DC Brushless Motor Driver

Multi-function Single-phase Full-wave FAN Motor Pre-Driver

BD61258MUV

General Description

BD61258MUV is pre-driver IC to drive single phase H bridge output composed of external MOS FET.
The power supply input pin and the drive output have voltage rating of 40 V, so it can be used in a 24 V power supply without using voltage drop down circuit.

Features

- Pre-Driver for External Power MOS FET (P-N Complementary Type)
- Speed Controllable by PWM / DC Voltage
- Minimum Output Duty Limit
- Input/Output Duty Characteristics Adjustment
- Quiet Drive by PWM Soft Switching
- Lead / Delay Angle Setting
- Soft Start
- Standby Function
- Current Limit
- Lock Protection and Automatic Restart
- Speed Pulse Signal (FG), Lock Alarm Signal (AL) Selectable
- Both Hall Elements / Hall ICs are Available

Key Specifications

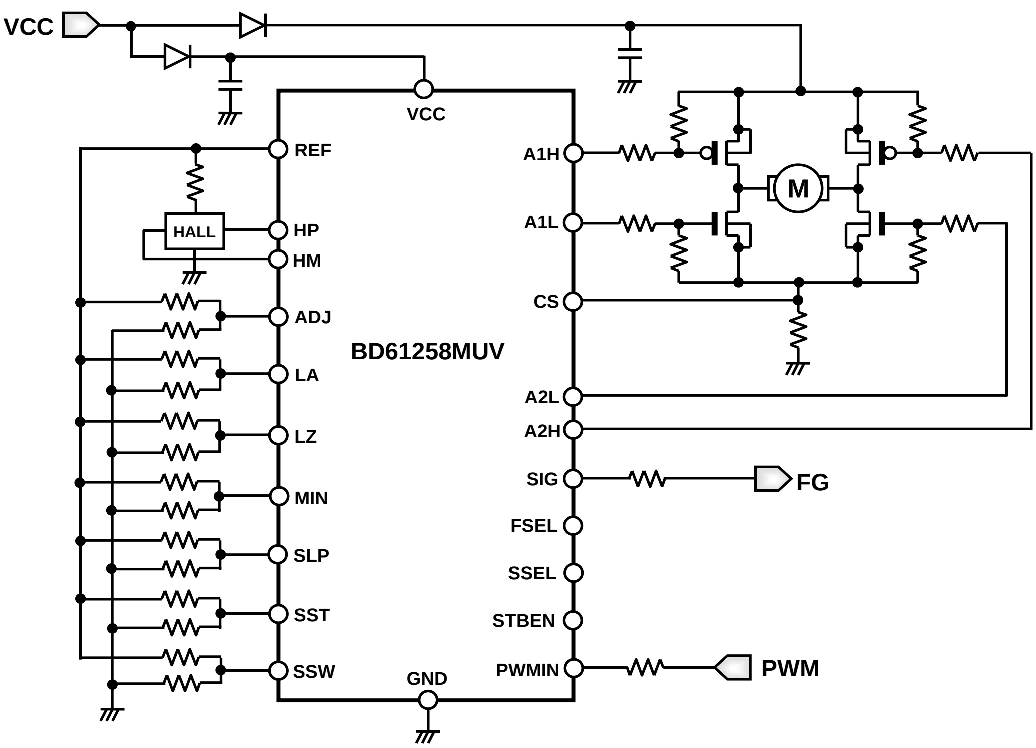
- Power Supply Voltage: 4.5 V to 36 V
- PWM Input Frequency: 1 kHz to 100 kHz
- PWM Output Frequency: 25 kHz / 50 kHz
- PWM Resolution: 8 bit

Applications

- FAN motor for General Consumer Equipment of Desktop PC, Server, etc.
- FAN motor for Office Equipment, Copier etc.

Package	W (Typ) x D (Typ) x H (Max)
VQFN024V4040	4.0 mm x 4.0 mm x 1.0 mm

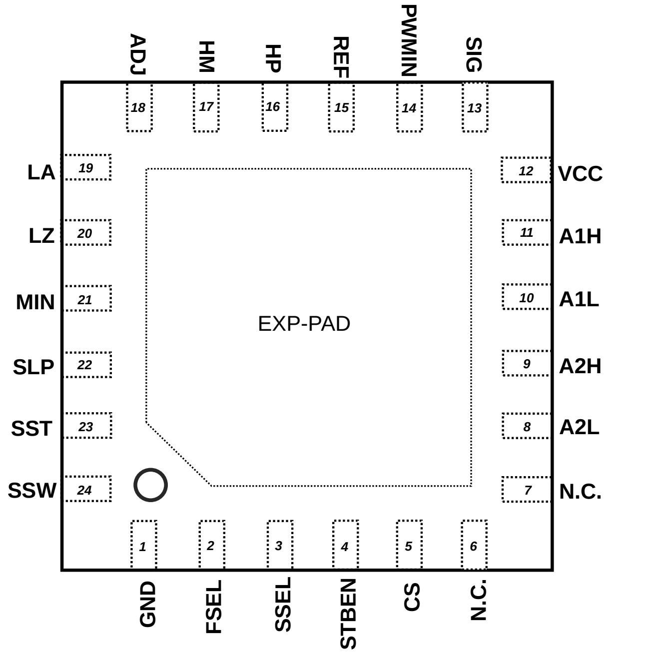
Typical Application Circuit



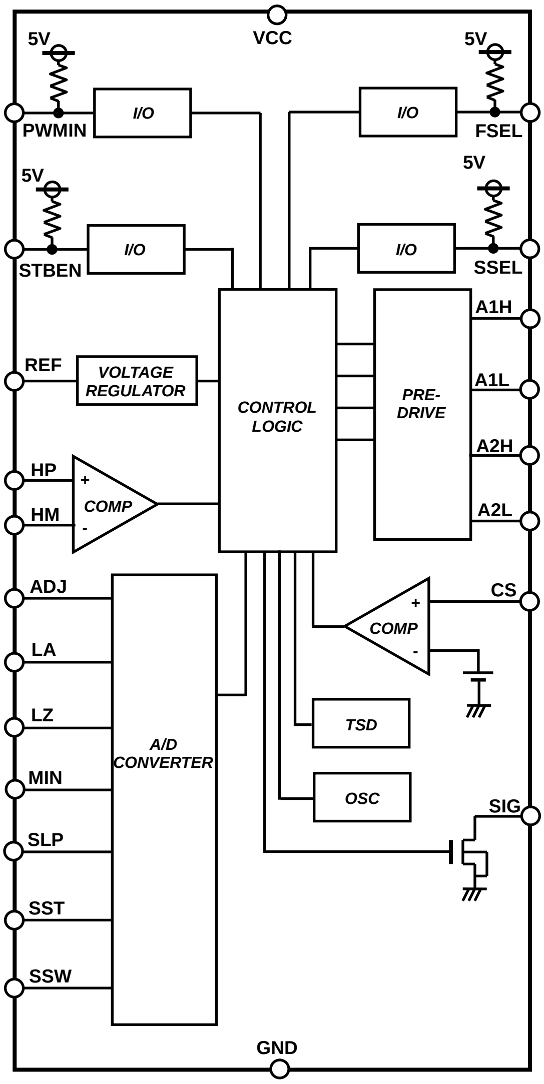
○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays

Pin Configuration

(TOP VIEW)



Block Diagram



Pin Description

Pin No.	Pin Name	Function
1	GND	Ground
2	FSEL	Drive PWM frequency select
3	SSEL	FG / AL signal select
4	STBEN	Standby mode enable select
5	CS	Output current sensing
6	N.C.	Non-connection *(Note 1)*
7	N.C.	Non-connection *(Note 1)*
8	A2L	Low side output 2
9	A2H	High side output 2
10	A1L	Low side output 1
11	A1H	High side output 1
12	VCC	Power supply
13	SIG	FG / AL signal output
14	PWMIN	PWM signal input
15	REF	Reference voltage output
16	HP	Hall signal input +
17	HM	Hall signal input -
18	ADJ	Output duty correction
19	LA	Lead / Delay angle setting
20	LZ	Re-circulate angle setting
21	MIN	Minimum output duty setting
22	SLP	Input/Output duty slope setting
23	SST	Soft start time setting
24	SSW	Soft switching angle setting
Bottom	EXP-PAD	Connect to GND

(Note 1) Can be connected to GND.

Thermal Resistance(Note 2)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s(Note 4)	2s2p(Note 5)	
VQFN024V4040				
Junction to Ambient	θ_{JA}	150.6	37.9	°C/W
Junction to Top Characterization Parameter(Note 3)	Ψ_{JT}	20	9	°C/W

(Note 2) Based on JESD51-2A (Still-Air).
(Note 3) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 4) Using a PCB board based on JESD51-3.
(Note 5) Using a PCB board based on JESD51-5, 7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70 μm

Layer Number of Measurement Board	Material	Board Size	Thermal Via(Note 6)	
			Pitch	Diameter
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt	1.20 mm	Φ0.30 mm

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 μm	74.2 mm x 74.2 mm	35 μm	74.2 mm x 74.2 mm	70 μm

(Note 6) This thermal via connect with the copper pattern of layers 1,2, and 4. The placement and dimensions obey a land pattern.

