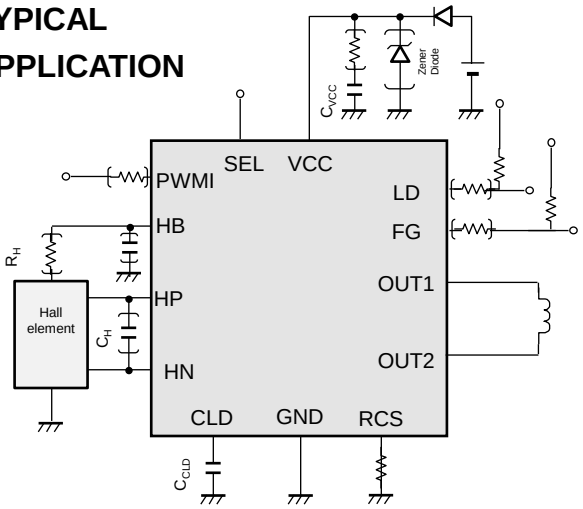
An automatic phase adjustment function is provided to optimize the soft switching section and its current, so it is possible to drive the motor with low noise and high efficiency regardless of the type of motor and operating environment with a small number of parts.

With a wide input voltage range of 12V/24V, this IC is most suitable for usage in home appliances, communication, OA, and FA equipment.

APPLICATIONS

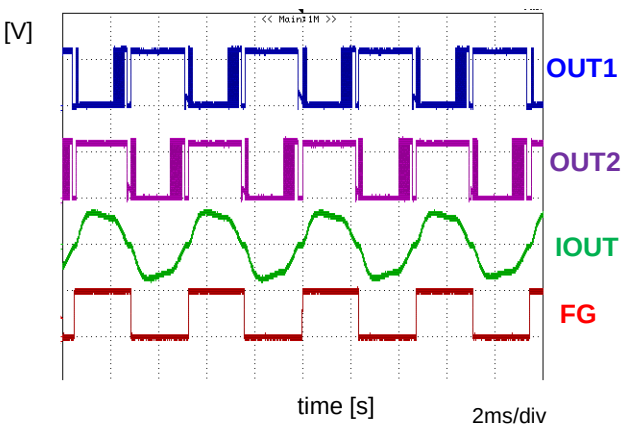
- Refrigerator, Projector, Printer, Factory automation

TYPICAL APPLICATION



Notes: The application circuit is an example. The operation of the mass production set is not guaranteed. Sufficient evaluation and verification is required in the design of the mass production set. The Customer is fully responsible for the incorporation of the above illustrated application circuit in the design of the equipment.

TYPICAL CHARACTERISTICS



condition : V_{CC} = 24V,PWMI=100%duty
C_{VCC} = 1μF,

CONTENTS

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Notes
Supply voltage	V_{CC}	36	V	*1
Operating ambient temperature	T_{opr}	–40 ~ +105	°C	*2
Junction temperature	T_j	–40 ~ +150	°C	*2
Storage temperature	T_{stg}	–55 ~ +150	°C	*2
Input Voltage Range	V_{CLD}, V_{HP}, V_{HN}, V_{RCS}, V_{SEL}	–0.3 ~ +6	V	—
	V_{PWM}	–0.3 ~ +36	V	—
Output Voltage Range	V_{OUT1}, V_{OUT2},	36	V	*1*3
	V_{FG}, V_{LD}	–0.3 ~ +36	V	—
	V_{HB}	–0.3 ~ +6	V	*3
Output Current Range	$I_{OUT1peak}$、$I_{OUT2peak}$	1.6	A	*5
	I_{OUT1}、I_{OUT2}	0.9	A	*6
	I_{FG}、I_{LD}	–5 ~ +10	mA	—
	I_{HB}	–20 ~ 0	mA	*4
ESD	HBM	2	kV	—
	MM	200	V	—

Notes: This product may sustain permanent damage if subjected to conditions higher than the above stated absolute maximum rating. This rating is the maximum rating and device operating at this range is not guaranteed as it is higher than our stated recommended operating range. When subjected under the absolute maximum rating for a long time, the reliability of the product may be affected.

*1: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.
*2: Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for Ta = 25℃.
*3: Applying external voltage into these pins is prohibited. Do not exceed the stated ratings even in transient state.
*4: Applying external current into these pins is prohibited. Do not exceed the stated ratings even in transient state.
*5: For VCC≧6 V, output current is only allowed within 1s.
*6: Applying external current into these pins is prohibited, the maximum value in the case of satisfying the rated power consumption and other rating items. However, I except the * 1 conditions.

POWER DISSIPATION RATING

Package	θ_{j-a}	PD (Ta=25 °C)	PD (Ta=105 °C)
TSSOP 14L (4.4x5.0x0.9mm3, Lead Pitch 0.65mm)	157.7°C/W	792.8mW	285.3mW

Notes: For the actual usage, follow the power supply voltage, load and ambient temperature conditions to ensure that there is enough margin and the thermal design does not exceed the allowable value.

*1: Glass-Epoxy Substrate (1 Layers) [70 × 70 × 1.6 t](mm)

CAUTION

Although this IC has built-in ESD protection circuit, it may still sustain permanent damage if not handled properly. Therefore, proper ESD precautions are recommended to avoid electrostatic damage to the MOS gates.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
Supply voltage range	V_{CC}	5.0	—	30	V	*1
Input voltage range	V_{HP}	0	—	1.5	V	*2
	V_{HN}	0	—	1.5	V	*2
	V_{PWM}	0	—	30	V	*2
External constants	C_{VCC}	—	1.0	—	µF	*3
	C_{CLD}	—	330	—	pF	*3

Notes *1: It is a value under the conditions which do not exceed the absolute maximum rating and the power dissipation.
*2: For setting range of input control voltage, refer to Electrical Characteristics and Operation.
*3: Operation of mass production set is not guaranteed. Perform enough evaluation and verification on the design of mass production set. If the VCC terminal voltage is raised by the regenerative current, at the time of start-up or stop operating Please connect a zener diode between VCC – GND terminal.

ELECTRICAL CHARACTERISTICS

V_{CC} = 24V

Note: T_a = 25°C ± 2°C unless otherwise noted.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Circuit Current							
V_{CC} current 1	I_{CC1}	Output OPEN, Lock State	—	1.5	3	mA	—
V_{CC} current 2	I_{CC2}	Output OPEN, 50% duty	—	2.0	4	mA	—
Vcc STBY current	I_{STB}	Stand By state	—	300	700	μA	—
FG							
Low-level output voltage	V_{OLFG}	I_O = 5mA	—	0.1	0.3	V	—
Output leak current	I_{LFG}	Vo=28V	—	—	30	μA	—
LD							
Low-level output voltage	V_{OLD}	I_O = 5mA	—	0.1	0.3	V	—
Output leak current	I_{LLD}	Vo=28V	—	—	30	μA	—
Power							
On resistance (High Side + Low Side)	R_{ONHL}	I_O = 200mA	—	1.25	1.8	Ω	—
Diode forward voltage	V_{DI}	I_O = 200mA	0.6	0.8	1	V	—
Hall input							
Input dynamic range	V_{HA}	—	0	—	1.5	V	—
Pin input current	I_{HA}	—	–2	0	2	μA	—
Minimum input voltage amplitude	V_{HA}	—	25	—	—	mV	—
Hysteresis width	V_{HAHYS}	—	—	10	20	mV	—
Hall Bias							
Output Voltage	V_{HB}	Io=–2mA	1.05	1.2	1.35	V	—
PWM Input							
Stop control input duty	V_{PWMMIN}		2	4	6	%	—
Maximum speed input duty	V_{PWMMAX}		—	100	—	%	*1*2
Low-level input voltage	V_{PWML}		—	—	0.8	V	—
High-level input voltage	V_{PWMH}		2.0	—	—	V	—
Low-level input current	I_{PWMINL}	Vi=0V	–39	–26	–13	μA	—
High-level input current	I_{PWMINH}	Vi=3.3V	5.5	11	16.5	μA	—
Input current at max. V_{CC}	$I_{PWMINHH}$	Vi=35V	480	686	892	μA	—
Input frequency range	F_{PWM}	—	3	—	50	kHz	—

Notes : *1: Typical Design Value.
*2: These are values checked by design but not production tested.

ELECTRICAL CHARACTERISTICS (continued)

V_{CC} = 24V

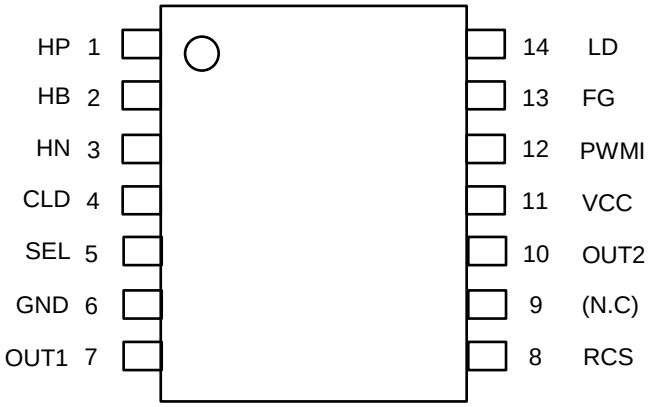
Note: T_a = 25°C ± 2°C unless otherwise noted.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SEL							
SEL Low-level input voltage	V_{SELL}		—	—	0.4	V	—
SEL High-level input voltage	V_{SELH}		1.05	—	—	V	—
Motor Lock Protection							
Lock protection time setting for reference clock frequency	F_{LOCK}	C_{CLD}=330pF	7.6	10.2	12.8	kHz	—
Lock detection time	t_{LOCK1}	C_{CLD}=330pF	—	0.48	—	s	*1*2
Lock release time	t_{LOCK2}	C_{CLD}=330pF	—	4.8	—	s	*1*2
Lock protection ratio	LD_{RATIO}	—	—	10	—	—	*1*2
Thermal Protection							
Protection operating temperature	TSD_{ON}	–	—	160	—	°C	*1*2
Hysteresis width	TSD_{HYS}	–	—	25	—	°C	*1*2
Under Voltage Lock Out							
Protection operating voltage	V_{LVON}	—	—	3.5	—	V	*1*2
Hysteresis width	V_{LVOHYS}	—	—	0.2	—	V	*1*2
Current Limit Protection							
Current Limit setting voltage	V_{CL}		135	150	165	mV	—
Current Limit setting voltage 2	V_{CL2}	In startup mode	70	90	110	mV	—

Notes : *1: Typical Design Value.
*2: These are values checked by design but not production tested.

