

## Driver IC for single phase Brushless Motor

# KA44168A Datasheet

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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

<b>Functional safety standards for automobiles ISO26262</b>	<b>No</b>
<b>AEC-Q100</b>	<b>No</b>
<b>Market failure rate</b>	<b>50Fit</b>

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.
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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.
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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: 5.0 V ~ 28 V
- Auto phase shift correction with built-in Soft Switching function
- Wide range operation (12V/24V)
- Motor lock protection and built-in Auto-recovery fixed with built-in clock
- Output pin for FG pulse (open drain)
- Various protection functions: Under Voltage Lock Out (UVLO), Thermal protection GND short protection, and Over Current Protection
- Package MSOP 8L (3x3x0.85mm<sup>3</sup>, Lead Pitch 0.65mm)



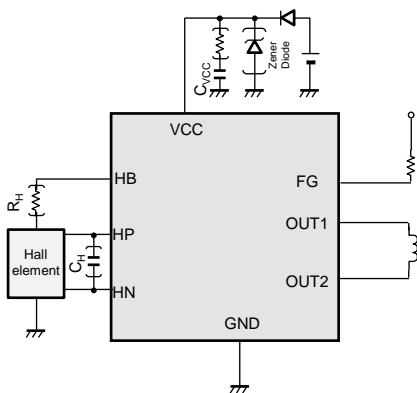
**DESCRIPTION**

- KA44168A is a high efficiency single phase motor driver IC with built-in Soft Switching function for low noise operation. The soft switching period is automatically adjusted based on the motor current. This eliminates the need for individual adjustment of the soft switching period based on the Motor's specifications.
- With a wide input voltage range of 12V/24V, this IC is most suitable for usage in OA and FA equipment.

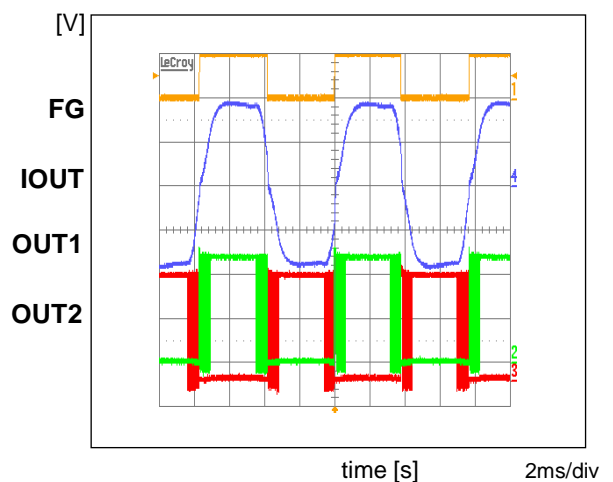
**APPLICATIONS**

- Refrigerator, Projector, Printer, Factory automation

**TYPICAL APPLICATION**



**TYPICAL CHARACTERISTICS**



Condition:  
 $V_{CC} = 12\text{ V}$ , PWMI = 100% duty,  $C_{vcc} = 1\ \mu\text{F}$

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.

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**ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Rating	Unit	Notes
Supply voltage	$V_{CC}$	-0.3 to +35	V	*1
Operating ambient temperature	$T_{opr}$	-40 to +105	°C	*2
Junction temperature	$T_j$	-40 to +150	°C	*2
Storage temperature	$T_{stg}$	-55 to +150	°C	*2
Input Voltage Range	$V_{HP}, V_{HN}$	-0.3 to +6	V	—
Output Voltage Range	$V_{OUT1}, V_{OUT2}$	-0.3 to +35	V	*1*3
	$V_{FG}$	-0.3 to +35	V	—
	$V_{HB}$	-0.3 to +6	V	*3
Output Current Range	$I_{OUT1}, I_{OUT2}$	-1000 to +1000	mA	*1*4
	$I_{FG}$	-5 to +10	mA	—
	$I_{HB}$	-10 to 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  $T_a = 25^\circ\text{C}$ .
- \*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.

**POWER DISSIPATION RATING**

Package	$\theta_{j-a}$	$P_D$ ( $T_a=25^\circ\text{C}$ )	$P_D$ ( $T_a=105^\circ\text{C}$ )
MSOP 8L (3x3x0.85mm <sup>3</sup> , Lead Pitch 0.65mm)	222.2°C/W	562.6mW	202.5mW

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	—	28	V	*1
Input voltage range	$V_{HP}$	0	—	1.5	V	*2
	$V_{HN}$	0	—	1.5	V	*2
External constants	$C_{VCC}$	—	1	—	$\mu F$	*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<sub>CC</sub> = 12.0 V