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply Voltage	V_{CC}	40	V
Storage Temperature Range	Tstg	-55 to +150	°C
Junction Temperature	Tj	+150	°C
High Side Output Voltage	V_{OH}	V_{CC}-7 to V_{CC}	V
Low Side Output Voltage	V_{OL}	0 to 7	V
Output Current	I_O	10	mA
Reference Voltage (REF) Output Current	I_{REF}	10	mA
Signal Output Voltage	V_{SIG}	40	V
Signal Output Current	I_{SIG}	10	mA
Input Voltage 1 (PWMIN, CS, FSEL, SSEL, STBEN)	V_{IN1}	5.3	V
Input Voltage 2 (HP, HM, A/D Converter Input Pins)	V_{IN2}	3.3	V

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	V_{CC}	4.5	12	36	V
Operating Temperature	Topr	-40	-	+105	°C
Hall Input Voltage	V_H	0	-	V_{REF}	V
Hall Common Mode Input Voltage *(Note 7)*	V_{CM}	0	-	2.0	V
PWMIN Input Frequency	f_{IN}	1	-	100	kHz

(Note 7) Set the hall intermediate voltage (or reference voltage of hall IC) falls within this range.

Input/Output Truth Table

Input		IC Output					Motor Drive Output	
HP	HM	A1H	A1L	A2H	A2L	FG	OUT1	OUT2
H	L	H	H	L	L	Hi-Z	L	H
L	H	L	L	H	H	L	H	L

H; High, L; Low, Hi-Z; High impedance
SIG output is open drain output.

Electrical Characteristics (Unless otherwise specified V_{CC} = 12 V, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Circuit Current	I_{CC1}	2.0	3.3	5.0	mA	
Standby Current	I_{CC2}	0.1	0.3	0.5	mA	
UVLO Release Voltage	V_{ON}	3.95	4.22	4.45	V	V_{CC} rising
UVLO Detect Voltage	V_{OFF}	3.50	3.75	4.00	V	V_{CC} falling
Hall Input Hysteresis	V_{HYS}	±5	±10	±15	mV	
PWM Input High Level	V_{PWMH}	2.0	-	5.3	V	
PWM Input Low Level	V_{PWML}	-0.3	-	+0.8	V	
PWM Input Current	I_{PWMH}	-10	0	+10	μA	V_{PWM} = 5 V
	I_{PWML}	-50	-25	-12	μA	V_{PWM} = 0 V
PWM Drive Frequency 1	f_{PWM1}	35	50	65	kHz	FSEL open
PWM Drive Frequency 2	f_{PWM2}	17.5	25.0	32.5	kHz	FSEL GND short
Reference Voltage	V_{REF}	2.7	3.0	3.3	V	I_{REF} = -1 mA
Current Limit Voltage	V_{CL}	140	160	180	mV	
High Side Output High Voltage	V_{OHH}	V_{CC}-0.6	V_{CC}-0.4	V_{CC}-0.1	V	I_O = -3 mA
High Side Output Low Voltage	V_{OHL}	V_{CC}-5.2	V_{CC}-4.9	V_{CC}-4.6	V	I_O = +3 mA
Low Side Output High Voltage	V_{OLH}	4.1	4.5	4.8	V	I_O = -3 mA
Low Side Output Low Voltage	V_{OLL}	-	0.1	0.2	V	I_O = +3 mA
FSEL Input Low Level	V_{FSELL}	-0.3	-	+0.8	V	FSEL = OPEN : f_{PWM} = 50 kHz FSEL = GND : f_{PWM} = 25 kHz
SSEL Input Low Level	V_{SSELL}	-0.3	-	+0.8	V	SSEL = OPEN : SIG = FG SSEL = GND : SIG = AL
STBEN Input Low Level	V_{STBL}	-0.3	-	+0.8	V	STBEN = OPEN : Standby function enable STBEN = GND : Standby function disable
SIG Output Low Voltage	V_{SIGL}	0	-	0.3	V	I_{SIG} = +5 mA
SIG Output Leak Current	I_{SIGL}	0	-	10	μA	V_{SIG} = 40 V
Lock Protection ON Time	t_{ON}	0.2	0.3	0.4	s	
Lock Protection OFF Time	t_{OFF}	4	6	8	s	

About current items, define the inflow current to the IC as a positive notation.

Typical Performance Curves

(Reference Data)

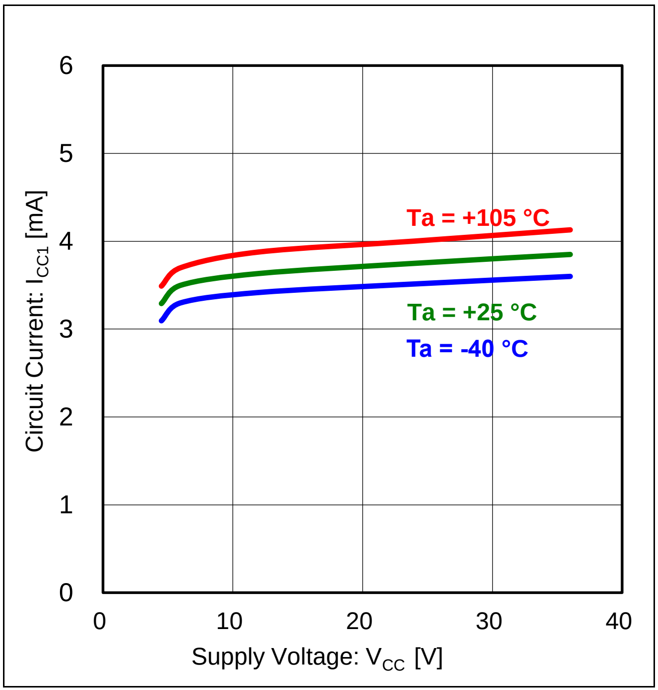


Figure 1. Circuit Current vs Supply Voltage

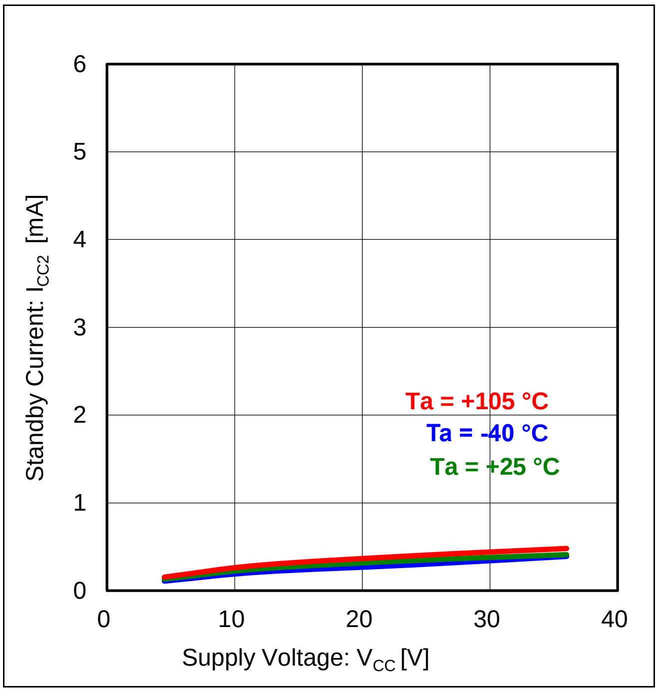


Figure 2. Standby Current vs Supply Voltage

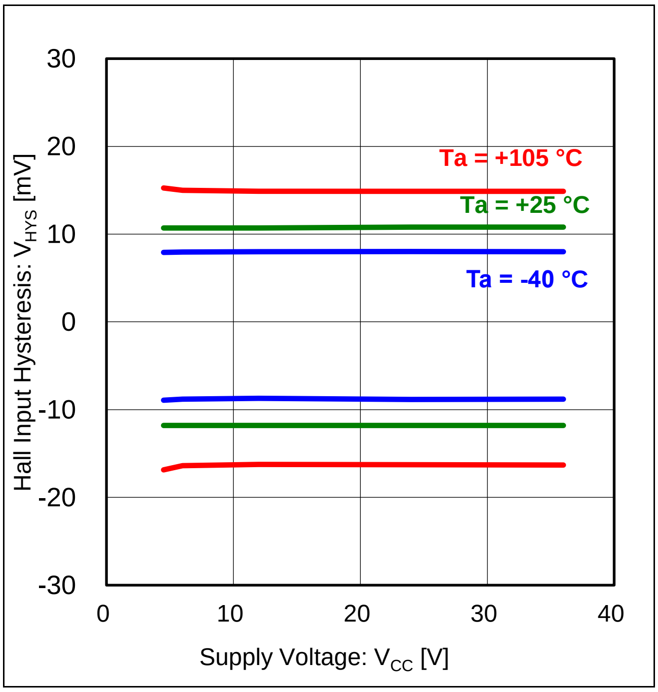


Figure 3. Hall Input Hysteresis vs Supply Voltage

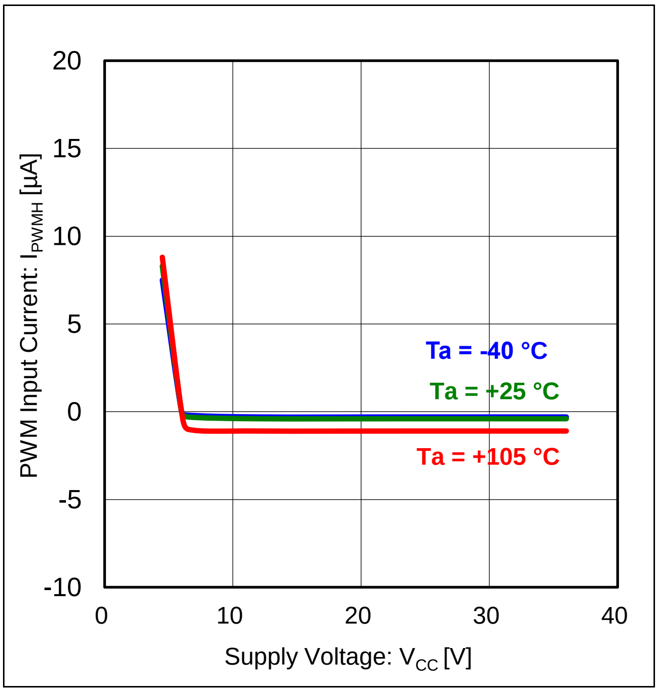


Figure 4. PWM Input Current vs Supply Voltage
(V_{PWM} = 5 V)