PIN CONFIGURATION

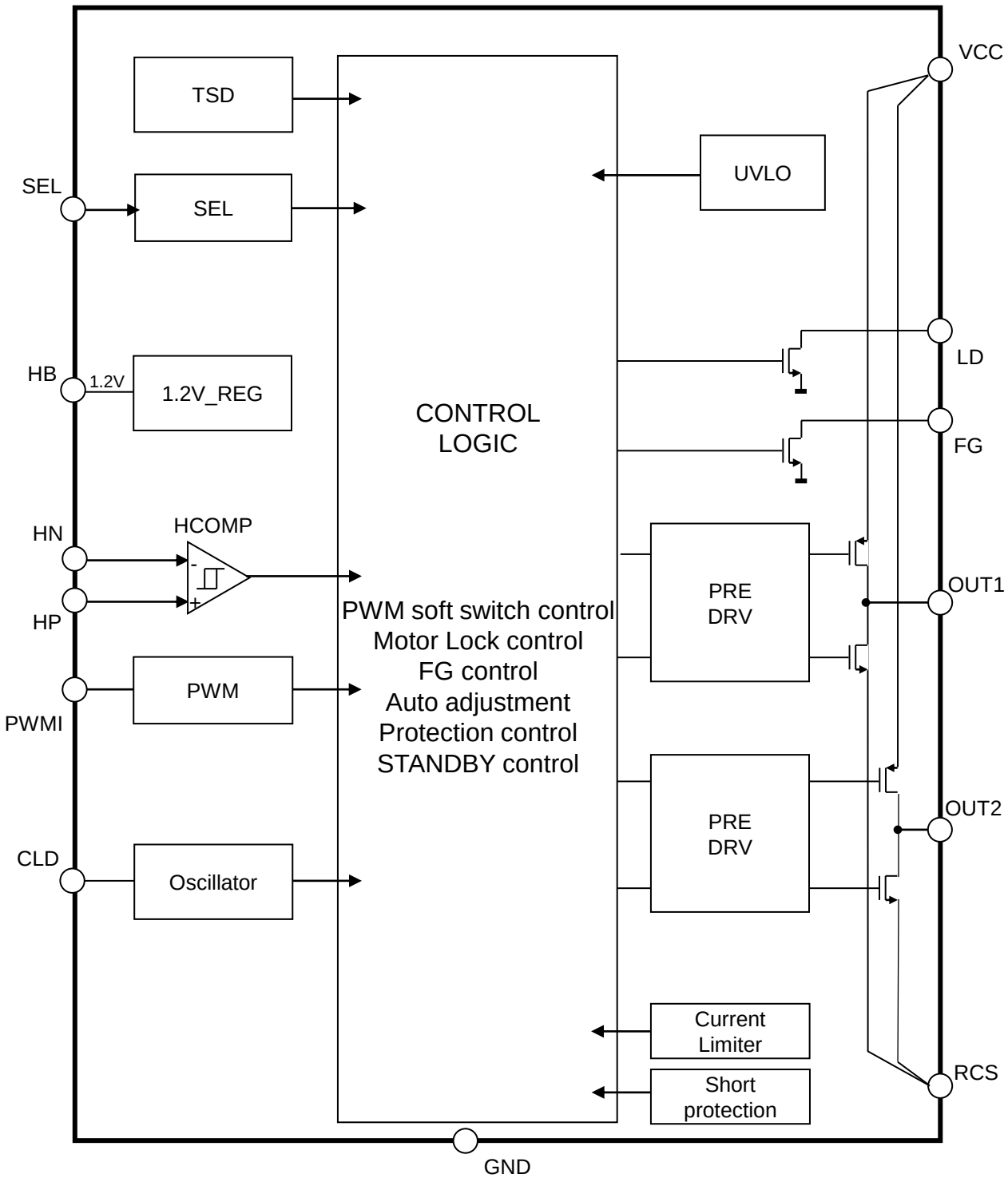
KA44170A pin configuration



PIN FUNCTIONS

Pin No.	Pin name	Type	ABSOLUTE Voltage(V)	Description
1	HP	In	6	Hall amplifier input (+)
2	HB	Out	6	Hall bias output
3	HN	In	6	Hall amplifier input (–)
4	CLD	In	6	Capacitor connection pin for reference clock
5	SEL	In	6	Select for Startup mode
6	GND	Ground	-	Ground
7	OUT1	Out	36	OUT1 : Motor drive output 1
8	RCS	In	6	Setting for Current Limit value
9	N.C	-	-	Non connection
10	OUT2	Out	36	OUT2 : Motor drive output 2
11	VCC	Vcc	36	Supply voltage for internal circuit
12	PWMI	In	36	Voltage input for setting rotating speed
13	FG	Out	36	FG external output
14	LD	Out	36	LD external output

BLOCK DIAGRAM



OPERATION

■Protection Function

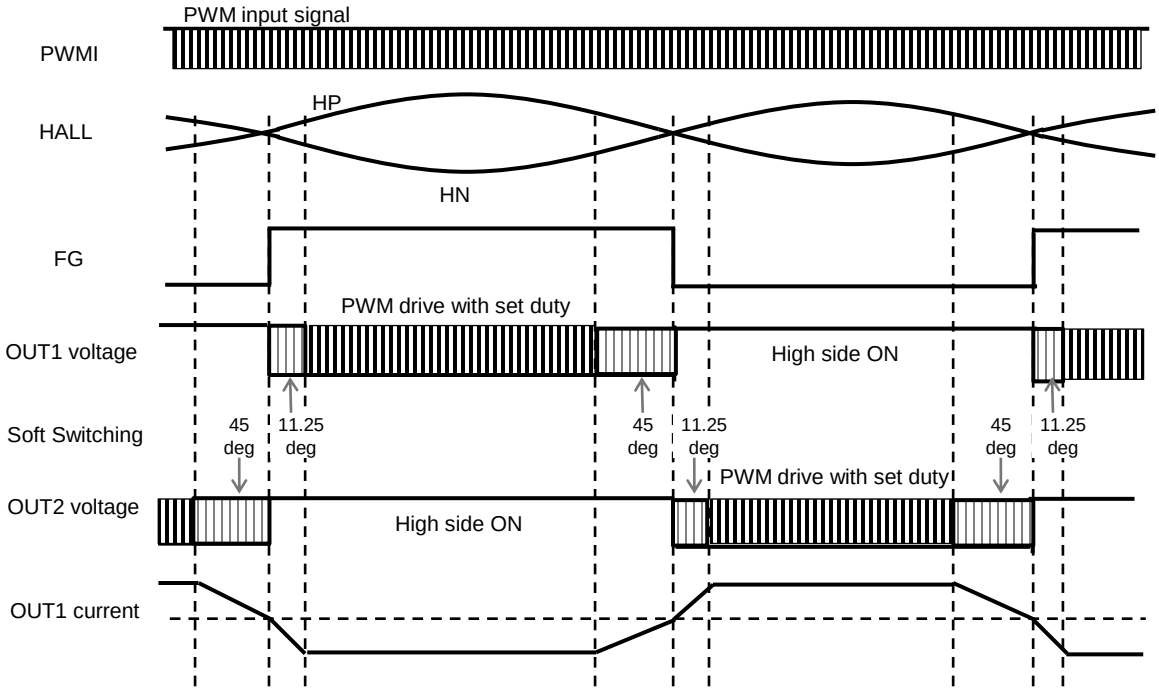
Note) The characteristics listed below are reference values derived from design of the IC and are not guaranteed.

Function name	Operate	Release	Note
TSD	160℃	135℃	Motor energization off while protection function works.
Current Limit	150mV or 90mV	After fixed time progress	When the motor current reaches the current value determined by the resistance value connected to the RCS terminal and the internal reference value, output current will be restricted in turning off an output for a fixed time. ON time , and OFF time are such as below. In normal mode; ON:2µsec, OFF:20µsec (in startup mode; ON:1.5µsec, OFF:40µsec) Also, the internal reference voltage is Fix 150mV at SEL = L. When SEL = Open or H, Normal drive mode ⇒ 150mV, during Startup mode ⇒ 90mV.
UVLO (VCC)	3.5V	3.7V	It is protection of the low-voltage condition of the power supply voltage. Motor energization off while protection function works.
Motor locked protection	When FG pulse does not change within a set time.	・at UVLO ・After fixed time progress ・at PWMI stop control	Motor energization off while protection function works. UVLO and PWMI stop control release protection and a count are reset. A protection setting time is determined by the external capacitance connected to the CLD pin. (Time(s) = External Cap(pF)×0.00145) Restart after this time ×10 ※ Motor Locked protection works even if the motor stops during TSD protection.
Short protection of Motor output - VCC	Current limiting	After fixed time progress	Protection by output current limiting
Short protection of Motor output - GND	latch protection by constant time detection.	・at UVLO	Latch protection is carried out. Release is performed by UVLO.

OPERATION

■ Drive State Diagram (Soft Switching)

Note) : Unless otherwise specified, numerical values are shown as typical values.



OPERATION (continued)

■ Functional explanation

Note) : Unless otherwise specified, numerical values are shown as typical values.

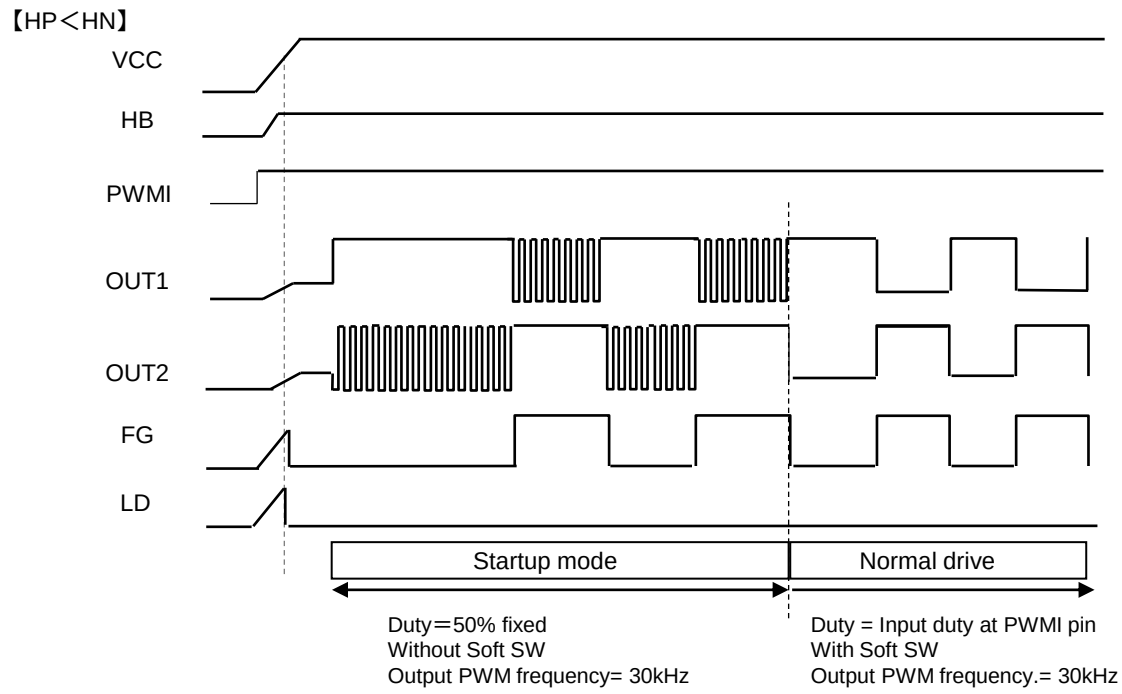
1. Startup mode and Normal drive

The startup mode is applied under the following conditions.
- VCC rises (VCC <3.5 V → VCC> 3.7 V) and STBY is released.
- PWM control is changed from stop to drive.

PWM duty at startup mode can be selected by input voltages of the PWMI pin.

SEL = Open or H	Fixed 50% duty
SEL = L	Duty set at PWMI pin

The startup mode shifts to the normal drive with a duty set at PWMI terminal after starting.
IC drives motor at the startup mode under smaller FG frequency than 6.67Hz and at the normal drive under larger than 6.67Hz.
Output PWM frequency is a fixed 30kHz.



OPERATION (continued)

■ Functional explanation (continued)

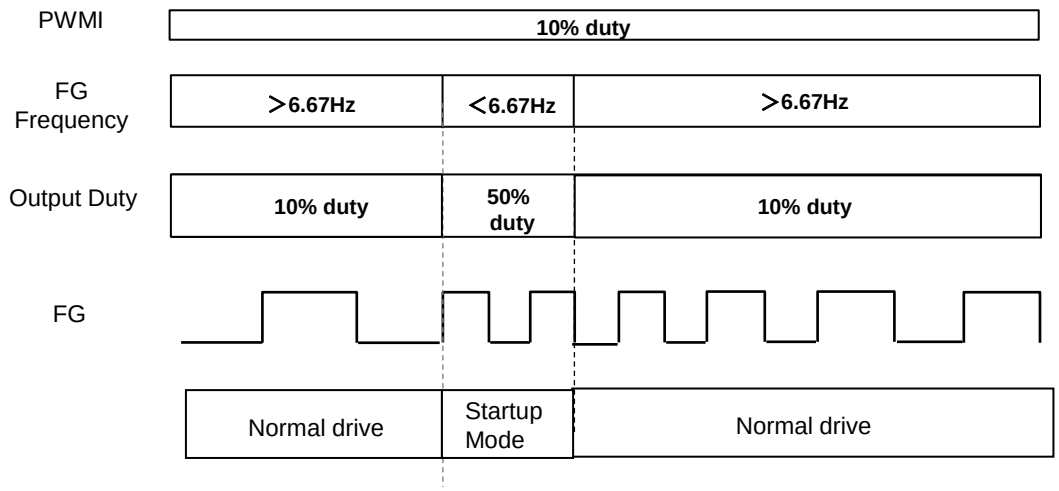
Note) : Unless otherwise specified, numerical values are shown as typical values.