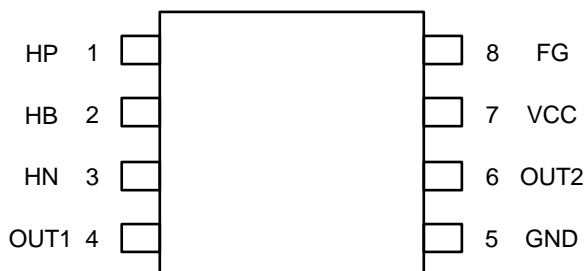
Note: T<sub>a</sub> = 25°C ± 2°C unless otherwise noted.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
<b>Circuit Current</b>							
V <sub>CC</sub> current 1	I <sub>CC1</sub>	Output OPEN, Lock State	—	1.5	3	mA	—
V <sub>CC</sub> current 2	I <sub>CC2</sub>	Output OPEN, 50% duty	—	2.0	4	mA	—
<b>FG Block</b>							
Low-level output voltage	V <sub>OLFG</sub>	I <sub>O</sub> = 5 mA	—	0.1	0.3	V	—
Output leak current	I <sub>LFG</sub>	V <sub>O</sub> =28V	—	—	30	μA	—
<b>Power Block</b>							
On resistance (High Side + Low Side)	R <sub>ONHL</sub>	I = 200 mA	—	1.6	2.25	Ω	—
Diode forward voltage	V <sub>DI</sub>	I = 200 mA	0.6	0.8	1	V	—
<b>Hall Block</b>							
Input dynamic range	V <sub>HA</sub>	—	0	—	1.5	V	—
Pin input current	I <sub>HA</sub>	—	-2	0	2	μA	—
Minimum input voltage amplitude	V <sub>HA</sub>	—	25	—	—	mV	—
Hysteresis width	V <sub>HHYS</sub>	—	—	10	20	mV	—
<b>Hall Bias</b>							
Output Voltage	V <sub>HB</sub>	I <sub>O</sub> = -2mA	1.05	1.2	1.35	V	—
<b>Motor Lock Protection</b>							
Lock protection time setting for reference clock frequency	F <sub>LOCK</sub>	—	7.4	10.6	13.8	kHz	—
Lock detection time	t <sub>LOCK1</sub>	—	—	0.5	—	s	*1*2
Lock release time	t <sub>LOCK2</sub>	—	—	5	—	s	*1*2
Lock protection ratio	PR <sub>RATIO</sub>	—	—	10	—	—	*1*2
<b>Thermal Protection</b>							
Protection operating temperature	TSD <sub>ON</sub>	—	—	160	—	°C	*1*2
Hysteresis width	TSD <sub>HYS</sub>	—	—	25	—	°C	*1*2
<b>Under Voltage Lock Out</b>							
Protection operating voltage	V <sub>LVON</sub>	—	—	3.5	—	V	*1*2
Hysteresis width	V <sub>LVOHYS</sub>	—	—	0.2	—	V	*1*2

Notes: \*1: Typical Design Value.

\*2: These are values checked by design but not production tested.

**PIN CONFIGURATION**

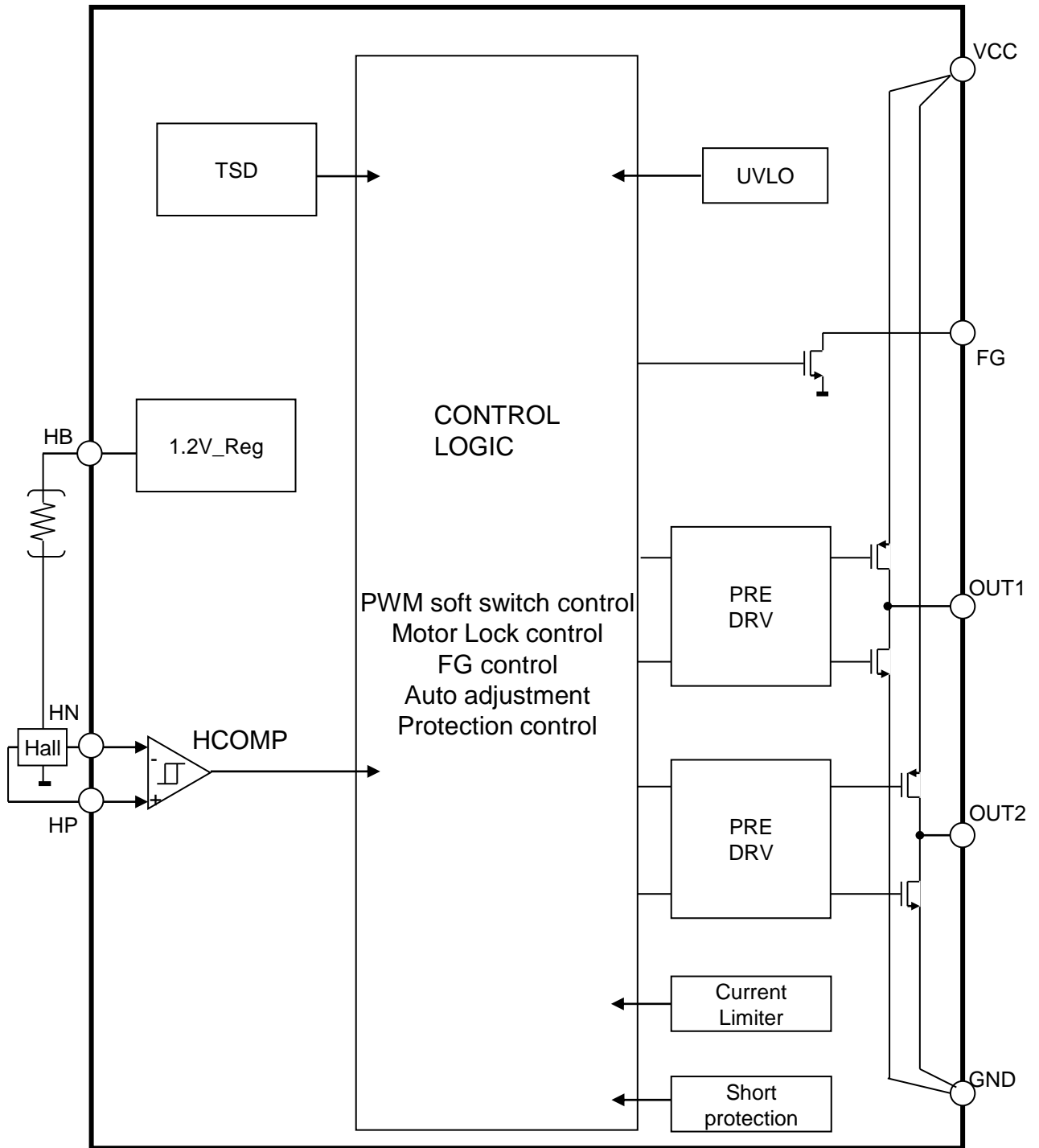


**PIN FUNCTIONS**

Pin No.	Pin name	Type	Description
1	HP	Input	Hall amplifier input (+)
2	HB	Output	Hall bias output
3	HN	Input	Hall amplifier input (-)
4	OUT1	Output	OUT1 : Motor drive output 1
5	GND	Ground	Ground
6	OUT2	Output	OUT2 : Motor drive output 2
7	VCC	Power	Supply voltage for internal circuit
8	FG	Output	FG 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.