Typical Performance Curves – continued
(Reference Data)

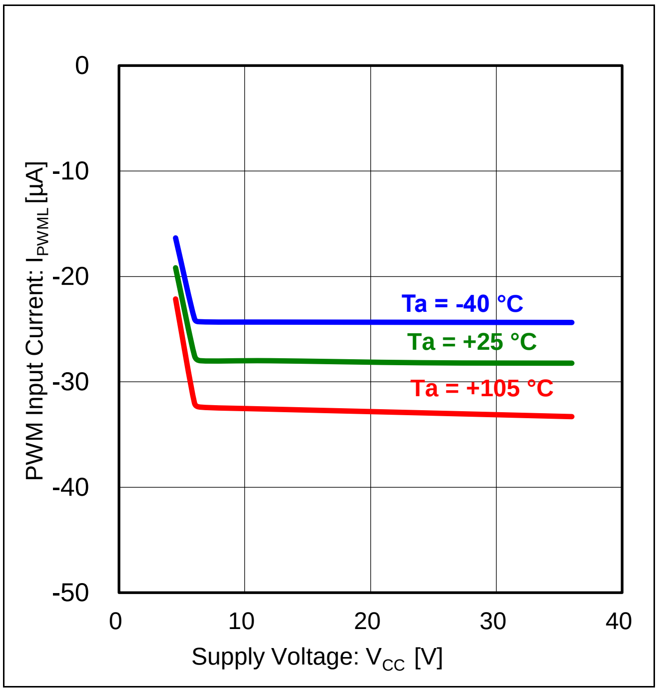


Figure 5. PWM Input Current vs Supply Voltage
(V_{PWM} = 0 V)

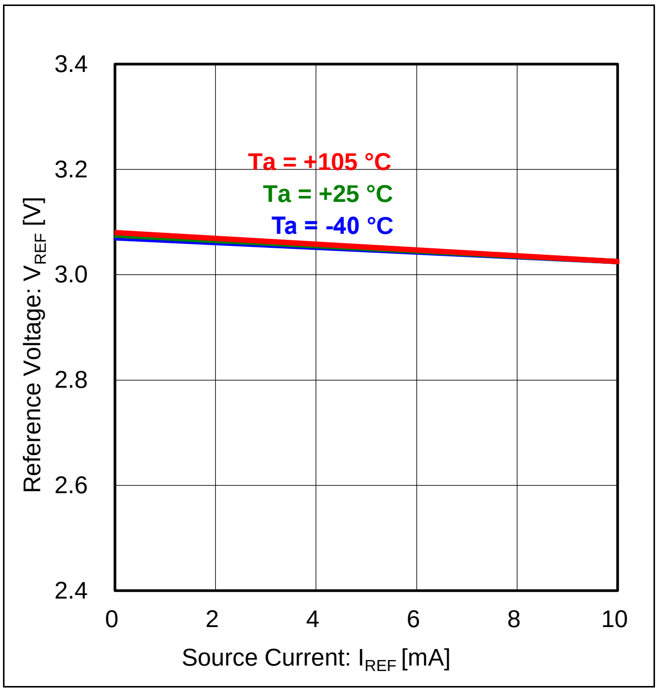


Figure 6. Reference Voltage vs Source Current
(V_{CC} = 12 V)

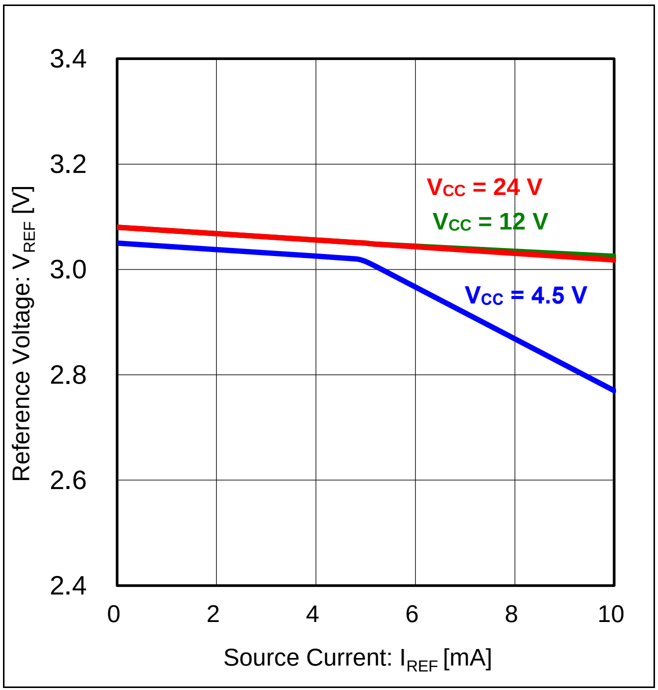


Figure 7. Reference Voltage vs Source Current
(Ta = 25 °C)

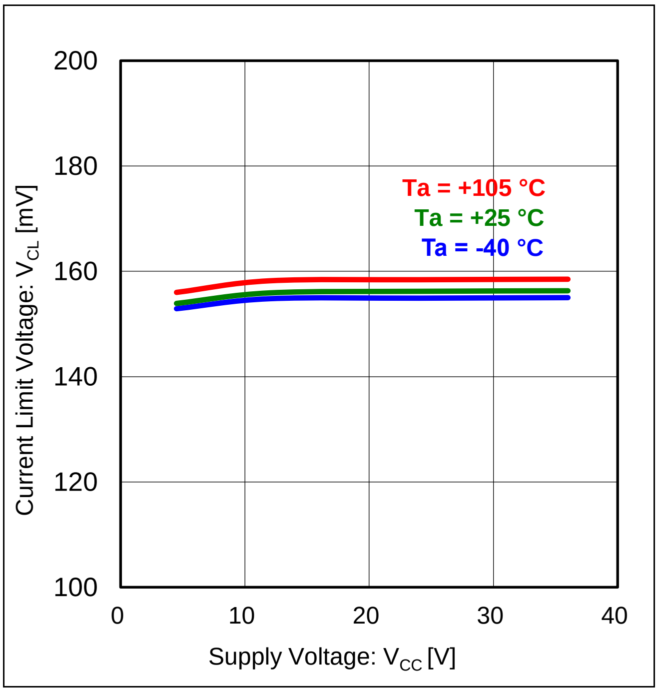


Figure 8. Current Limit Voltage vs Supply Voltage

Typical Performance Curves – continued

(Reference Data)

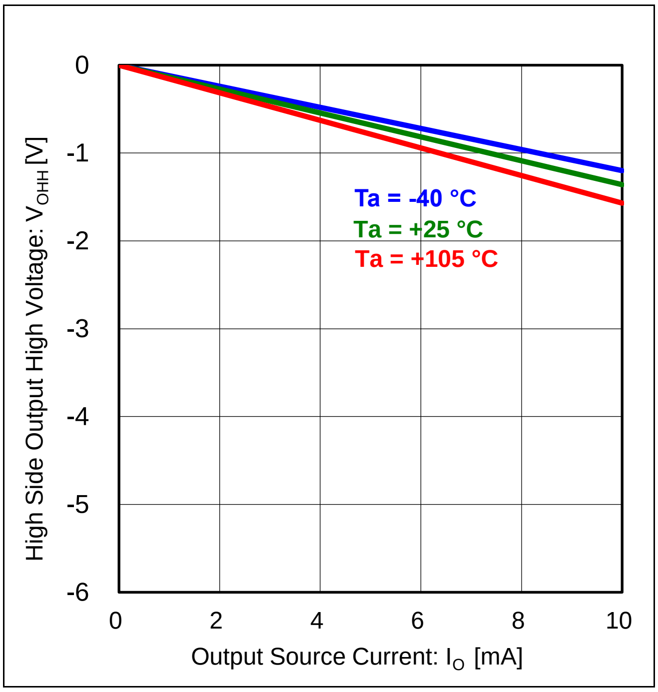


Figure 9. High Side Output High Voltage
(V_{CC} = 12 V, Differential voltage to V_{CC})