●Notes under Normal drive

When the rotation speed is set to around 6.67Hz as FG frequency after starting up,
IC drives motors as below.

(Example) In case of crossing 6.67Hz as FG frequency at input PWM duty = 10%

【SEL= Open or H】



For example, when the rotational speed of the motor drive with input PWM = 10% and output drive duty = 10% in SEL = Open setting becomes 6.67Hz or less as FG frequency, Since the shift to the startup mode, the output duty becomes 50%, and as a result, the rotation speed in this section rises momentarily and shift to the normal drive mode, the output drive duty becomes 10%.

If SEL = L, even in the startup mode, the input duty = output duty drive, so this phenomenon is less likely to occur.

OPERATION (continued)

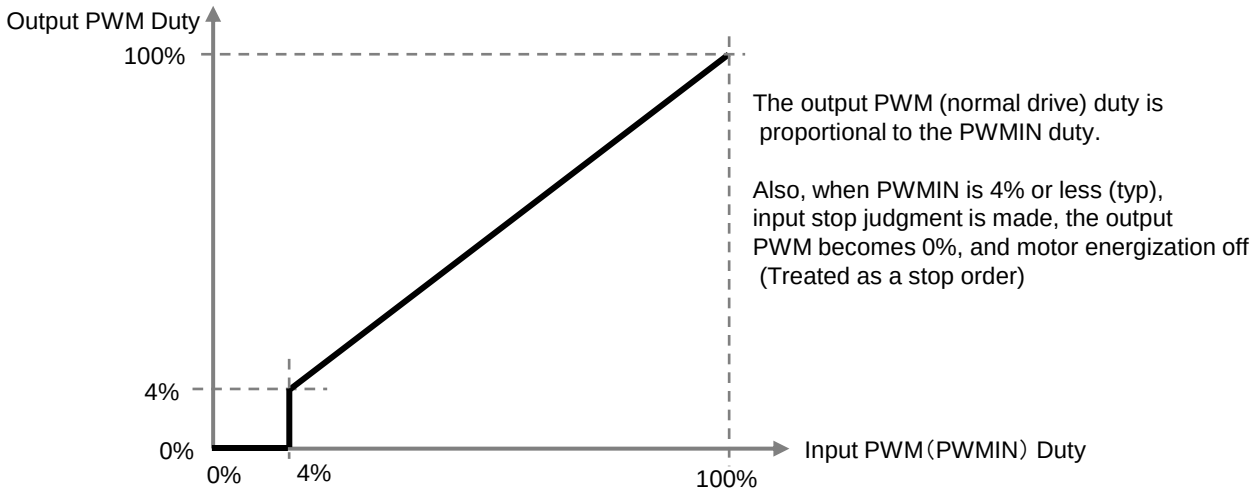
■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

2. Speed control

Motor rotation speed can be controlled by the duty of the PWM signal to the PWMI pin.
PWM signal is a high duty.
Input PWM frequency range is a typical from 3kHz to 50kHz (typical value).
Output PWM frequency is a fixed 30kHz(typical value).

The frequency range which can be input to IC is from 3kHz to 50kHz. The output drive frequency is fixed at 30 kHz (typ).



The KA44170A has SLOW acceleration control for the acceleration signal. SLOW acceleration control operates with acceleration change of input Duty about 3% or more. The assignment of SLOW acceleration control is constant, and changes 2 seconds for a change from Duty 0% to 100%. (0.02 sec /%)
However, SLOW deceleration control isn't built in.

For example, if the input PWM signal duty changes from 50% to 80%,
= 2sec ×(80% - 50%) / 100% = 0.6sec
= (80%-50%) × 0.02 sec / % = 0.6sec
SLOW acceleration is performed with a control time of 0.6 seconds.

OPERATION (continued)

■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

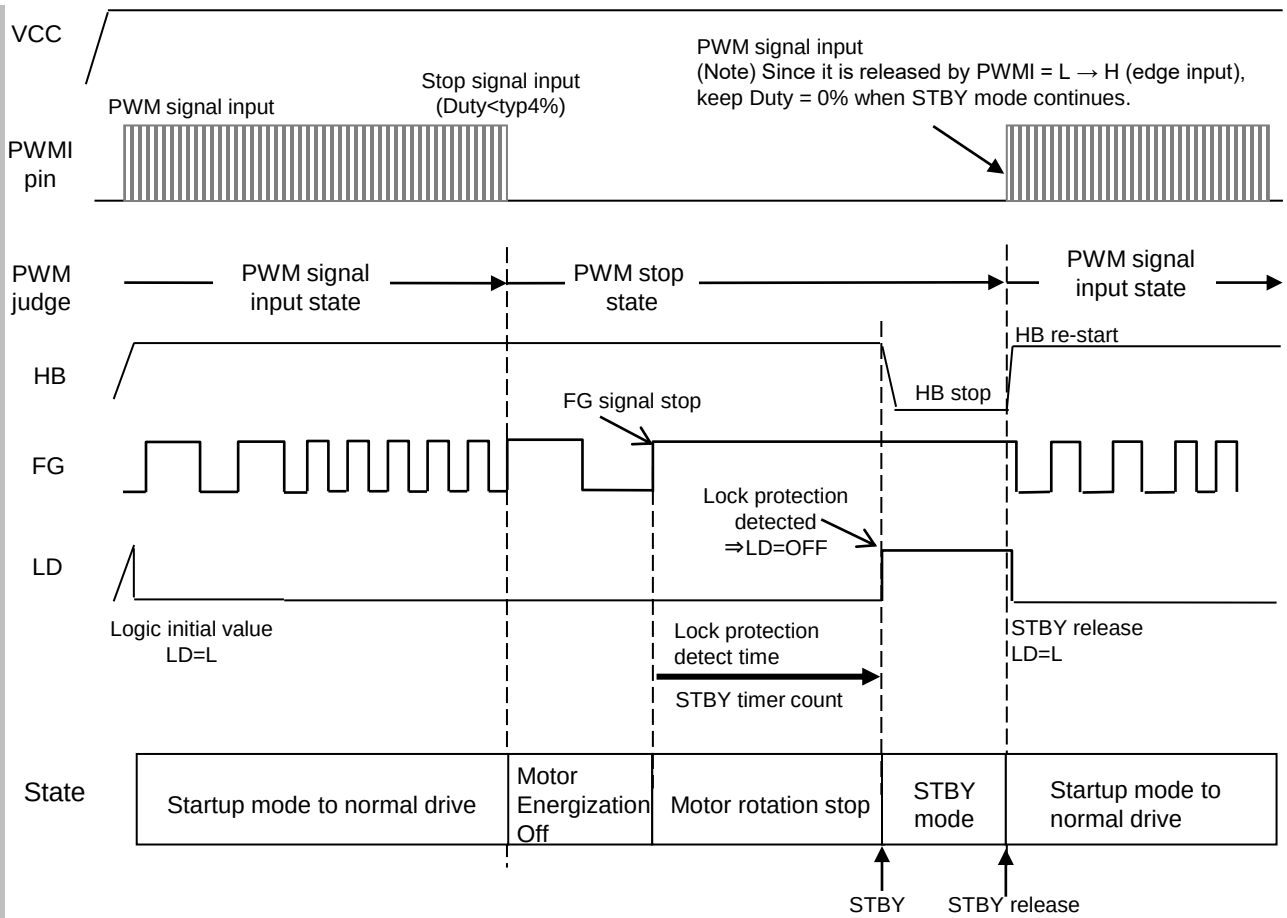
3. STBY operation

KA44170A has an auto STBY operation and release function.
After the motor rotation stops in the PWM signal stop judgment, it shift to STBY mode after the set time has elapsed.
The STBY mode is released by re-inputting the PWM signal.

※When the CLD pin is grounded to GND, the protection counter does not operate, so it does not shift to STBY mode.

STBY mode ･･･After the PWM stop signal is input, the motor's rotation is stopped, and when the FG signal is not detected, the mode shifts to STBY mode after a lapse of time.

STB release ･･･STBY mode is released by inputting PWM signal during STBY mode, motors starts up at the startup mode and then, the startup mode is shifted to the normal drive.



Since STBY mode is released by PWMI = L → H (edge input), keep Duty = 0% when STBY mode continues.
If the PWMIN pin is open (HiZ) in STBY mode, the STBY mode is released.

※When the CLD pin is grounded to GND, the protection counter does not operate, so it does not shift to STBY mode.

OPERATION (continued)

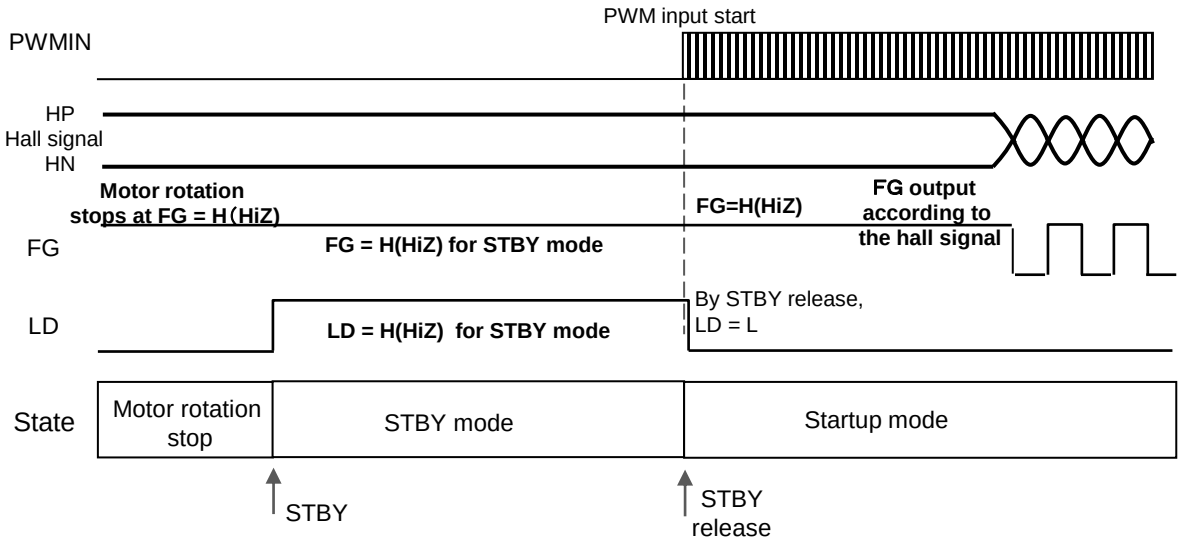
■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

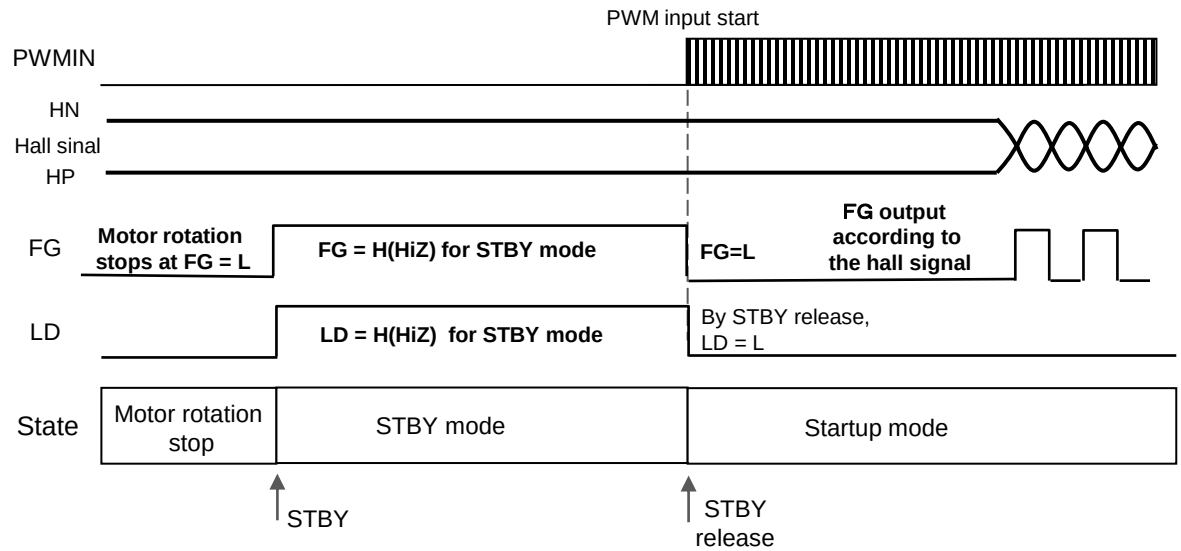
3. About logic of FG output and LD at the shift to STBY

In STBY mode, FG, LD, OUT1 and OUT2 are all OFF (HiZ),
Therefore, differences in the FG signal output is occurred at the STBY transition depending on the FG signal logic before shifting to STBY mode.