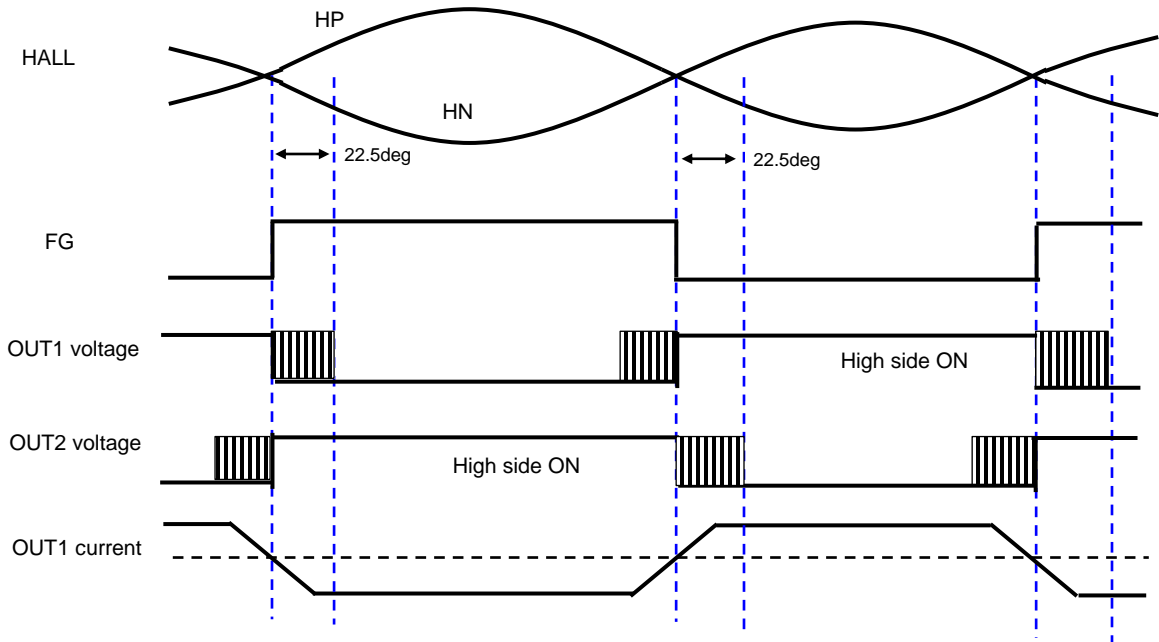
Function name	Operate	Release	Note
TSD	160°C	135°C	Motor energization off while protection function works.
Current limit	1.2A	After fixed time progress	If motor current reaches 1.2A, output current will be restricted in turning off an output for a fixed time. ON time , and OFF time are such as below. (ON : 2μsec, OFF : 10.0μsec)
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. (latch protection)	• at UVLO • After fixed time progress	UVLO release protection and a count are reset. A protection setting time is determined by internal circuit. (Time(s) = 0.5 sec) Restart after 5 sec.
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 .

Note : These are values checked by design but not production tested.

**OPERATION (continued)**

**■ Drive State Diagram**

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



**OPERATION (continued)**

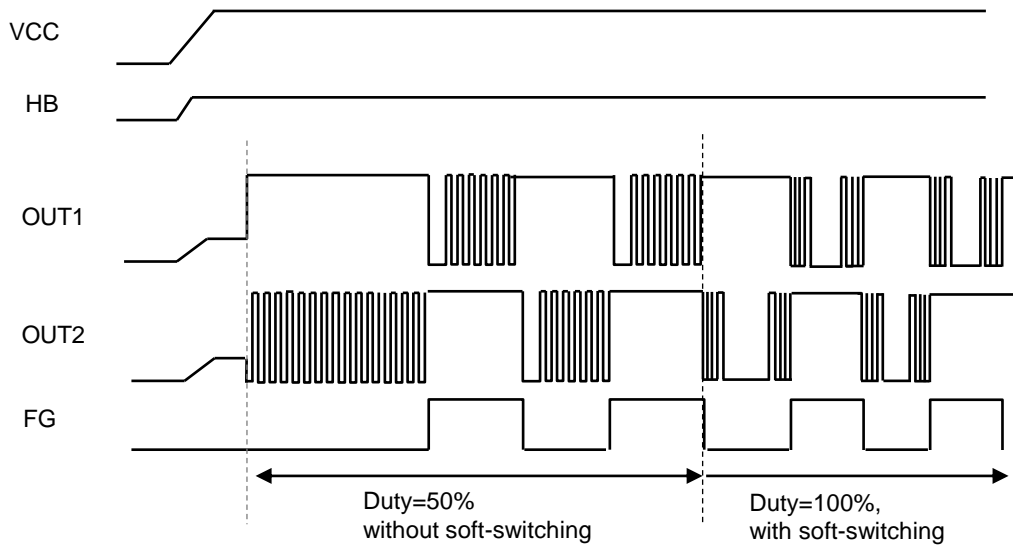
**■ Functional explanation**

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

**1. Start up, Normal drive**

After applying the VCC of power supply within the operation limits, IC becomes startup mode.

In startup, it will start on the PWM operation at a fixed duty (duty=50%, f=40kHz). Then it becomes normal driving of duty = 100%.



**OPERATION (continued)**

**■ Functional explanation (continued)**

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

**2. Motor locked protection circuit**

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 off .

The value of the locked protection time can be calculated by the following equation approximately.