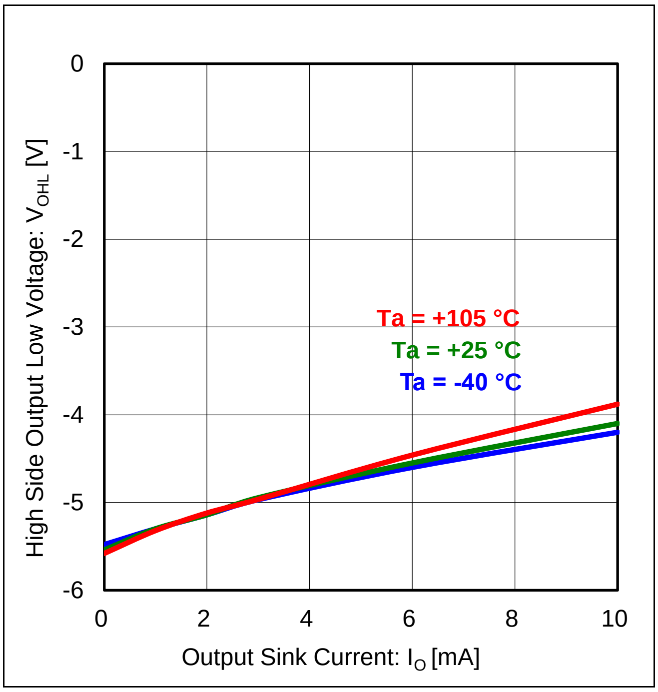


Figure 10. High Side Output Low Voltage
(V_{CC} = 12 V, Differential voltage to V_{CC})

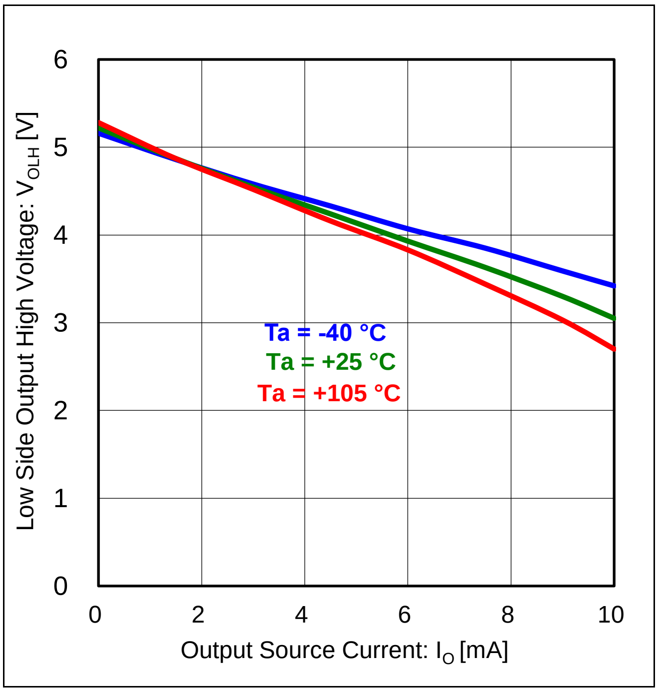


Figure 11. Low Side Output High Voltage
(V_{CC} = 12 V)

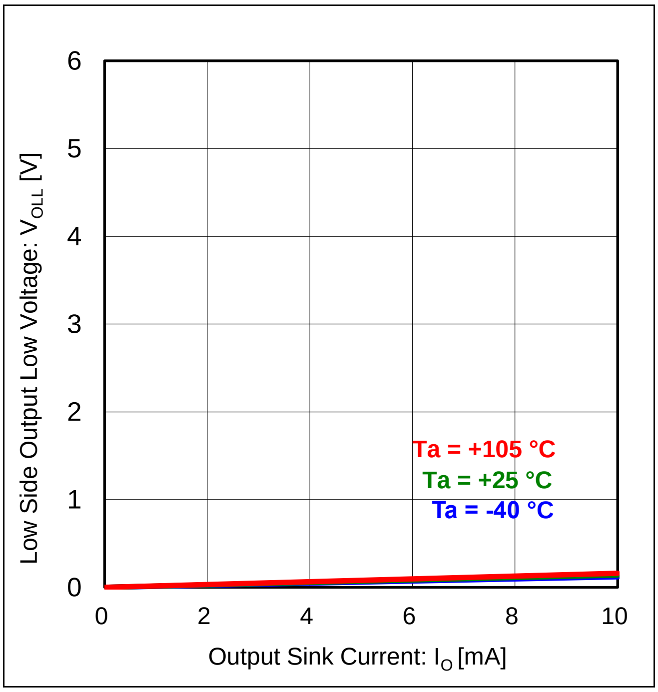


Figure 12. Low Side Output Low Voltage
(V_{CC} = 12 V)

Typical Performance Curves – continued

(Reference Data)