■ Shift to the STBY mode at hall signal HP > HN



■ Shift to the STBY mode at hall signal HP < HN



OPERATION (continued)

■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

4. Motor locked protection

When FG non-signal state continues for a certain period of time in the motor normal operation mode, locked protection circuit operates.
In the locked protection mode, motor energization is off and LD is H(HiZ).
The value of the locked protection time can be calculated by the following equation approximately.

Restricted protection setting time (sec) ≒ Capacitance value of CLD (pF) x 0.00145

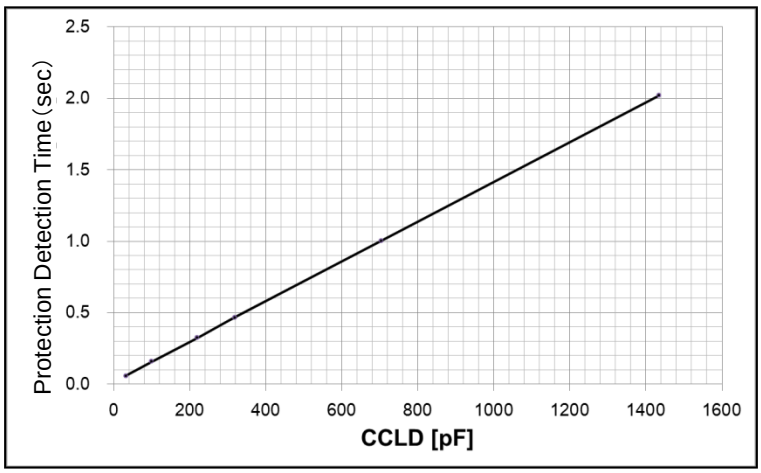
If you connect capacitance of 330pF in CLD pin, the restricted protection time is about 0.48s.
Make setting with a margin for motor start-up time.

Conditions to release the motor restricted protection, and to reset the counter are as follows.
- ・In detecting UVLO mode
- ・After fixed time progress (Restricted protection setting time x 10 (sec), : about 4.8 sec / CCLD=330pF)
- ・at inputting PWMI stop control

Also, in the LD output = H(HiZ) state, the motor rotates again and shift to LD = L after the falling edge of 2 periods of the FG signal.

If you do not use Motor locked protection, ground the CLD terminal to GND.

■Correlation table of CLD pin capacitance and Motor locked protection detection time (reference value)）



CLD Terminal Capacitance（pF） (VCC=12V,Ta=25deg)

OPERATION (continued)

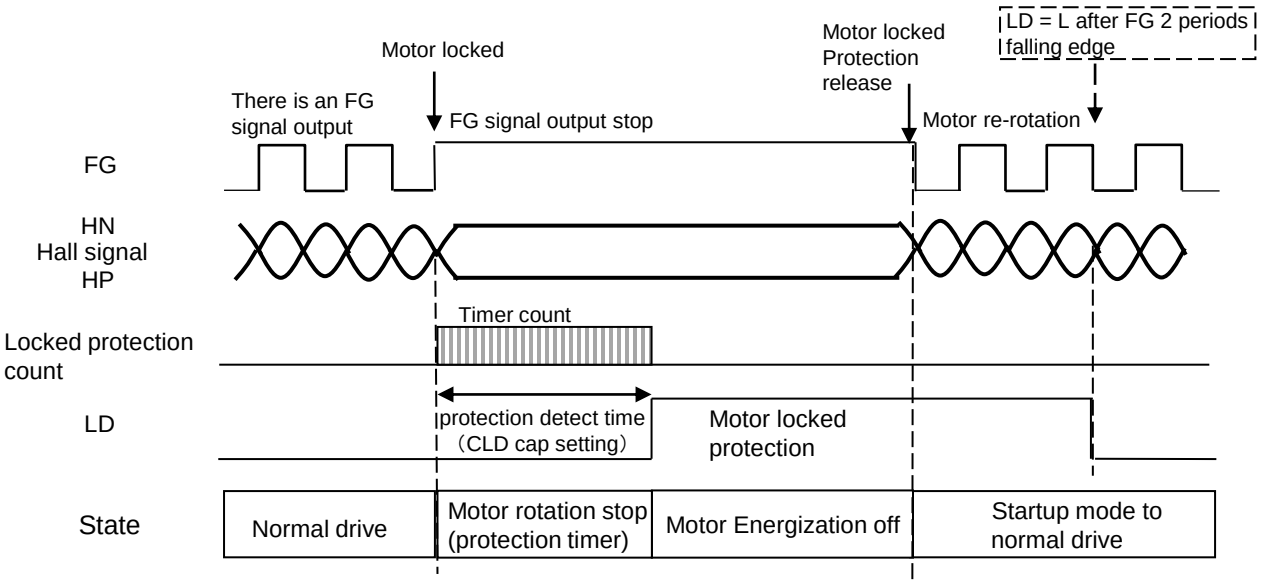
■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

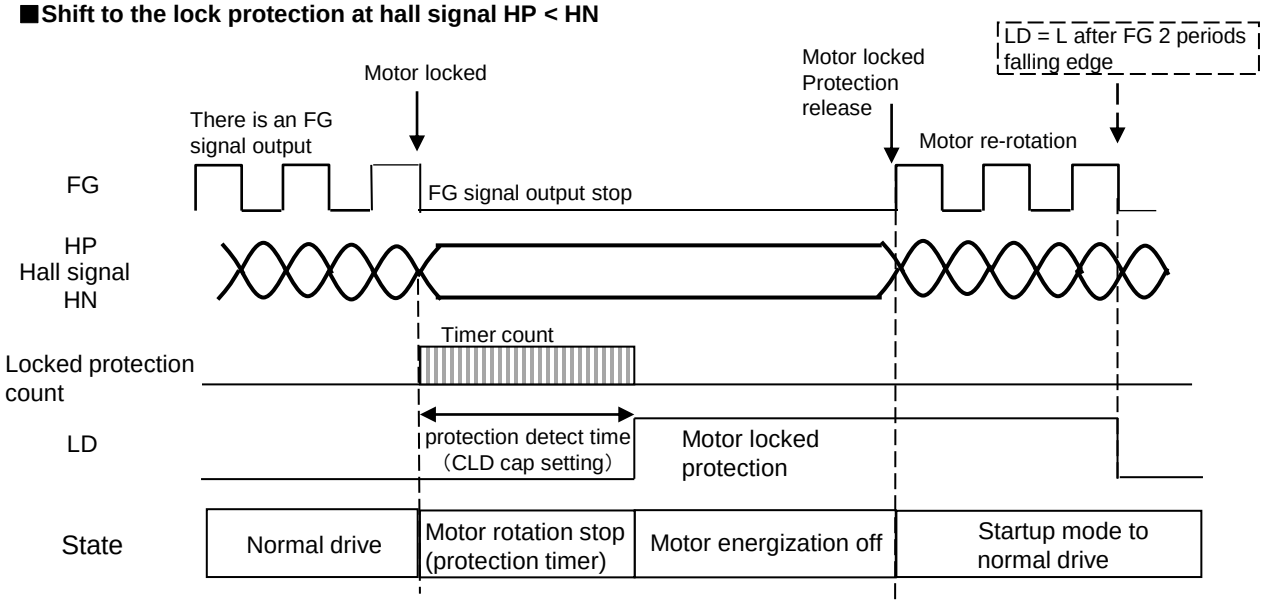
4. Motor locked protection

Explain of Motor locked protection

■Shift to the lock protection at hall signal HP > HN



■Shift to the lock protection at hall signal HP < HN



OPERATION (continued)

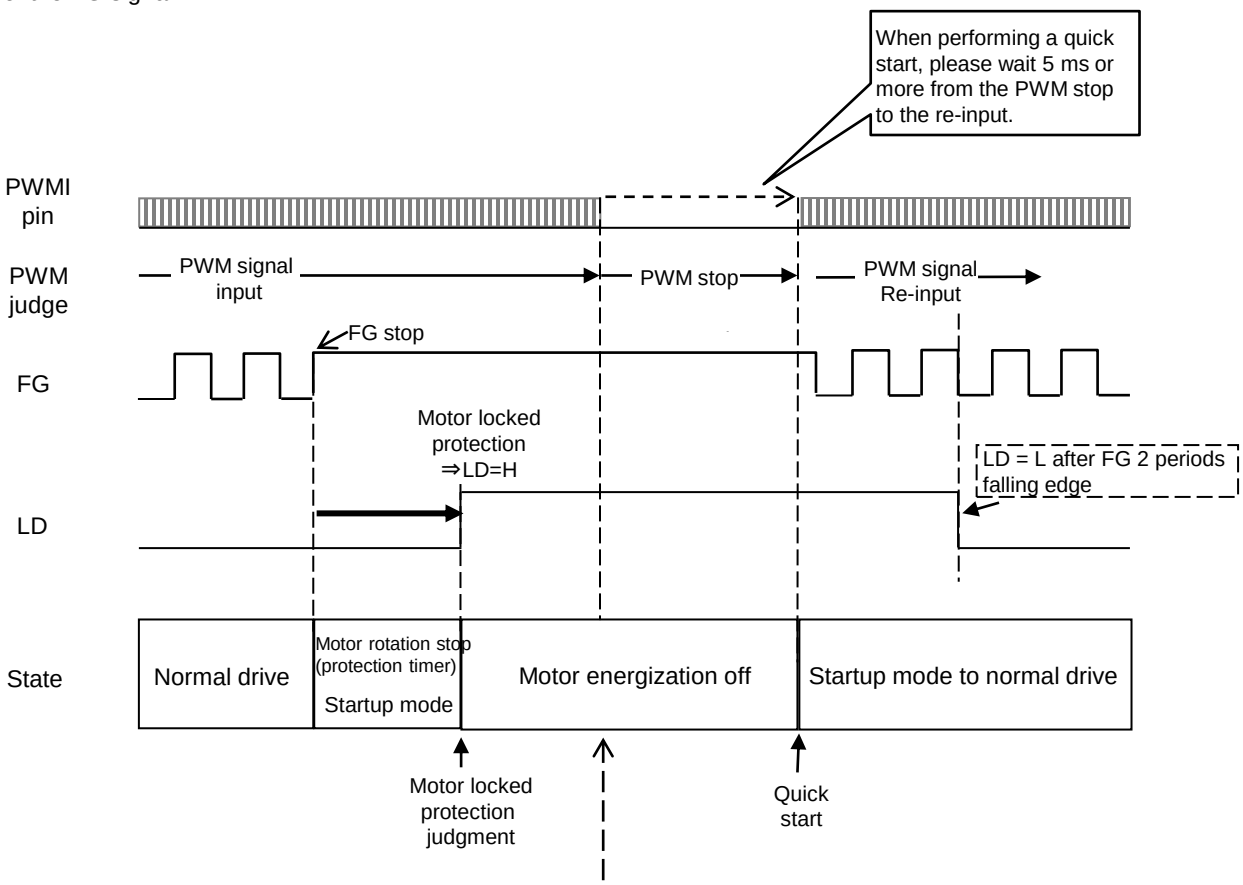
■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

4. Motor locked protection（Quick start）

By inputting the PWMI stop signal before automatic release during Motor locked protection,
and re-inputting the PWM signal,
You can release the Motor locked protection state and perform a quick start to restart the motor.
※When performing a quick start, please wait 5 ms or more from the PWM stop to the re-input.

The LD output = H state, the motor rotates again and shift to LD = L after the falling edge of 2 periods of the FG signal.