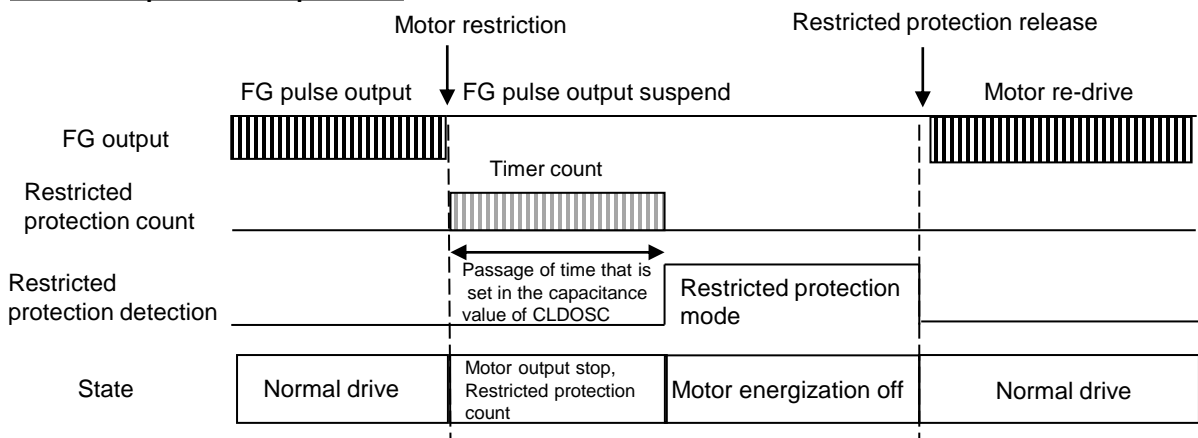
$$\text{Restricted protection setting time (sec)} \cong 0.5 \text{ sec}$$

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 ( about 5 sec )

**•Restricted protection explanation**



**OPERATION (continued)**

**■ Functional explanation (continued)**

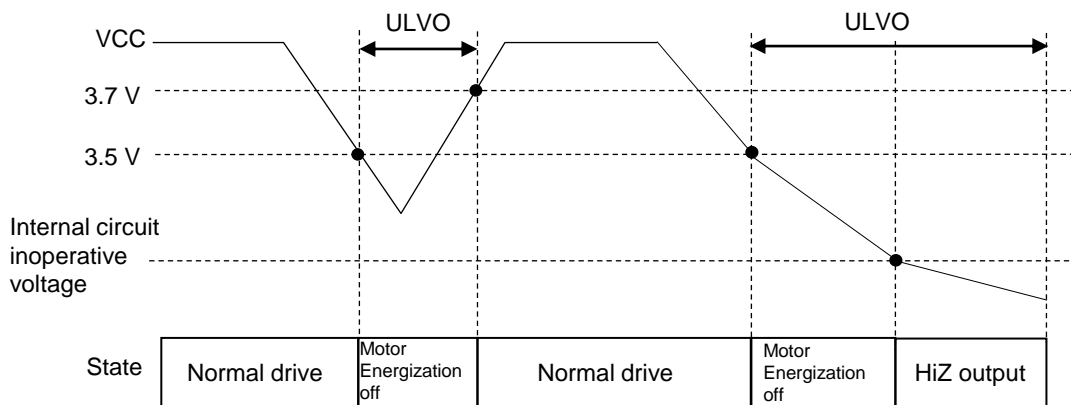
Note) The characteristics listed below are reference values derived from design of the IC and are not guaranteed.

**3. 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, motor energization 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).

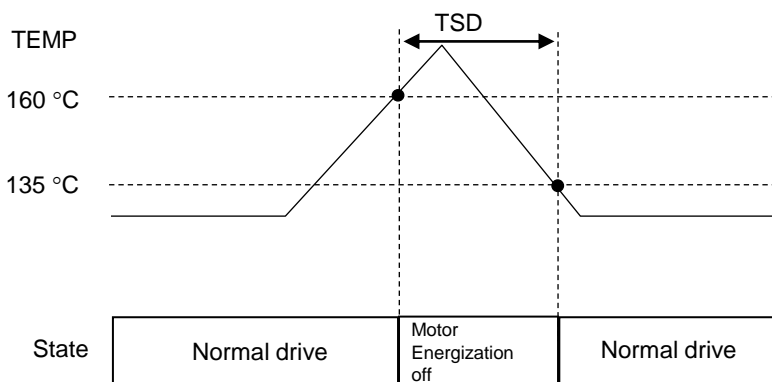
Hysteresis of 0.2V is set in the VCC low voltage protection function. If the VCC is restored to 3.7V from protection mode, the low voltage protection is released.



**4. Thermal protection (TSD)**

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

If the IC junction temperature is 135°C (design target value) or less, the protection is released.



**OPERATION (continued)**

**■ Functional explanation (continued)**

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

**5. Overcurrent protection**

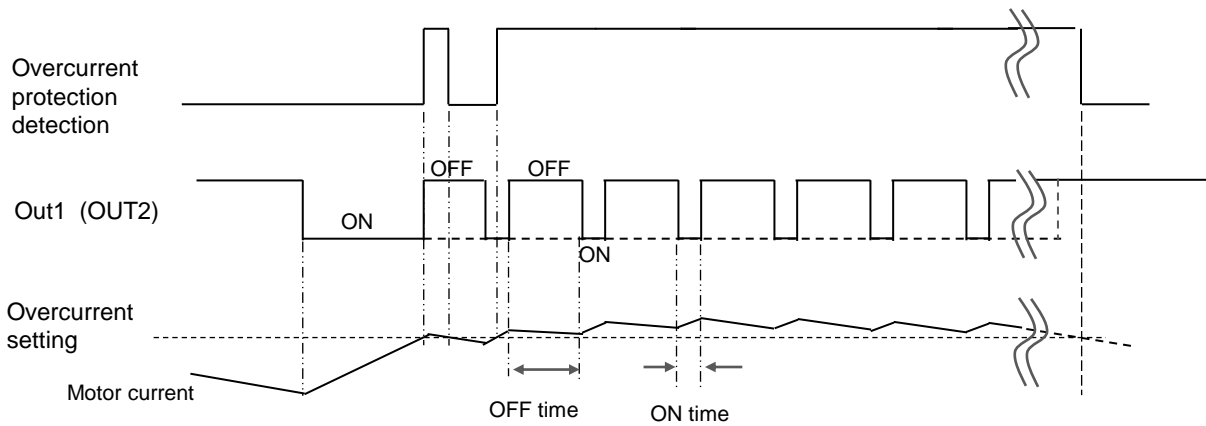
Here, describes the overcurrent protection.