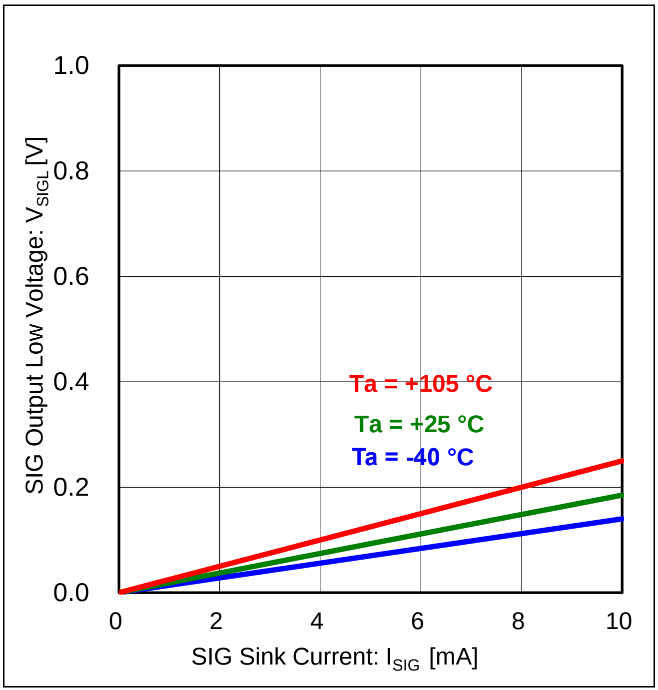


Figure 13. SIG Output Low Voltage vs Sink Current

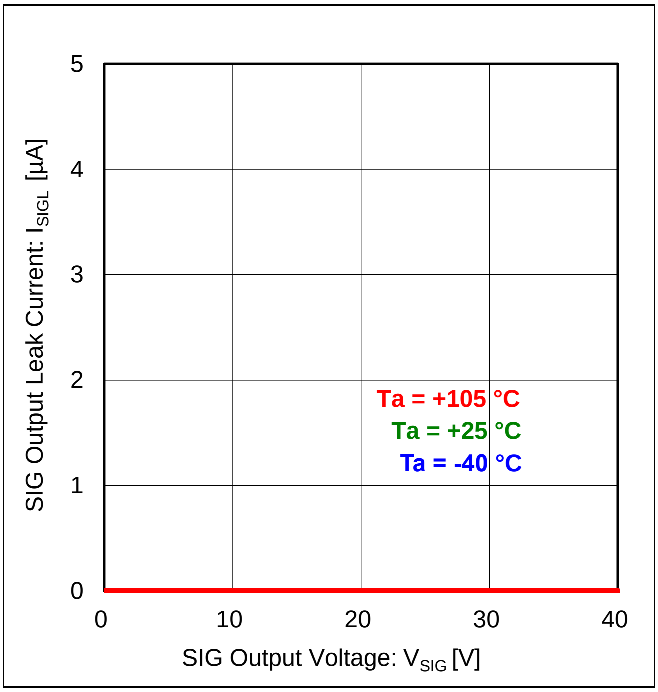


Figure 14. SIG Output Leak Current vs SIG Output Voltage

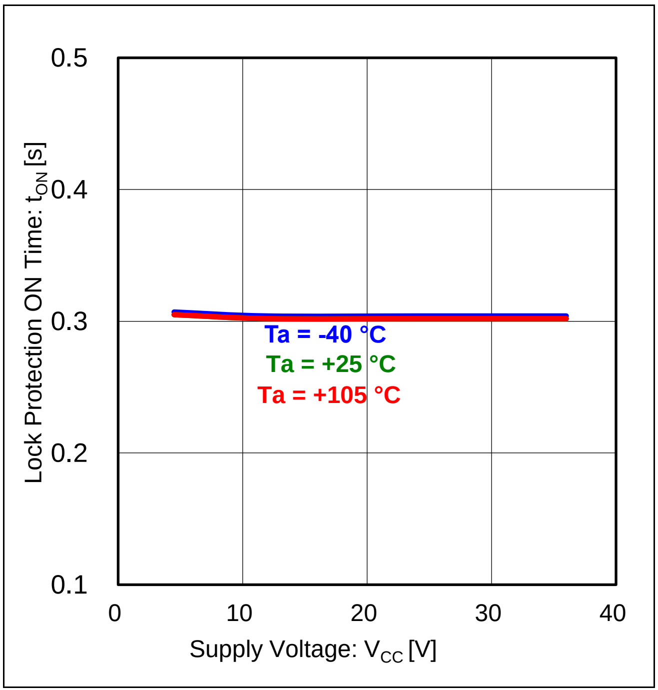


Figure 15. Lock Protection ON Time vs Supply Voltage

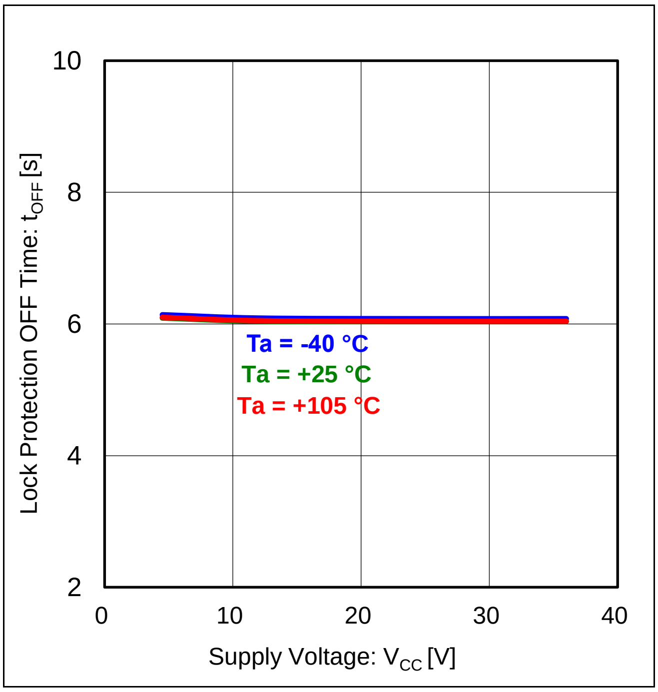
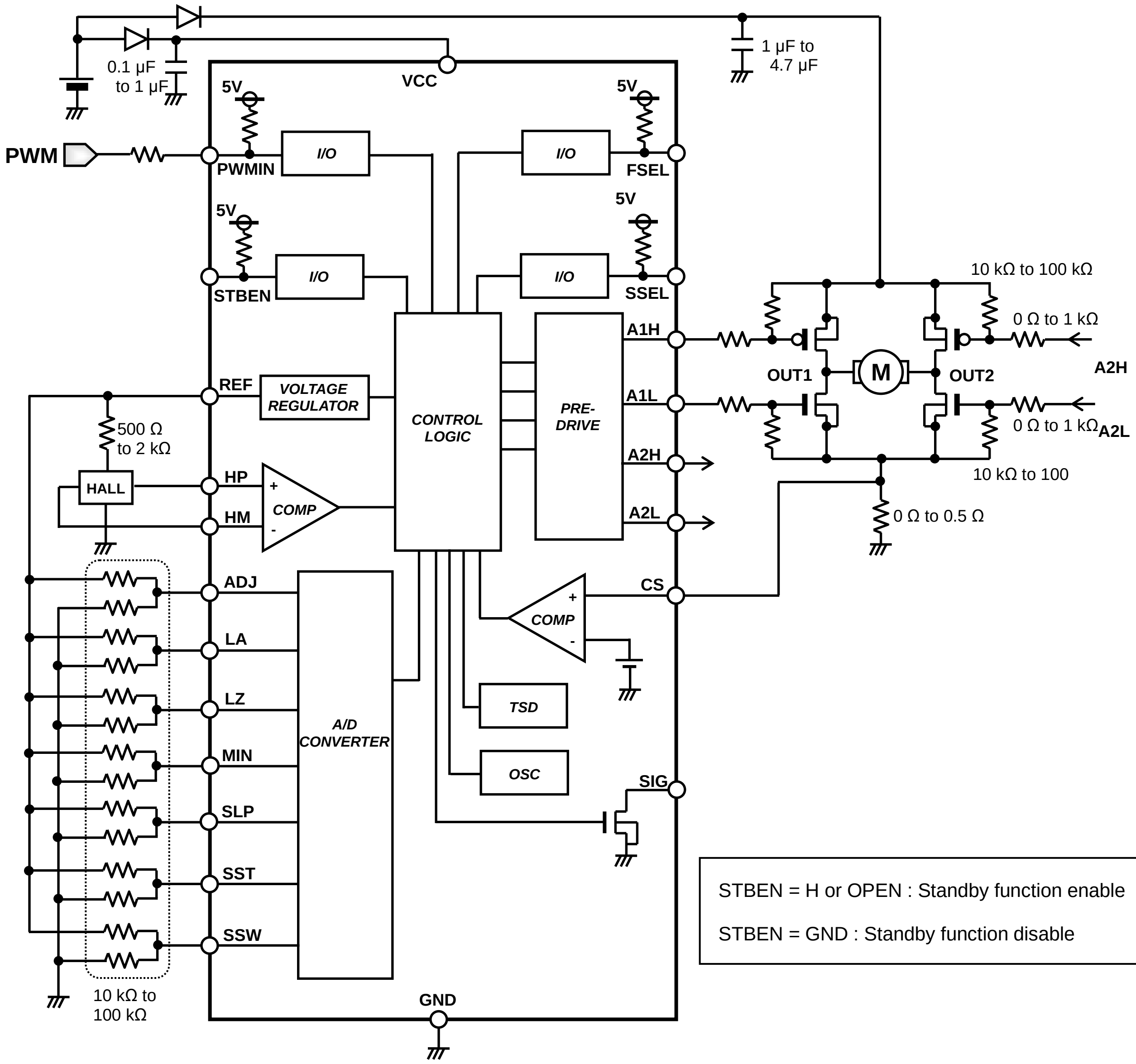


Figure 16. Lock Protection OFF Time vs Supply Voltage

Application Reference Circuit

1. PWM Control Application

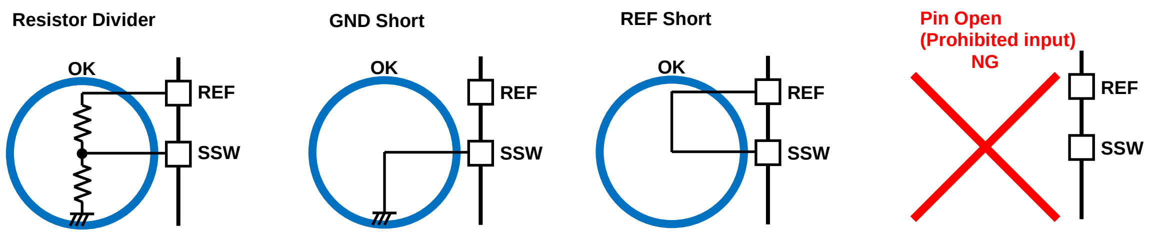
This is the application example of direct PWM input into PWMIN pin. Minimum rotational speed is set in MIN pin voltage.



STBEN = H or OPEN : Standby function enable

STBEN = GND : Standby function disable

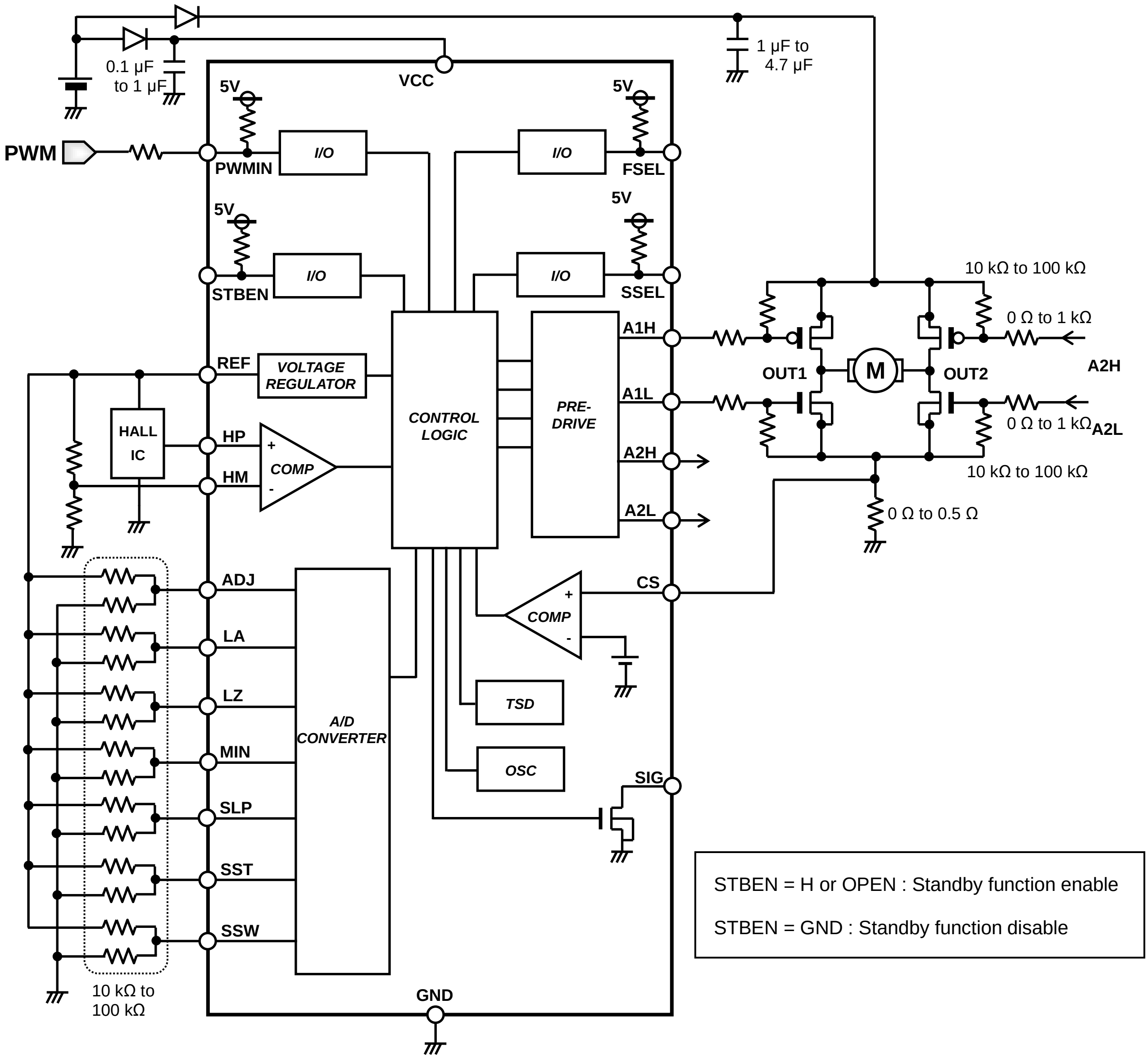
When a function is not used, do not let the A/D converter input pin open.