※During motor locked protection,
the shift to STBY mode does not occur
even after PWM stop input.

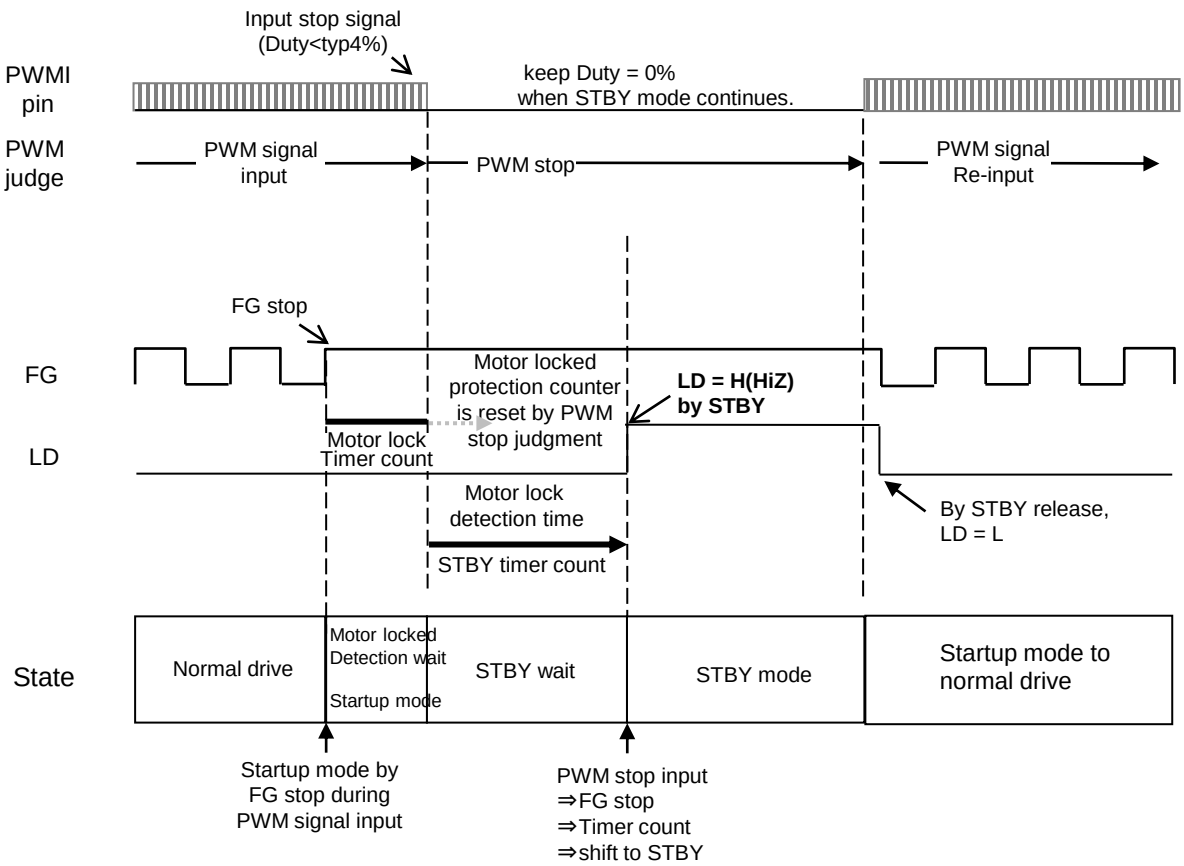
OPERATION (continued)

■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

4. Stop of PWM input signal during Motor locked protection detection time

If a PWM stop signal is input during the Motor locked protection detection time,
Motor locked protection timer count is reset.
(Because the stop signal, the Motor locked protection function becomes invalid.)
After the PWM stop signal is input, shift to STBY mode is made by STBY timer count. (LD = OFF by STBY)
After STBY, STBY is released by the input of the PWM signal.



OPERATION (continued)

■ Functional explanation (continued)

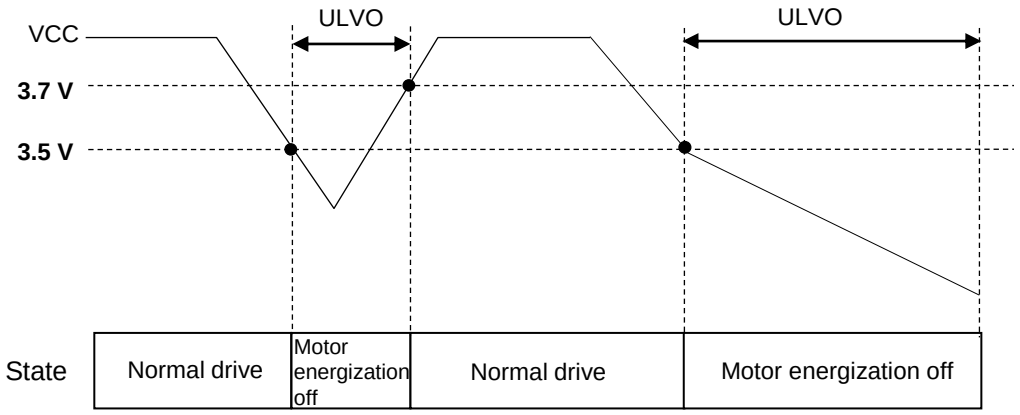
Note) : Unless otherwise specified, numerical values are shown as typical values.

5. Low voltage protection

This IC monitors the voltage VCC. If VCC voltage becomes 3.5V or less, low-voltage protection is activated.
In the low voltage protection operation, and motor energization is off

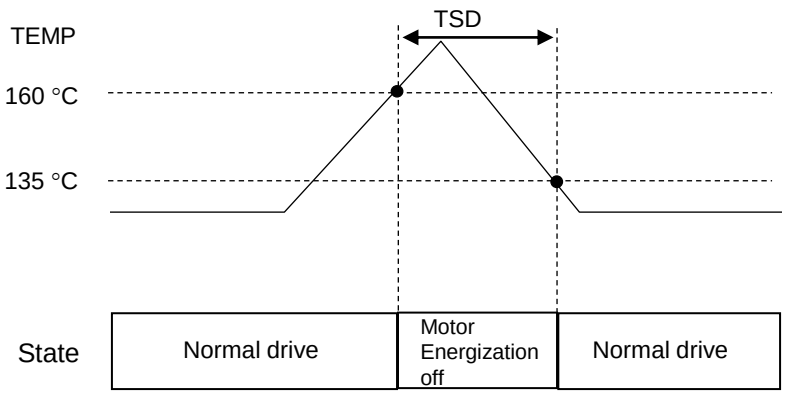
In addition, if the VCC voltage drops further, the internal circuit is no longer working properly, the outputs, all phases are HiZ (all phases OFF).

Hysteresis of 0.2V is set in the VCC low voltage protection function. If the VCC is restored to 3.7V from protection mode, the low voltage protection is released.



6. Thermal protection (TSD)

If an IC junction temperature is 160℃ (design target value) or more, the thermal protection is activated, and motor energization is off
If the IC junction temperature is 135℃ (design target value) or less, the protection is released.



OPERATION (continued)

■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

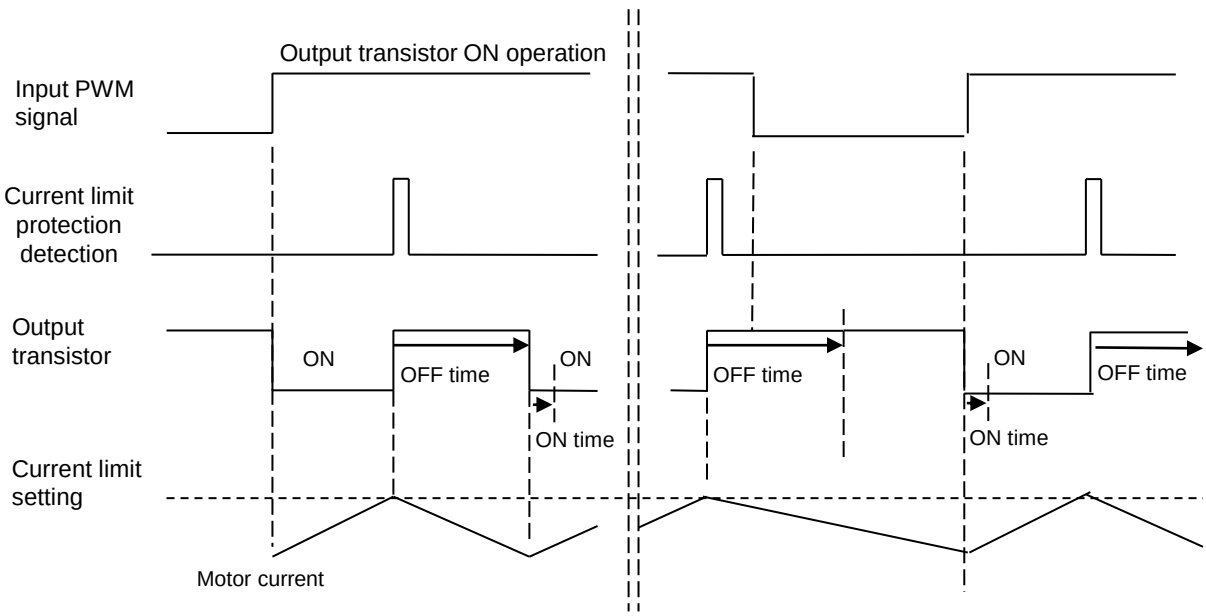
7. Current Limit protection

Describes the current limit protection setting at motor drive.
Overcurrent is detected at the RCS pin so that excessive current does not flow to OUT1 and OUT2.
The current limit setting value is determined by the resistance value connected to the RCS pin.

Current limit setting value (A) = current limit protection setting voltage (V) / RCS resistance value (Ω)

Current limit setting voltage is binary switched when SEL = Open or H.
It is 150mV at normal drive mode and 90mV at startup mode.
When SEL = L, it will be 150mV with one value fixed.

When Current limit is detected, the output transistor is turned off for a fixed time to protect over current.
On time 2 µsec (in startup mode : 1.5µsec)
Off time 20 µsec (in startup mode : 40µsec)



OPERATION (continued)

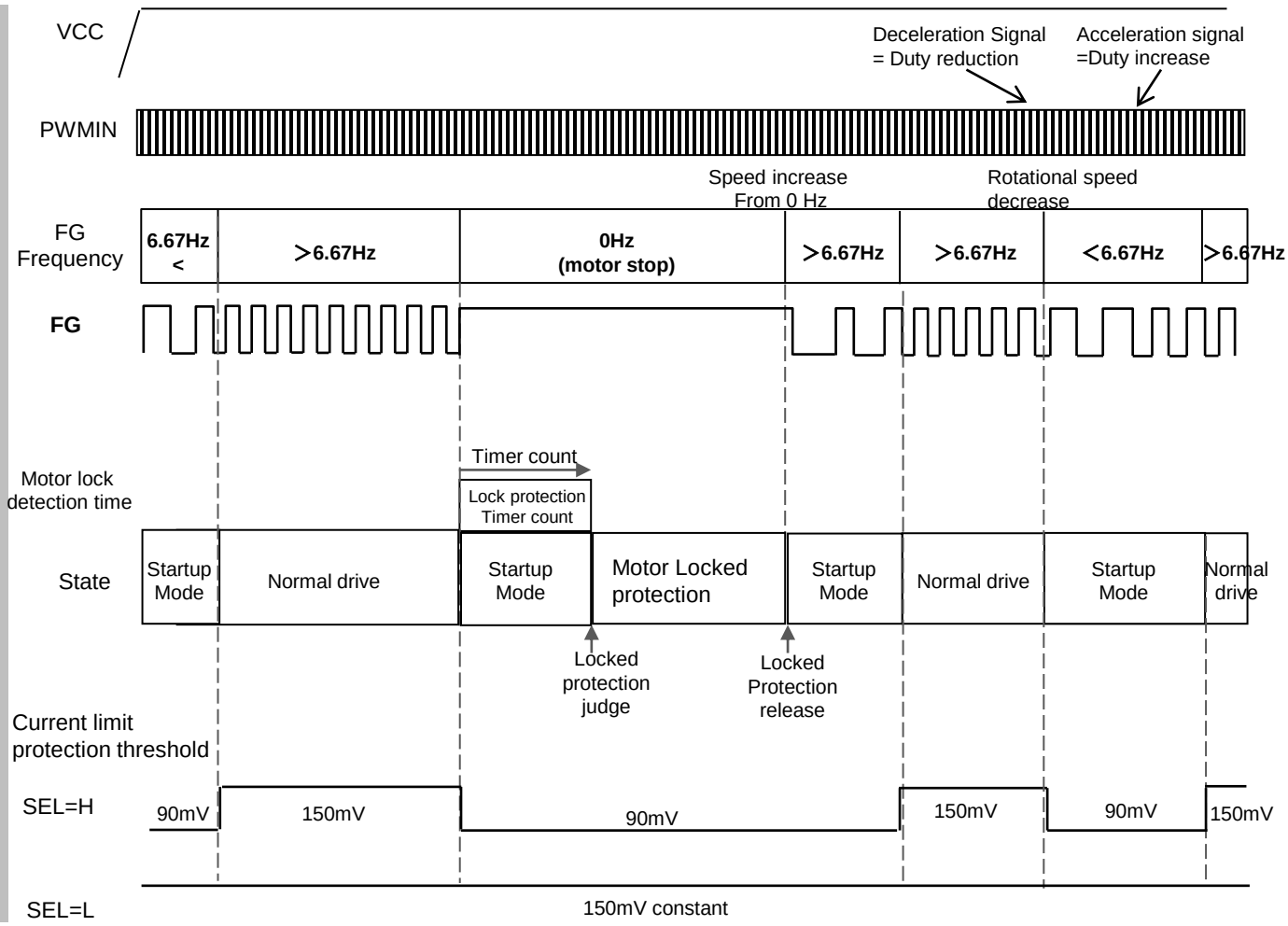
■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