It detects an overcurrent at 1.2A, as overcurrent does not flow at OUT1, OUT2

After detecting a current greater than the setting value, by shutting off the output transistor during the predetermined time, it protects an over-current.

On time 2  $\mu$ sec (in start up period 1.5 $\mu$ sec)

Off time 10  $\mu$ sec (in start up period 40 $\mu$ sec)



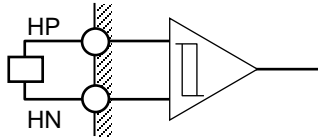
**OPERATION (continued)**

**■ Functional explanation (continued)**

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

**6. 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).

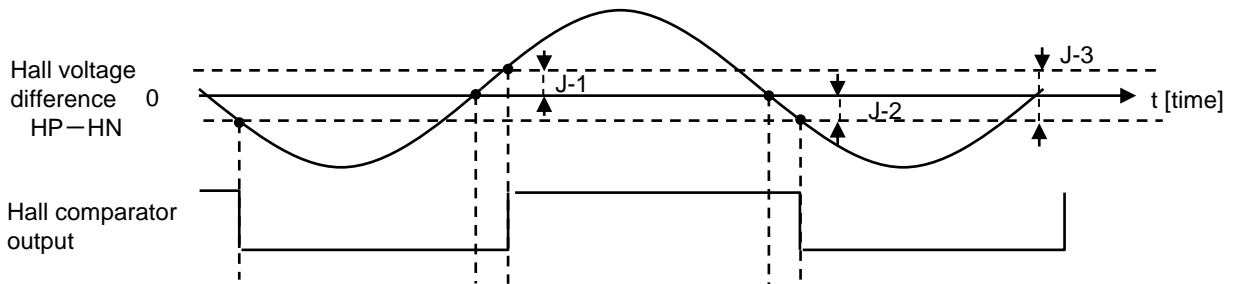


The following is a schematic diagram of the characteristics.

J-1 hysteresis level: 5 mV L → H

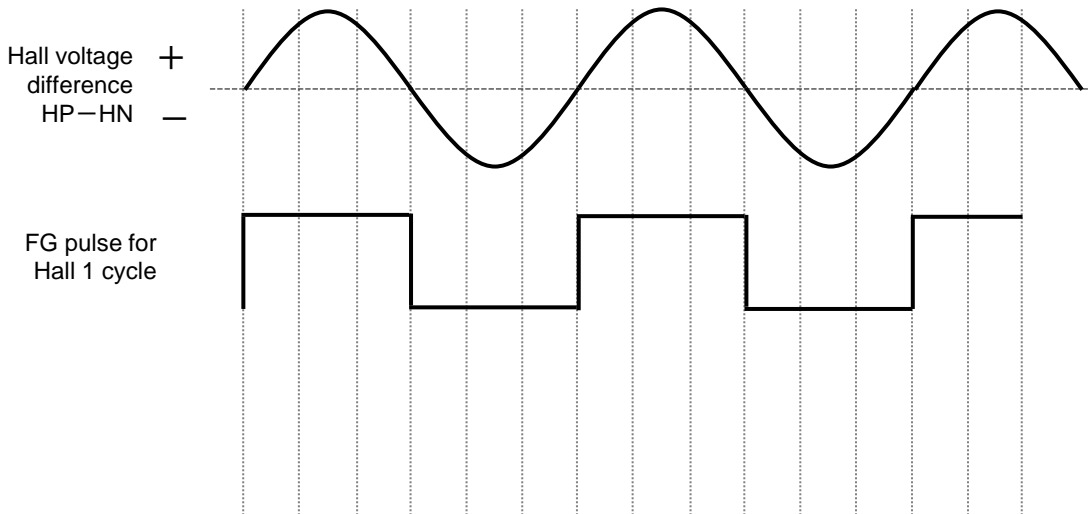
J-2 hysteresis level: 5 mV H → L

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.



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## OPERATION (continued)

### ■ Functional explanation (continued)

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

#### 7. 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.

#### 8. 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 0.1 $\mu$ F.

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.

**PIN EQUIVALENT CIRCUIT**

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

Pin No.	Internal circuit	Impedance	Description
1, 3	<p>The diagram shows two pins, 1 and 3, connected to a common node. Pin 1 is labeled with a circled '1' and Pin 3 with a circled '3'. This node is connected to ground through a diode pointing downwards. Another diode is connected between the two pins, pointing from pin 1 to pin 3.</p>	—	<p>Pin1(HP) :Hall amplifier + input pin</p> <p>Pin3(HN) :Hall amplifier – input pin</p>
2	<p>The diagram shows Pin 2 (HB) connected to a node. This node is connected to VCC through a diode pointing upwards. It is also connected to ground through a 120kΩ resistor and a diode pointing downwards.</p>	120kΩ	<p>Pin2(HB) :Hall bias 1.2V output pin</p>

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**PIN EQUIVALENT CIRCUIT (continued)**

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

Pin No.	Internal circuit	Impedance	Description
4, 6		—	Pin4(OUT1), Pin6(OUT2) :Motor drive output pin
5		—	Pin5 (GND) :GND pin
7		—	Pin7 (VCC) :Power supply pin
8		—	Pin8(FG) :FG signal output pin