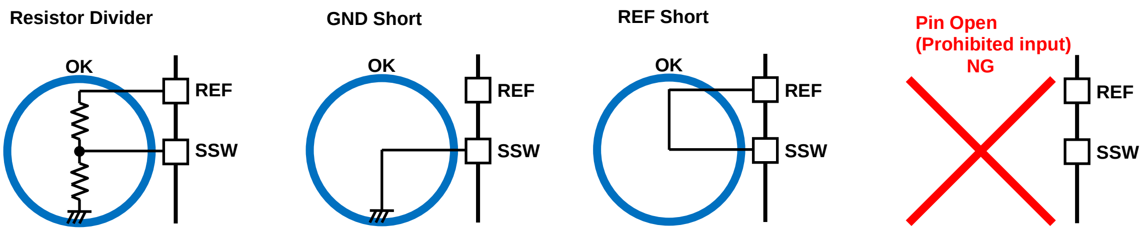
Application Reference Circuit - continued

2. Application Using Hall IC

This is a PWM application using Hall IC.
Connect the Hall IC output to either the HP or HM pins.
For the other pin, bias the voltage value that crosses the Hall IC output signal so that it falls within the Hall common mode voltage range. Also, depending on the Hall IC, add an output pull-up resistor.



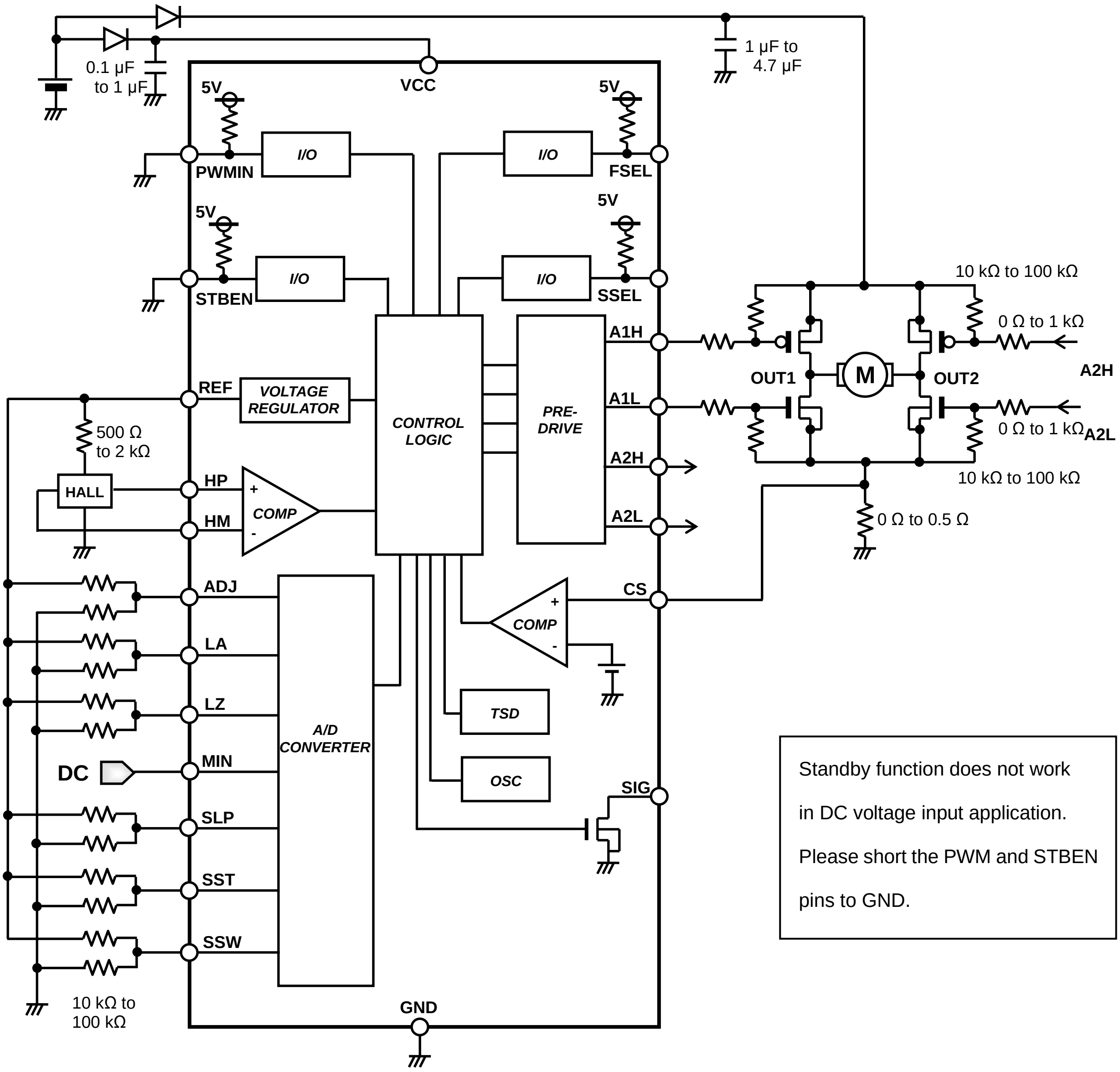
When a function is not used, do not let the A/D converter input pin open.



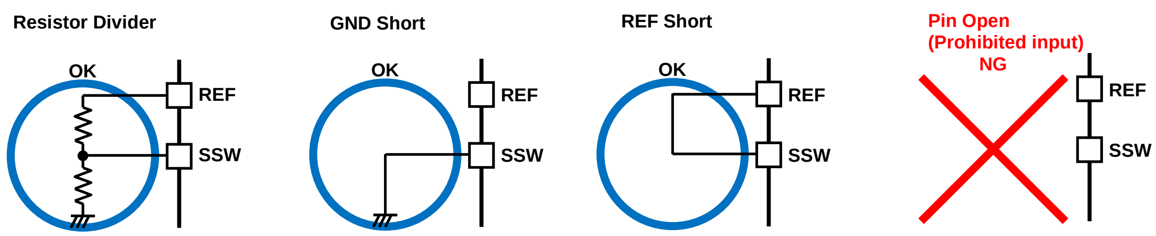
Application Reference Circuit – continued

3. Voltage Control Application

This is the application example of DC voltage into MIN pin. Minimum rotational speed setting is disable.



When a function is not used, do not let the A/D converter input pin open.



Functional Description

1. Speed Control

There are 2 ways to control the speed of motor.
(1) PWM Control (Input PWM pulse into PWMIN pin)
(2) Voltage Control (Input DC voltage into MIN pin)
The resolution of (1) input duty, (2) input voltage are 8 bit (256 steps) both. Output PWM resolution is 8 bit, output PWM frequency is 50 kHz (FSEL = open) or 25 kHz (FSEL = GND). When computed duty is less than 2.3 %, a driving signal is not output.

1.1. PWM Control

Output PWM duty is changed depending on input PWM duty from PWMIN pin, and rotational speed is controlled. Please refer to input voltage 1 (P.4) and recommended operating conditions for the signal input condition from the PWMIN pin. In the case of PWMIN pin is open, internal voltage (about 5 V) is applied to PWMIN pin, and output is driven in 100 %. Because the PWM signal is filtered inside the IC and is signal processed, the PWM frequency of the drive output is not same to the input PWM frequency.