7. Current Limit protection

・Threshold level of current limit changes depend on a input voltage of SEL pin.

SEL＝Open or H	Threshold voltage at the startup mode	90mV
	Threshold voltage at the startup mode	150mV
SEL=L	Constant threshold voltage	150mV



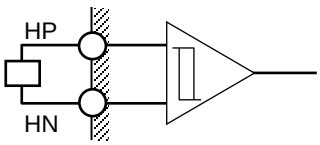
OPERATION (continued)

■ Functional explanation (continued)

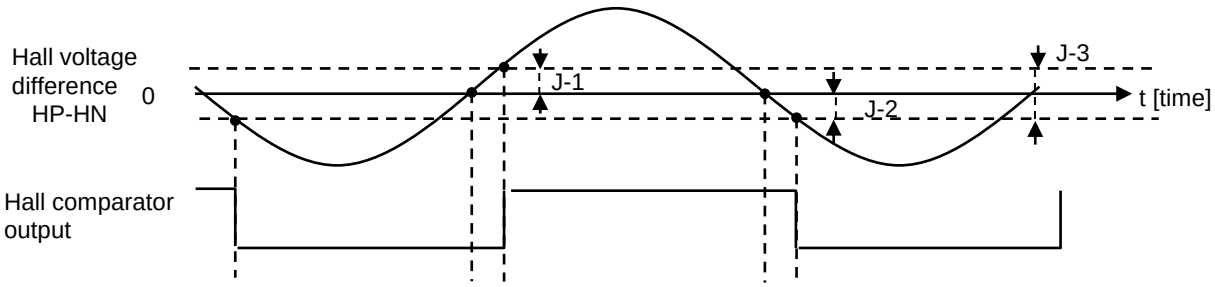
Note) : Unless otherwise specified, numerical values are shown as typical values.

8. Hall input

Hall hysteresis comparator carries out position detection. If the amplitude of the sine wave is small, the phase delay of the comparator output becomes significant, therefore, increase the amplitude. Recommendation is 200 mV or more. Also, if the hole chattering occurs, put capacitor between HP (1 pin) and HN (3 pin).

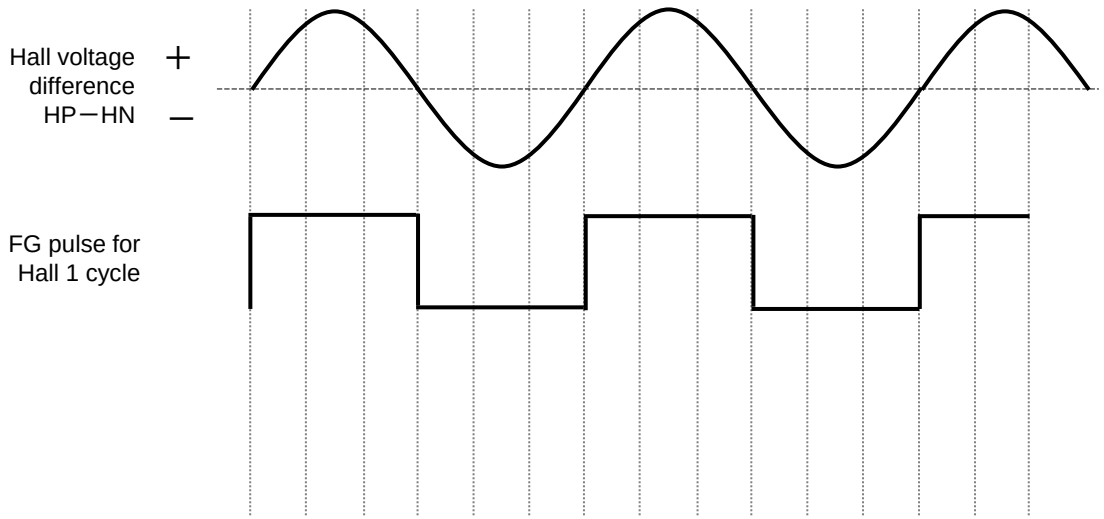


The following is a schematic diagram of the characteristics.
J-1 hysteresis level: 5 mV L → H
J-2 hysteresis level: 5 mV H → L
J-3 hysteresis width: 10 mV (typ)



・Relationship between Hall voltage and FG

For the one cycle sine wave of Hall, it outputs FG pulse one cycle.



OPERATION (continued)

■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

9. CLD pin

CLD pin is the terminal that generates a clock for lock protection.
By varying the capacitor connected to this terminal, to set the protection time.
When you use 330pF, it is detected by 0.48sec, and restart after stopping during 4.8sec.

10. LD pin

LD pin outputs the judgment of lock protection.
Since it is an open-drain output, please connect a pull-up resistor to the power supply,
when you use this function.
In the normal operation, LD outputs low during detection ,and LD outputs high during protection.

11. FG pin

FG pin outputs a switching of HALL signal.
Since it is an open-drain output, please connect a pull-up resistor to the power supply,
when you use this function.
FG outputs high, when HP voltage > HN voltage.

12. PWMI pin

PWMI pin is a terminal for inputting a PWM signal, which is a high duty.
When you open PWMI terminal ,it is biased about 1.9V by the internal circuit,
and it outputs as 100% duty for the motor drive.

13. HB pin

HB pin is a terminal for supplying the bias voltage to the hall element .
1.2V is outputted from HB terminal.
If it is necessary to take countermeasures to prevent the noise, please add the hall capacitance between HB terminal and GND terminal.
The maximum value of the hall capacitance is 0.1μF.

It has the effect of suppressing the heat generation of the IC by adding a series resistor to the Hall element.
However, Hall amplitude should be setting the resistance constant perform sufficient evaluation
because it becomes smaller in proportion.

OPERATION (continued)

■ Functional explanation (continued)

Note) : Unless otherwise specified, numerical values are shown as typical values.

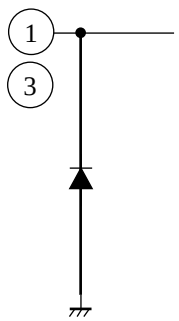
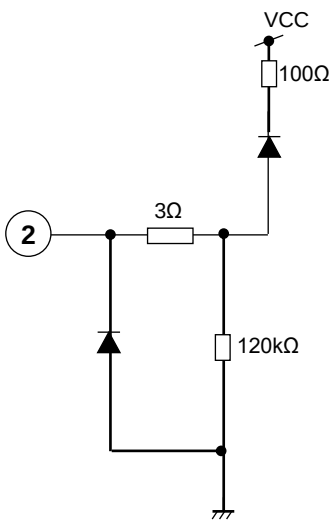
14. SEL pin

It is a setting pin of startup mode.
SEL pin = Open or H, 50% duty fixed specification is selected as the startup mode.
SEL pin = L, PWM input duty specification is selected as the startup mode.
In addition, the specification of the current limit protection changes with the setting of SEL pin.
Please check the table below for details.

SEL pin	Startup mode	Current limit	Current limit setting voltage
Open or H	50% duty fixed	2 values	At Normal drive: 150mV At Startup mode: 90mV
L	PWM input duty	1 value fixed	always: 150mV

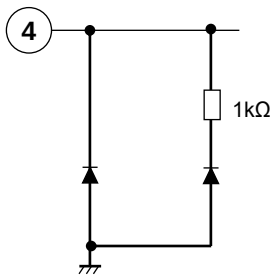
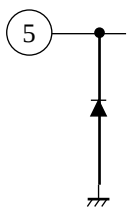
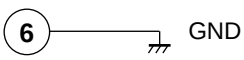
PIN EQUIVALENT CIRCUIT

Note: Unless otherwise specified, values are shown as standard values. (typical values)

Pin No.	Internal circuit	Impedance	Description
1, 3	Internal voltage 	—	Pin1(HP) :Hall amplifier + input pin Pin3(HN) :Hall amplifier – input pin
2		120kΩ	Pin2(HB) :1.2V output for Hall bias

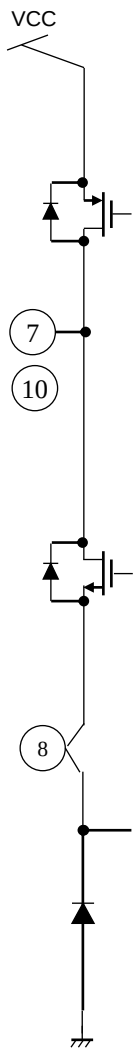
PIN EQUIVALENT CIRCUIT (continued)

Note: Unless otherwise specified, values are shown as standard values. (typical values)

Pin No.	Internal circuit	Impedance	Description
4		—	Pin4(CLD) :Connect a capacitor to set oscillation frequency for motor restricted protection
5		—	Pin5(SEL) :Startup mode select
6		—	Pin6（GND） :GND

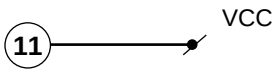
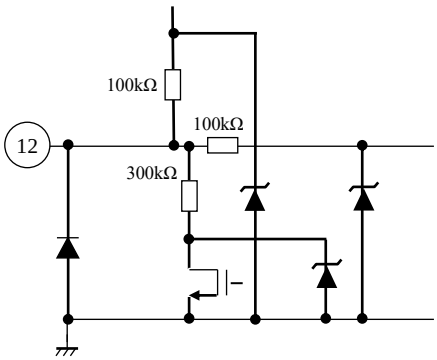
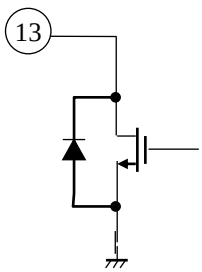
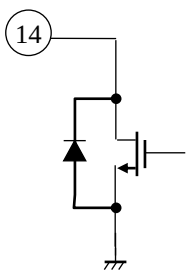
PIN EQUIVALENT CIRCUIT (continued)

Note: Unless otherwise specified, values are shown as standard values. (typical values)

Pin No.	Internal circuit	Impedance	Description
7, 10, 8		—	Pin7(OUT1), Pin10(OUT2) :Motor drive output pin Pin8(RCS) :setting for current limit protection

PIN EQUIVALENT CIRCUIT (continued)

Note: Unless otherwise specified, values are shown as standard values. (typical values)

Pin No.	Internal circuit	Impedance	Description
11		—	Pin11（VCC） : VCC
12		—	Pin12(PWMI) :PWM signal input pin, High period is output → on, Low period is output → off
13		—	Pin13(FG) :FG signal output pin
14		—	Pin14(LD) :Motor Lock detection signal output pin

APPLICATION INFORMATION

1. Precaution at restarting under decelerating.

When IC turns on and starts up, IC drives motor with rectangle drive at starting up.
When restarting during stop/inertia rotation, because the possibility which the motor current is switched before the motor current becomes to zero is high, the motor current flows into VCC. So VCC rises higher than setting voltage, there is possibility that VCC voltage is over IC's absolute maximum voltage.