**APPLICATION INFORMATION**

**1. Precaution at restarting under decelerating.**

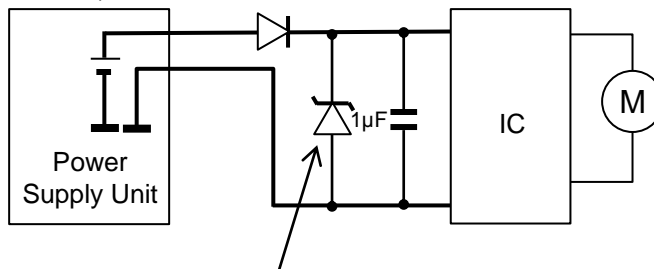
When IC turns on, The duty of PWM pulse is forced 50%. When restarting during motor deceleration, because the possibility which the motor current is switched before the motor current becomes to zero is high, the motor current flows into VCC. So VCC rises higher than setting voltage, there is possibility that VCC voltage is over IC's absolute maximum voltage.

**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 above 1 or 2 occurs and the countermeasure is needed, please countermeasure to clamp 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)**

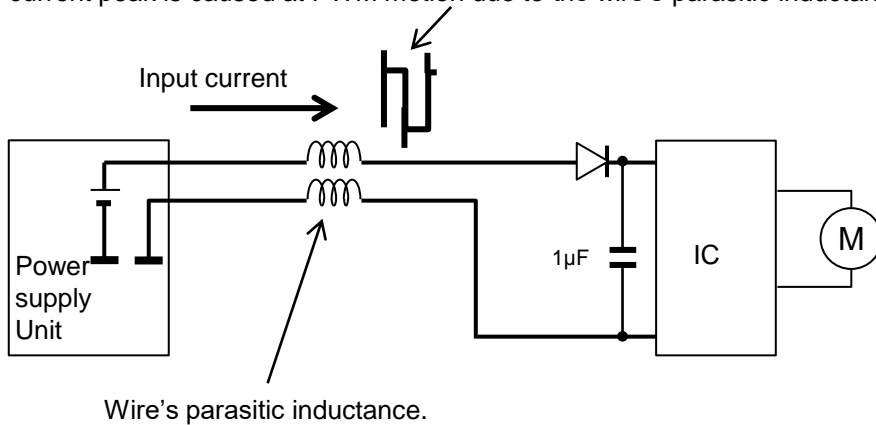
**3.Precaution at PWM Motion**

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.

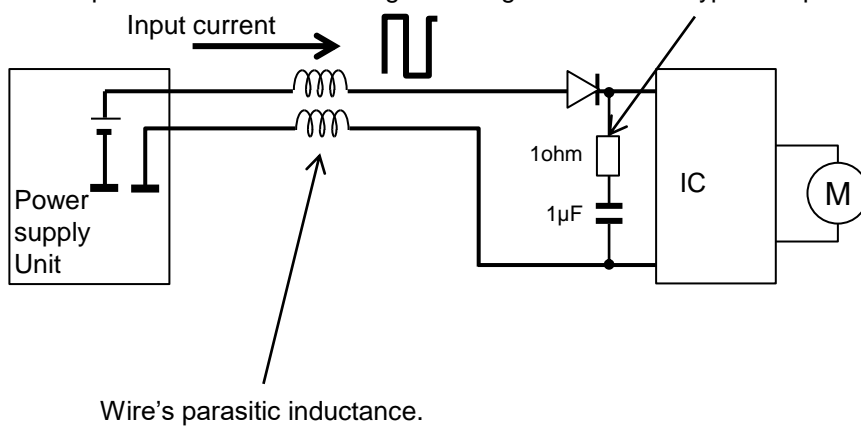
(Circuit)

The current peak is caused at PWM motion due to the wire's parasitic inductance.



(Countermeasure Circuit)

The current peak is reduces according to adding in series with bypass capacitance.

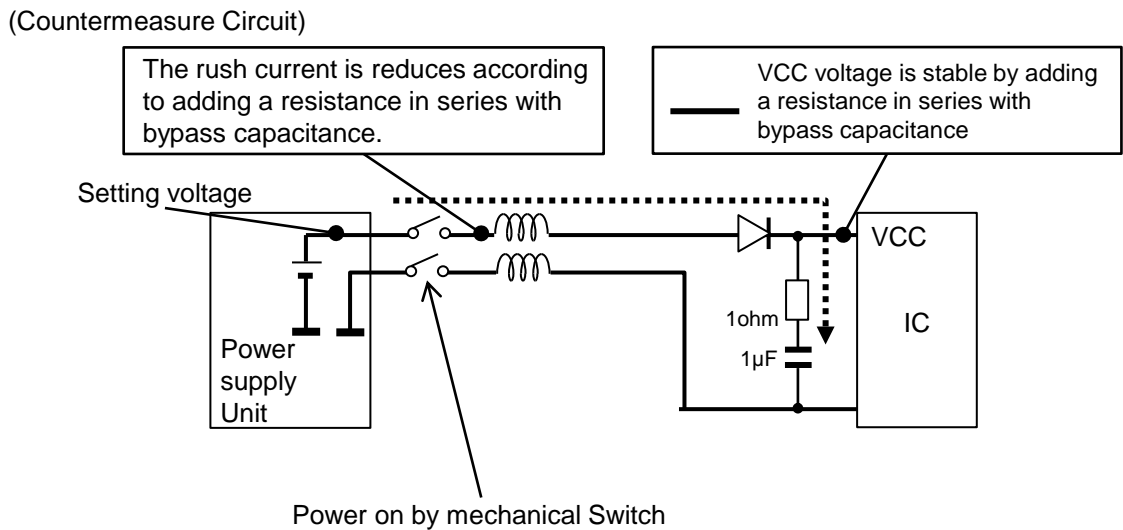
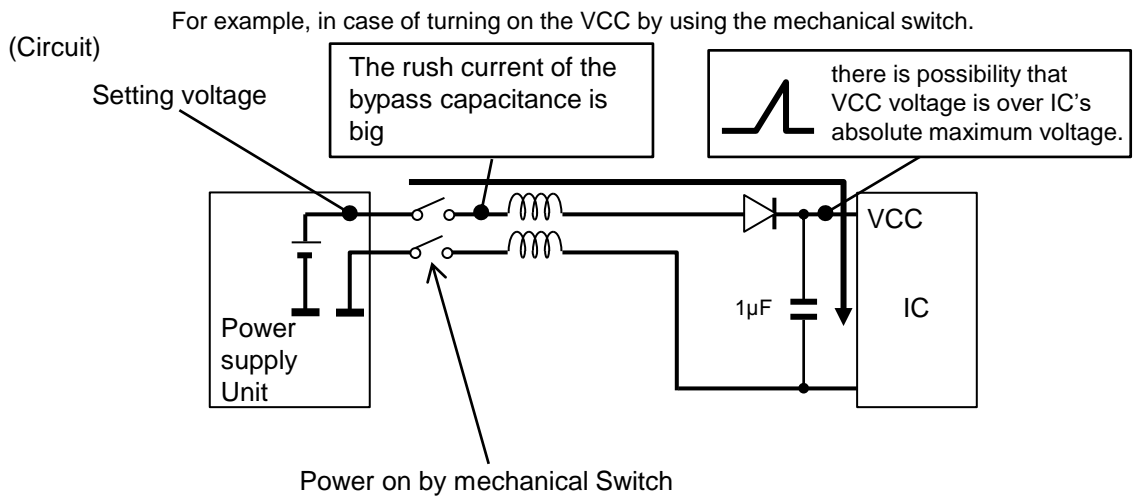