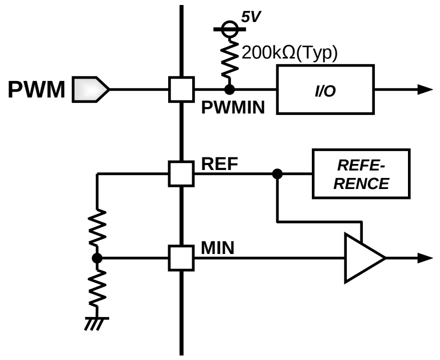


Figure 17. PWM Input and Minimum Output Duty Setting

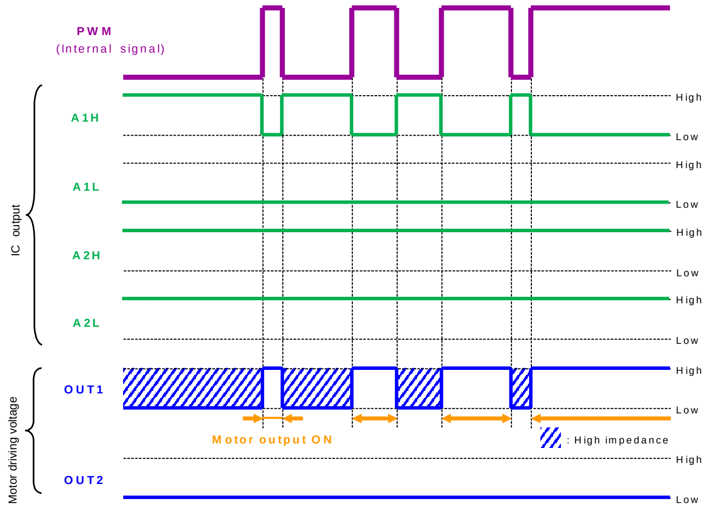


Figure 18. Output PWM Operation Timing Chart

○Minimum Output Duty Setting (MIN)
The voltage which divided REF pin voltage by resistance like Figure 17 is input into MIN pin, and minimum output duty is set. When input duty from a PWMIN pin is lower than minimum output duty which is set by MIN pin, the output duty does not fall to lower than minimum output duty.

The MIN pin is the input pin of the A/D converter to have an input voltage range of the REF voltage, and the resolution is 256 steps (0.39 % per step). When minimum output duty is not set, short the MIN pin to GND.

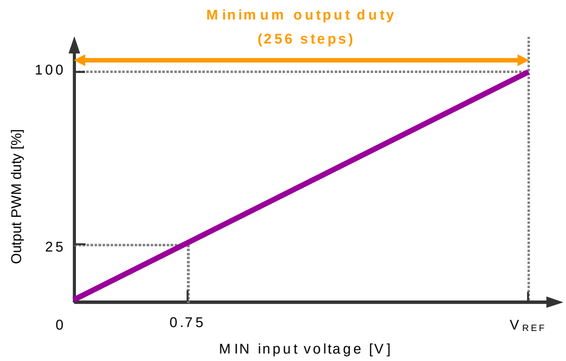


Figure 19. Relation of MIN Input Voltage and Output Duty

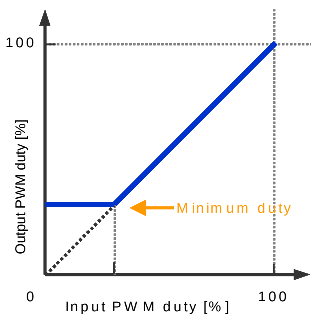


Figure 20. Relation of Input/Output Duty When Minimum Duty Is Set

1. SPEED Control – continued

1.2. Voltage Control

Output duty is controlled by input voltage from MIN pin. Output duty is 100 % when MIN pin voltage is 3 V (Typ), output duty is 0 % when MIN pin voltage is 0 V. (If using SLOP function, it is not like this.)

In voltage control mode, set the PWMIN pin and STBEN pin voltage to GND. Standby function is disabled. Voltage control uses the voltage input from MIN pin that is read with A/D converter, and output duty is decided. A/D converter is off in standby mode, so A/D converter cannot read the input voltage. Set the standby function disable in voltage control.

Please refer to input voltage 2 (P.4) for the input condition of the MIN pin. Because pin voltage becomes unsettled when MIN pin is in an open state, like application of Figure 21, please be applied some voltage to MIN pin. Minimum output duty cannot be set in voltage control.

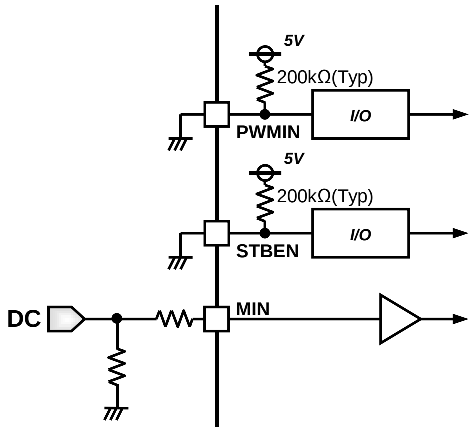


Figure 21. Voltage Input Application

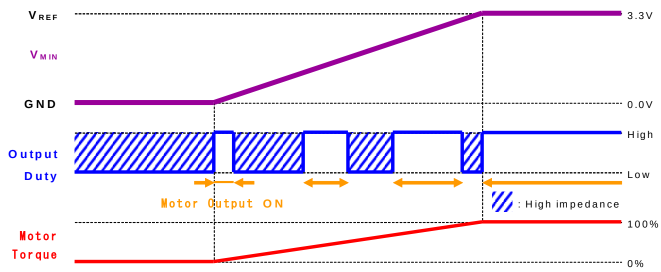


Figure 22. Operation of MIN Pin Input

2. Input/Output Duty Characteristics Adjustment (SLP)

Slope properties of input duty and output duty can be set with SLP pin like Figure 23. SLP setting work in both mode, PWM control and voltage control. The resolution is 128 steps.

The voltage of SLP pin is less than 0.325 V (Typ), slope of Input/Output duty characteristic is fixed to 1. And fixed to 0.5 in 0.325 V to 0.75 V (Typ) (refer to Figure 24). When slope setting is not set, short SLP pin to GND.

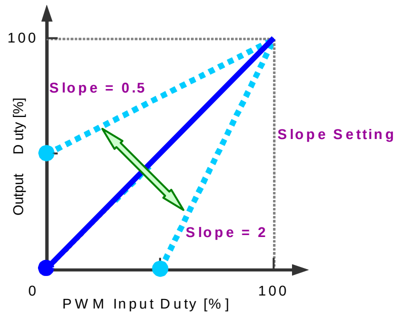


Figure 23. Properties of Input/Output Duty Slope Setting

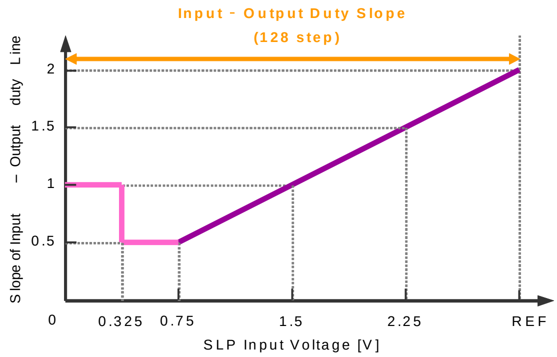


Figure 24. Relations of SLP Pin Voltage and the Input/Output Duty Slope Characteristics

Functional Description – continued

3. **Input/Output Duty Properties Adjustment Function (ADJ)**
When input duty vs output duty shows the characteristic of the straight line, rotational speed may become the characteristics that middle duty area swells by the characteristic of fan motor. (Figure 25)

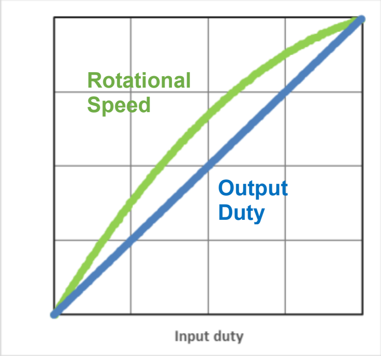


Figure 25. Properties Curve of Input PWM Duty vs Rotational Speed

This IC reduces duty in the middle duty area and can adjust rotational speed characteristics of the motor with a straight line.

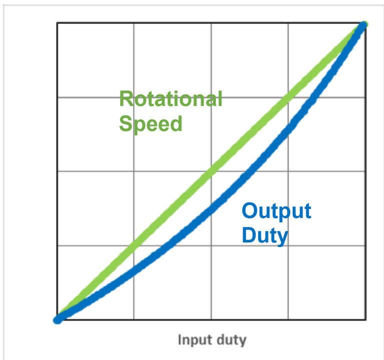


Figure 26. Properties Curve of Input PWM Duty vs Rotational Speed After Adjusting

The adjustment to reduce duty is performed by ADJ pin input voltage. The ADJ pin is input pin of A/D converter and the resolution is 256 steps. By input 0 of the ADJ pin, the characteristic of input duty vs output duty becomes straight line (no adjustment). The adjustment become maximum by input 256 (max), and output duty in input duty 50 % decreases to about 25 %.

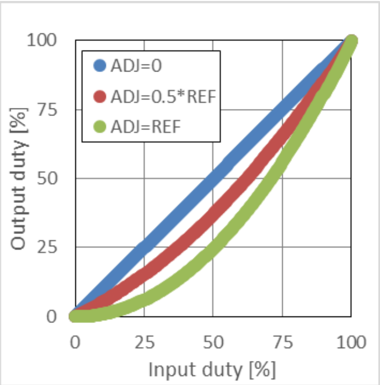


Figure 27. Input Duty vs Output Duty Characteristics

Set the voltage of ADJ pin so that motor rotation speed in input duty 50 % is on the diagonal which links the rotation speed of 0 % to 100 %. IC corrects output duty so that overall rotation speed properties match a straight line.

When using ADJ and SLP together, first perform ADJ adjustment when the slope is 1, and then perform SLP adjustment after matching the input duty vs rotation speed characteristics. Also, when setting the minimum duty using PWM control, make the MIN setting last after adjusting ADJ and SLP.