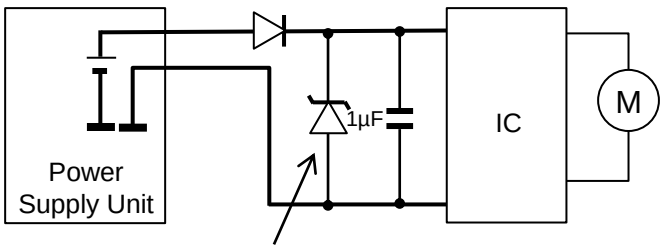
In case of that, it may be possible to suppress the VCC voltage rise described above by increasing the overcurrent protection setting resistance value of the RCS pin to suppress the current at startup.

2 . Precaution at turn off VCC

When the power supply voltage is turned off under high speed rotation. Because the motor's BEMF voltage is high, VCC is supplied by BEMF voltage, and IC repeats start and stop.
The possibility which the motor current flows into VCC is high, VCC rises higher than setting voltage, there is possibility that VCC voltage is over IC's absolute maximum voltage.

If the reverse current to VCC, including of above 1 or 2, occurs and the countermeasure is needed, please countermeasure to cramp VCC voltage by adding the zener diode in parallel with bypass capacitance and ensure sufficient evaluation is performed to verify that there is no problem.

(Countermeasure Circuit)

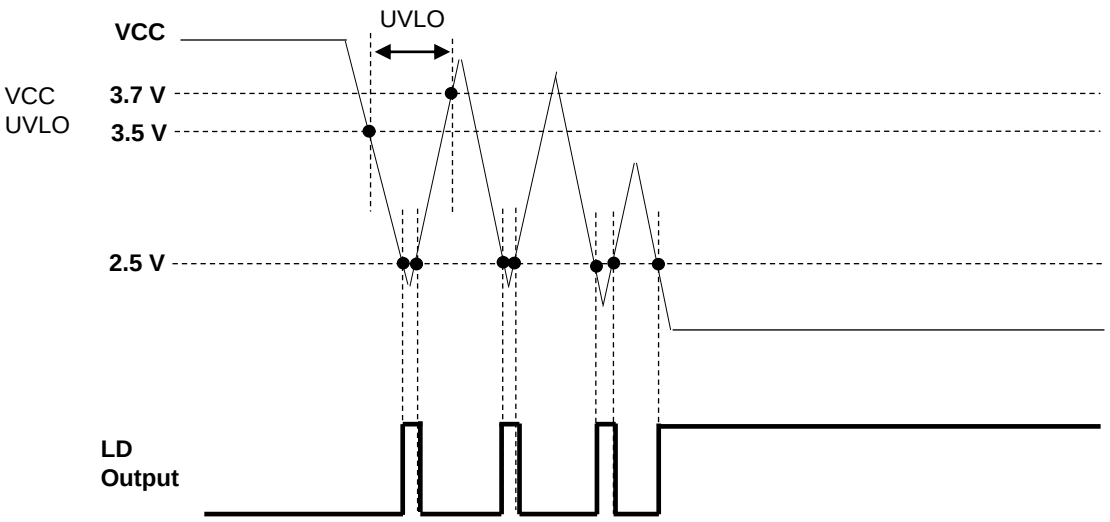


Add the zener diode in parallel with bypass capacitance

APPLICATION INFORMATION (continued)

3. Precautions when turning off the VCC

If the BEMF of the motor is large after the VCC is turned off while the motor is rotating, the deceleration stop and restart operations are repeated.
When the VCC is reduced and the voltage reaches 2.5V, the LD pin output becomes HiZ.
After that, if the VCC rises and restarts, the LD pin output will output L as the initial value.
Since the LD output also repeats "HiZ" and "L" when the VCC voltage repeats decreasing and increasing, please note it.



4. Precautions when starting from reverse rotation

If the motor is started with the motor rotating backward due to some external factor, the motor may swing and a reverse current may flow.
Please note when using under such conditions.

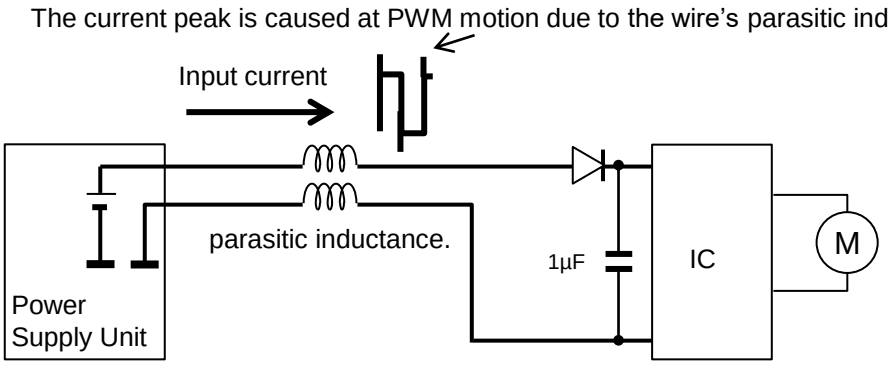
APPLICATION INFORMATION (continued)

5. Precaution at PWM Drive

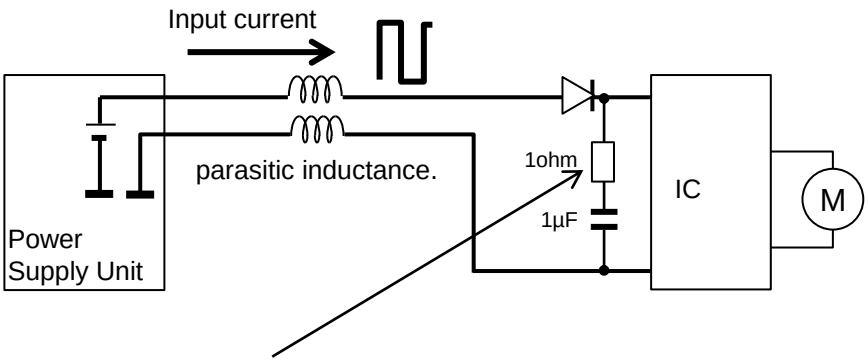
When VCC and GND wire is long, There is possibility which current peak of motor input current is caused at PWM motion due to wire's parasitic inductance.

Please countermeasure to reduce current peak of motor input current by adding a resistance in series with bypass capacitance and ensure sufficient evaluation is performed to verify that there is no problem.

(Occurrence example)



(Countermeasure Circuit)



APPLICATION INFORMATION (continued)

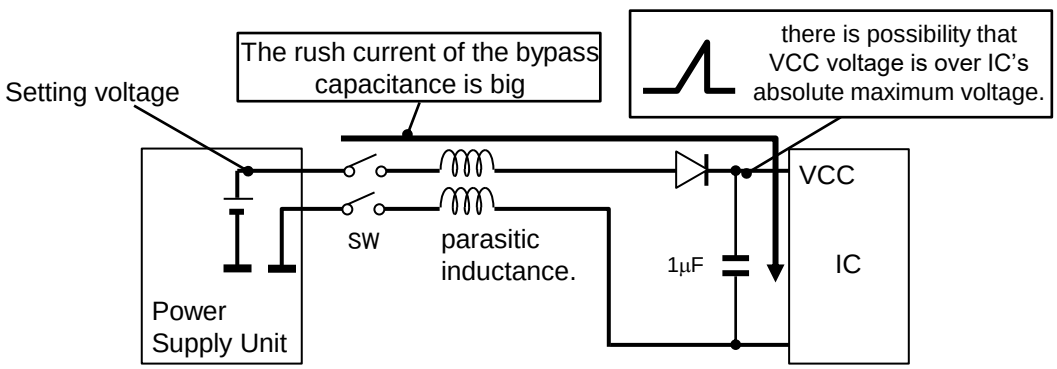
6. Precaution at inputting power to VCC

When the IC is powered on, it is recommended that VCC voltage rises slower than 0.24V/us, also when IC is shut down, it is recommended that VCC voltage falls higher than -0.24V/us, When power up is performed at high-speed, rush current must flow into bypass capacitance between VCC and GND. So VCC rises higher than setting voltage due to wire's parasitic inductance, there is possibility that VCC voltage is over IC's absolute maximum voltage. Please note.

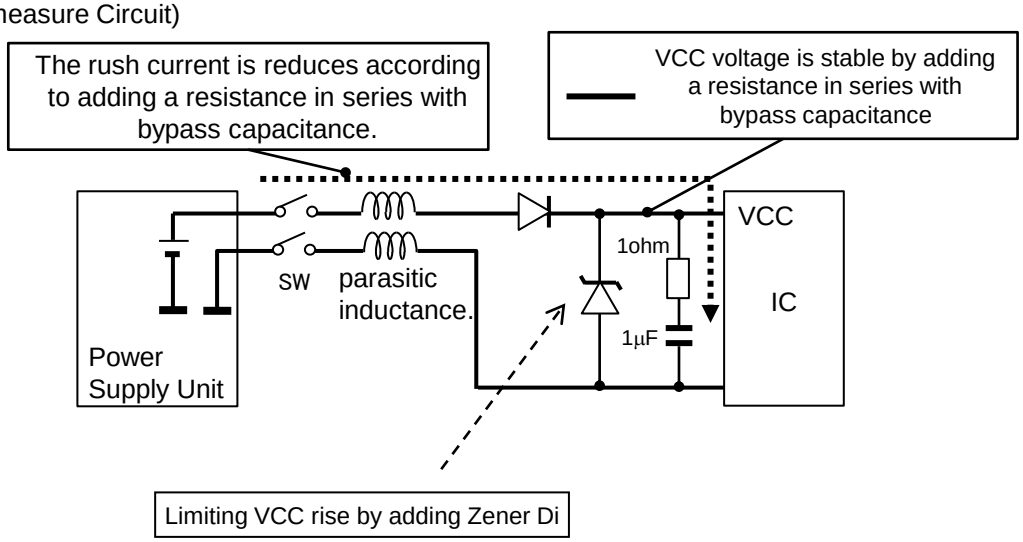
If this phenomenon occurs, add a Zener Di between VCC and GND of the IC to prevent it from exceeding the IC rating.
Please also note the rating of the Zener Di to be added.
Also, by inserting a resistor in series with the bypass capacitance to reduce the rush current, there is a suppressing effect, so please confirm the countermeasure effect.

(Occurrence example)

For example, in case of turning on the VCC by using the mechanical switch.