**APPLICATION INFORMATION (continued)**

**4. Precaution at inputting power to VCC**

When input power to VCC, it is recommended that VCC voltage rises slower 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 countermeasure to reduce rush current by adding a resistance in series with bypass capacitance and ensure sufficient evaluation is performed to verify that there is no problem.



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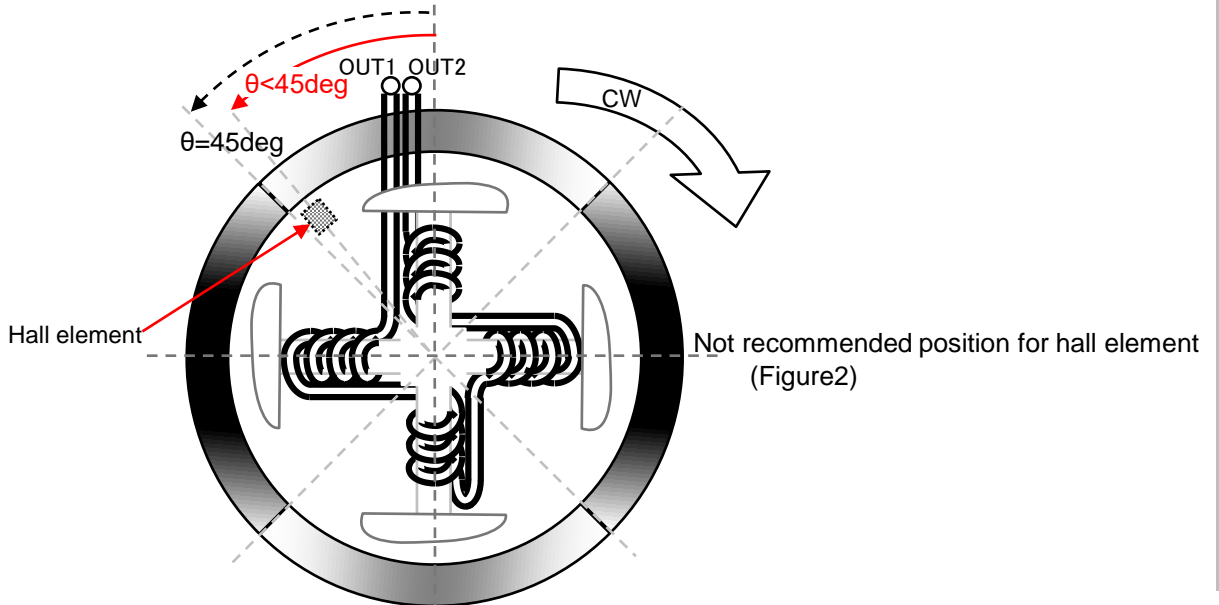
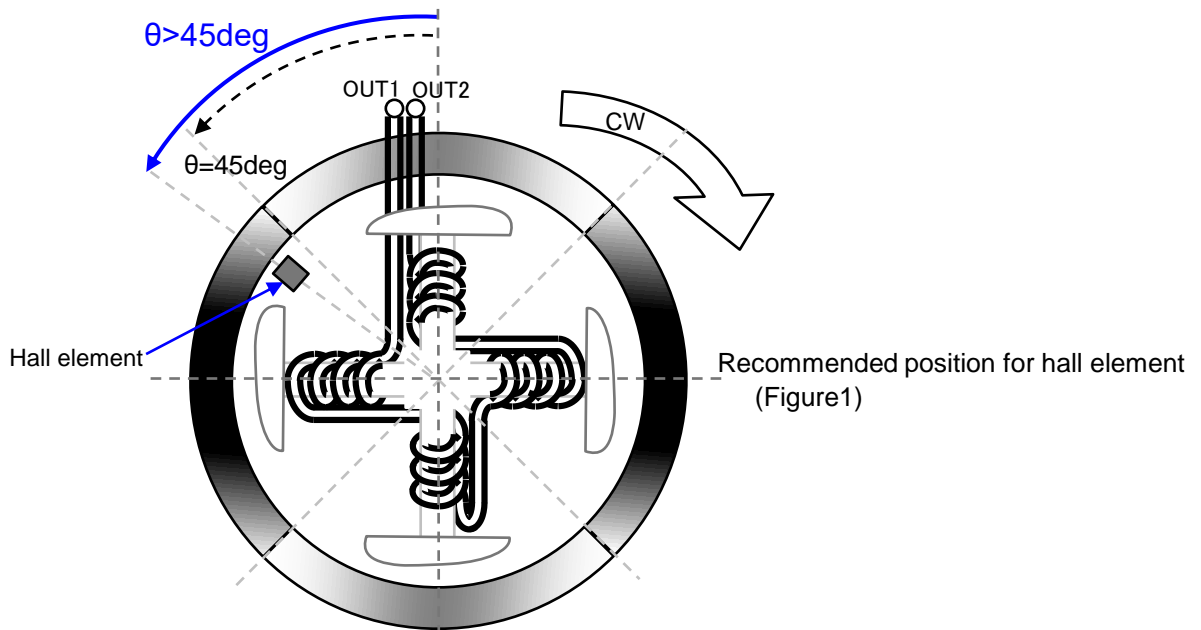
**APPLICATION INFORMATION (continued)**

**5. Recommended position for hall element**

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.

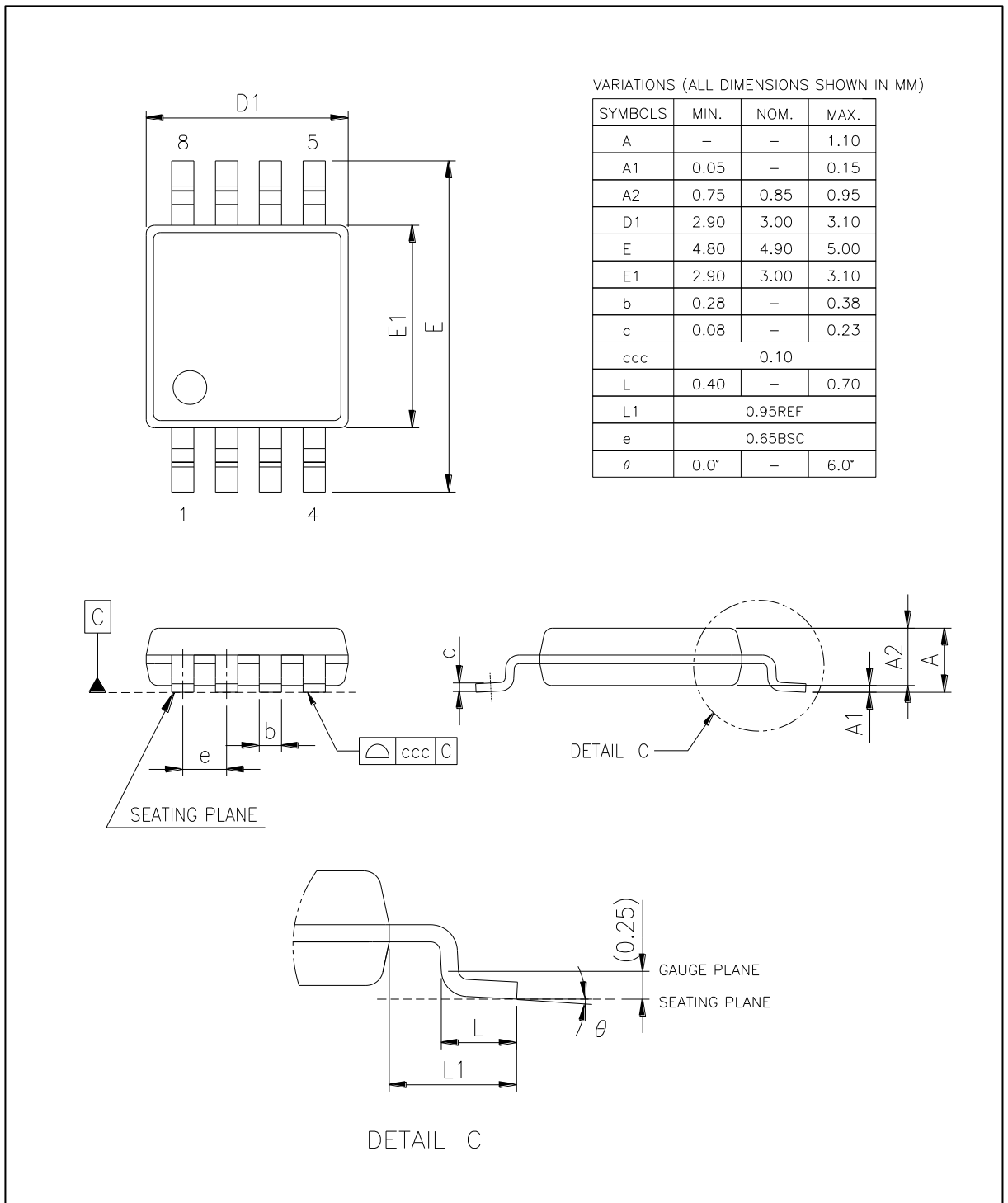
If you set the hall element in the position shown in the following figure2, it may not be started the motor and it may be that automatic phase adjustment is low performance.



PACKAGE INFORMATION

Outline Drawing

MSOP 8L 3x3mm<sup>2</sup>, Thickness 0.85mm, Lead Pitch 0.65mm, Lead Length 0.95mm



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**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 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 comes with short circuit protection function, the protection may be damaged depending on the VCC voltage. Pins with short circuit protection function: OUT1 and 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 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. 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. Dip soldering is not recommended.
11. 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.
12. 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.	
2022.1.27	1.05	1 Changed important notice	Page2
		2 Remove important notice page from previous version page26,27	-
		3 Added usage notes	Page27
2023.8.31	1.06	1 Changed power dissipation rating notice	Page5
		2 Changed block diagram composition	Page9
		3 Changed pin equivalent circuit composition	Page18,19

KA44168A DATASHEET

## 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.

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