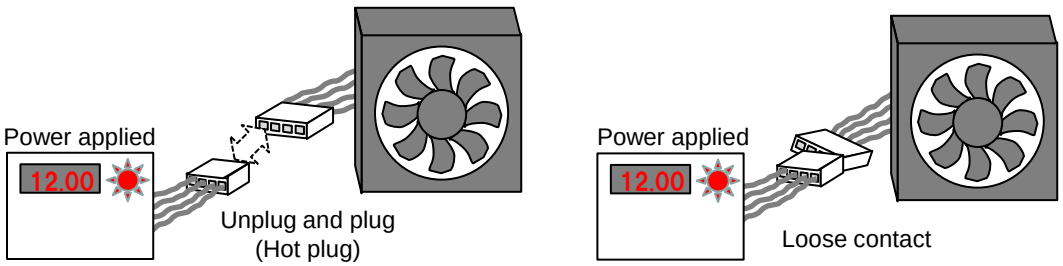
(Countermeasure Circuit)



APPLICATION INFORMATION (continued)

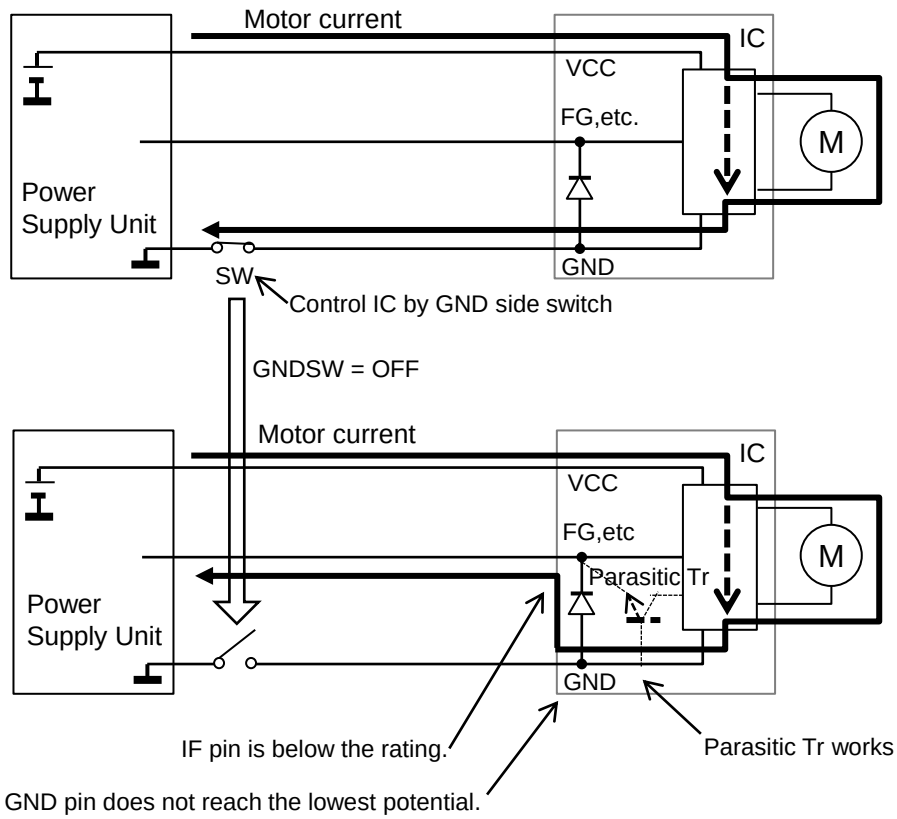
7. Hot plug, loose contact

When power is applied, VCC, GND, I/F pins (PWMI, FG, LD, etc.) hot plugs and loose contacts may be damaged by the application of voltage or current exceeding the absolute maximum rating of the IC. Please note.



8. About GND pin

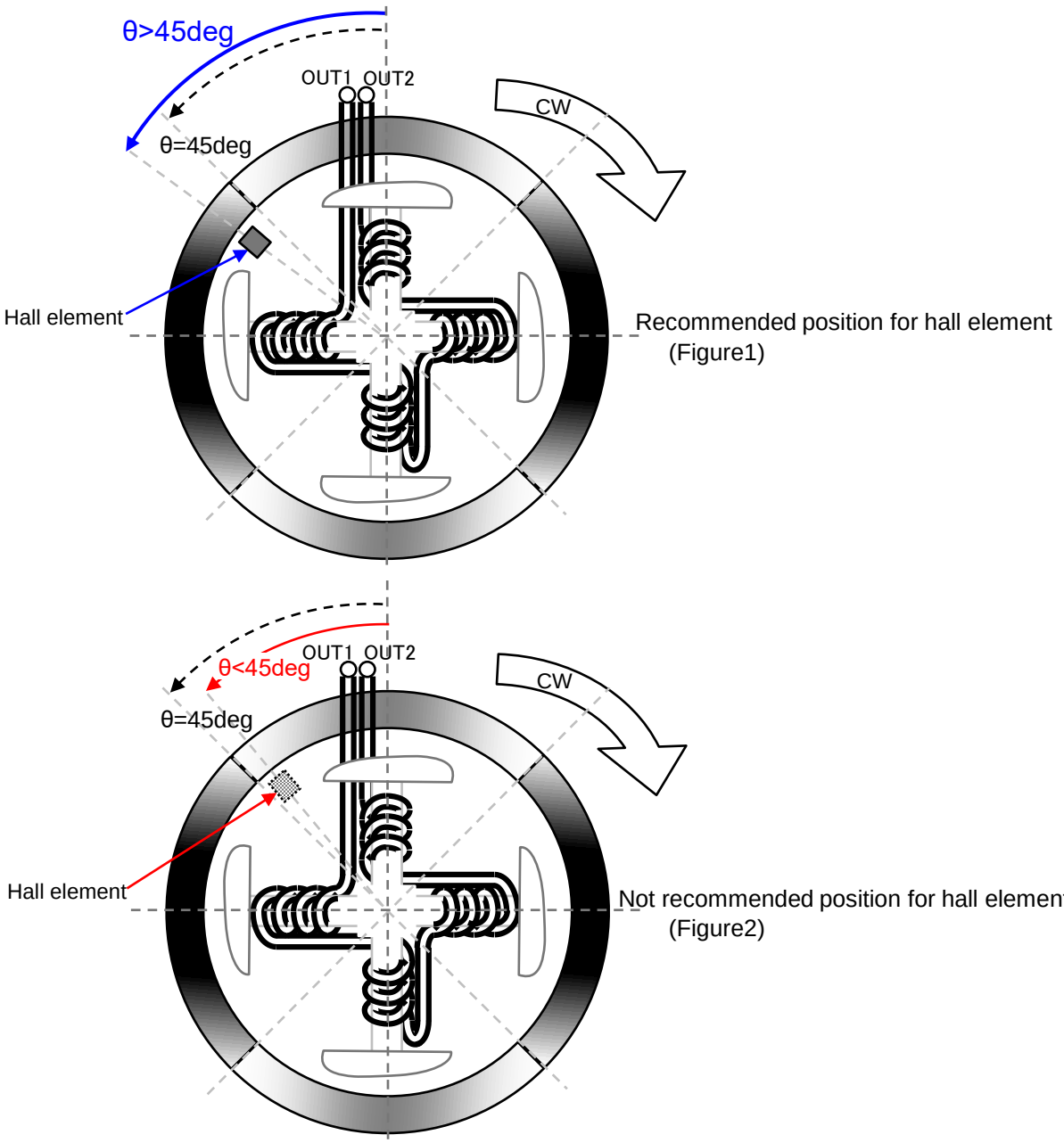
Be sure to use the GND pin of the IC so that it has the lowest potential with respect to other pins. Regarding the operation of turning on and off the GND pin of the IC and controlling the motor, the GND pin of the IC does not reach the minimum potential, the IF pin falls below the rating, and the parasitic Tr operates and the IC may be destroyed. Please note.



APPLICATION INFORMATION (continued)

Recommended position for hall element

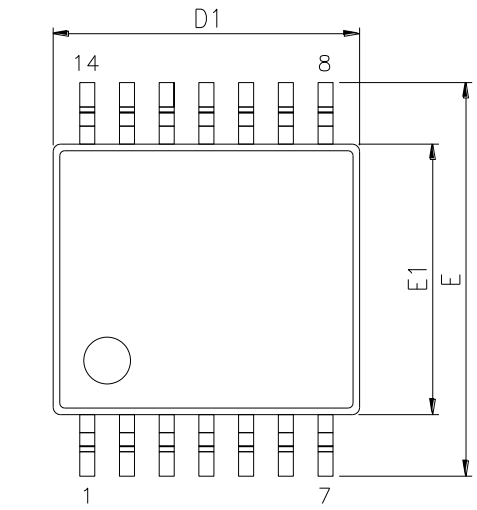
This driver detects the ineffective current during phase switching and this driver has automatic phase adjustment for optimized motor current.
We recommend that you set the hall element in the position shown in the following figure1.
If you set the hall element in the position shown in the following figure2, it may not be started the motor and it may be that automatic phase adjustment is low performance.



PACKAGE INFORMATION

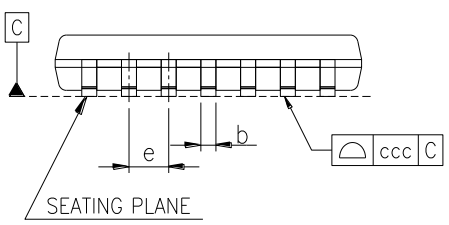
Outline Drawing

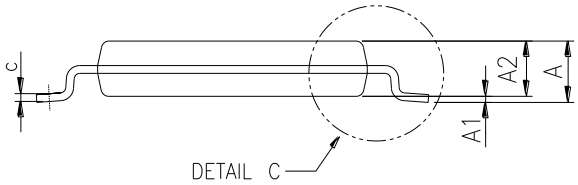
TSSOP 14L 4.4x5.0mm², Thickness 0.9mm, Lead Pitch 0.65mm, Lead Length 1mm

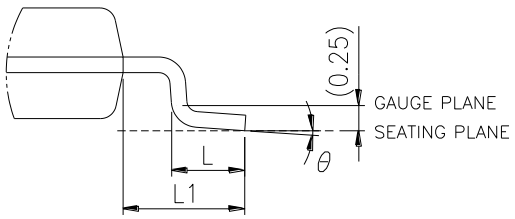


VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS	MIN.	NOM.	MAX.
A	–	–	1.10
A1	0.05	–	0.15
A2	0.85	0.90	0.95
D1	4.90	5.00	5.10
E	6.30	6.40	6.50
E1	4.30	4.40	4.50
b	0.19	–	0.30
c	0.13	–	0.20
ccc	0.10		
L	0.45	0.60	0.75
L1	1.00REF		
e	0.65BSC		
θ	0.0°	–	8.0°







DETAIL C

USAGE NOTES

1. Pay attention to the direction of the IC. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might be damaged.
2. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
3. Perform visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as solder-bridge between the pins of the IC. Also, perform full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the IC during transportation.
4. Take notice in the use of this IC that it might be damaged and be emitted a little smoke when an abnormal state occurs such as output pin-VCC short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short). Safety measures such as installation of fuses are recommended because the extent of the above-mentioned damage will depend on the current capability of the power supply.
   Although the following pins built in with short circuit protection function, the IC may be damaged and emit smoke depending on the VCC voltage.
   Pins with short circuit protection function : Pin7(OUT1), Pin10(OUT2)
5. The protection circuit is for maintaining safety against abnormal operation.
   When sudden voltage or current change is applied to the pin, it may exceed the designated voltage and current level and therefore, customer shall perform sufficient evaluation and verification to ensure these are not exceeded in the usage.
   Especially for the thermal protection circuit, if the area of safe operation or the absolute maximum rating is momentarily exceeded due to output pin to VCC short (Power supply fault), or output pin to GND short (Ground fault), the IC might be damaged and emit smoke before the thermal protection circuit could operate.
6. Unless specified in the product specifications, make sure that negative voltage or excessive voltage are not applied to the pins because the IC might be damaged, which could happen due to negative voltage or excessive voltage generated during the ON and OFF timing when the inductive load of a motor coil or actuator coils of optical pick-up is being driven.
7. This Product which has specified ASO (Area of Safe Operation) should be operated in ASO
8. Verify the risks which might be caused by the malfunctions of external components.
9. Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process.
10. Supply a power supply with sufficiently low impedance to VCC and connect a bypass capacitor near the IC.
11. After supplying VCC, if the VCC voltage drops due to the motor drive while VCC rises to the prescribed voltage, it may not start normally, so please thoroughly evaluate and study the current capability of the power supply.
12. Follow the power supply voltage, load and ambient temperature conditions to ensure that there is enough margin and the thermal design does not exceed the allowable value.
13. Pin 12(PWMIN) pins are MCU interface. In the case that the current setting of the motor is large and lead line of GND is long, the potential of GND pin of the IC may be increased.
    If 0V is input from the MCU, there is a case to be negative potential in the potential difference between the GND pin of this IC and the interface pin. If these pins detect under -0.3V, note that there is a possibility to break or malfunction.
14. When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment, etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
    Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damage, for example, by using the products.

Revision History

Date	Revision		Description	
2020.10.31	1.00	1	Initially issued.	
2022.01.28	1.05	1	Changed important notice	Page2
		2	Remove important notice page from previous version page48,49	-
		3	Added usage notes	Page49
2023.8.31	1.06	1	Changed power dissipation rating notice	Page5
		2	Changed block diagram composition	Page10
		3	Changed pin equivalent circuit composition	Page28-31

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.