Functional Description – continued

4. Driving Waveform Settings

This is the setting for generating the voltage waveform applied to the motor coil. Set the soft switching section (SSUP, SSDW), re-circulate angle (LZ), and lead/delay angle (LA).

4.1. Soft Switching (SSW) Setting

Angle of the soft switching can be set by the input voltage of SSW pin. When one period of the hall signal is assumed 360°, the angle of the soft switching can be set from 0° to 90° by the input voltage of SSW pin (refer to Figure 28). Resolution of SSW pin is 128 steps. Operational image is shown in Figure 29.

Soft switching angle means the section where output PWM duty changes between 0 % and setting duty at the timing of output phase change. To smooth off the current waveform, the coefficient table that duty gradually changes is set inside IC, and the step is 16.

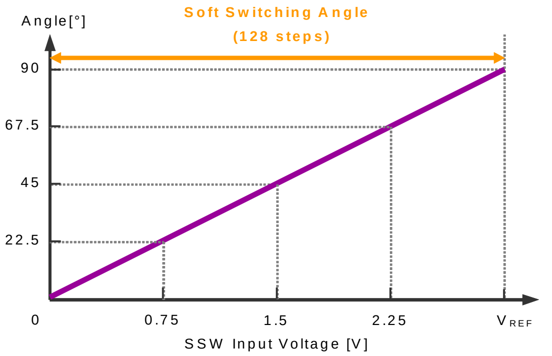


Figure 28. Relations of SSW Pin Voltage and the Angle of Soft Switching

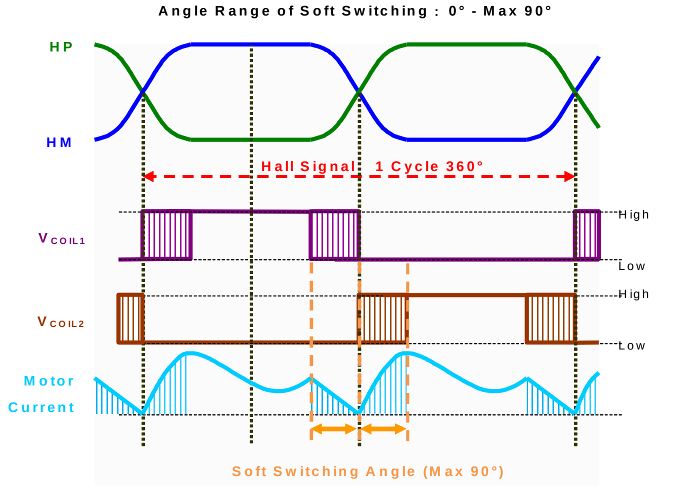


Figure 29. Soft Switching Angle

4.2. Re-circulate Angle Setting (LZ)

Re-circulate angle at the timing of output phase changes can be set by the input voltage of LZ pin. When one period of the hall signal is assumed 360°, the angle of the re-circulate can be set from 0° to 90° by the voltage of LZ pin (refer to Figure 30). Resolution of LZ pin is 128 steps. Operational image is shown in Figure 31.

Re-circulate angle means the section where the coil current re-circulate before the timing of output phase change. If it is set appropriately, it is effective to suppress leaping up of voltage by BEMF, and reduce invalid electricity consumption. The logic of the output transistor in the section is decided depending on the hall input logic. As for the output of the H logic, the logic of the motor output in high impedance (Hi-Z). The output of the L logic remains L.

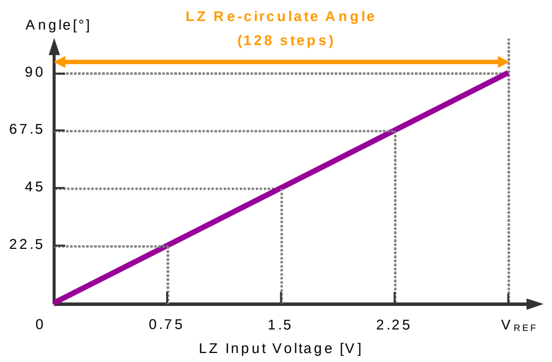


Figure 30. Relations of LZ Pin Voltage and the Angle of Re-circulate

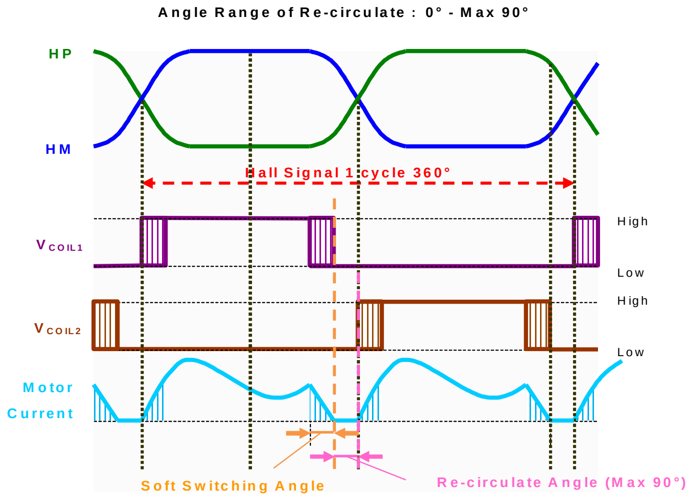


Figure 31. Re-circulate Angle

4. Driving Waveform Settings – continued

4.3. Lead/Delay Angle (LA) Setting

Angle of lead/delay of the output phase change timing to the hall signal can be adjusted. When one period of the hall signal is assumed 360°, lead/delay angle can be set from 0° to 22.5° by LA pin voltage (refer to Figure 32). Resolution of LA pin is 64 steps (0.7° per step). Operational image is shown in Figure 33.

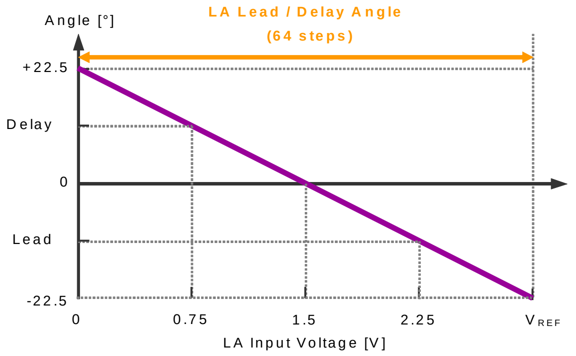


Figure 32. Relations of LA Pin Voltage and Lead / Delay Angle

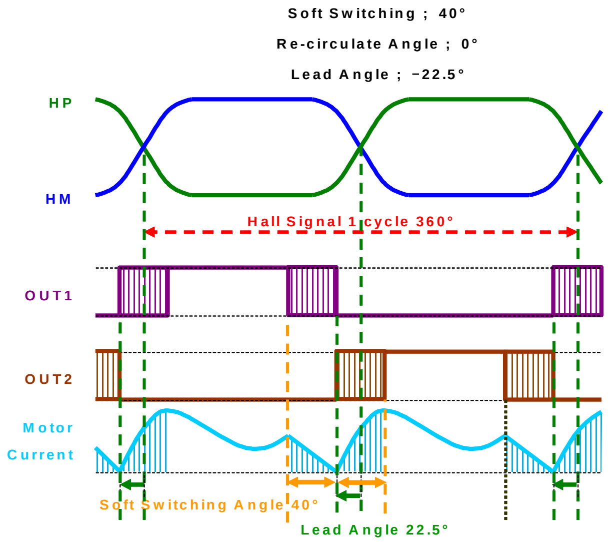


Figure 33. Lead Angle Operation

LA setting decide the point of output changing timing, PWM soft switching and LZ re-circulate angle are decided based on that point. When PWM soft switching, re-circulate, lead angle setting are changed each, operational example image is show in Figure 34.

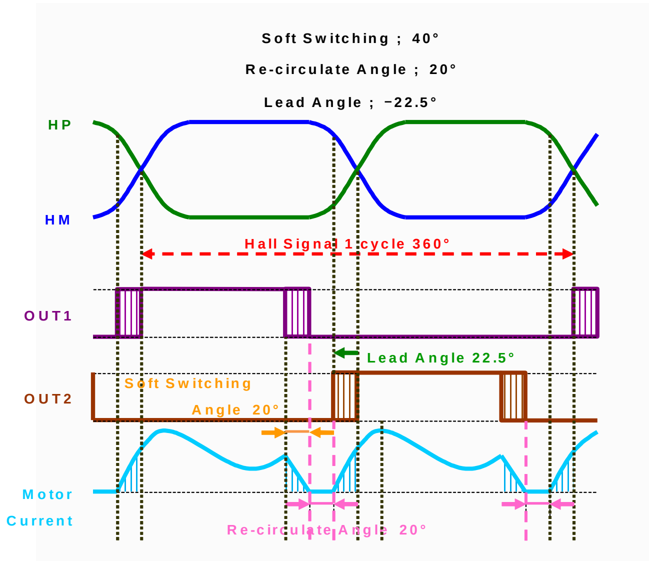


Figure 34. Motor Operation Waveform When Each Setting are Applied

Functional Description – continued

5. Soft Start

Soft start function gradually change drive duty to suppress sound noise and peak current when the motor start up etc. PWM duty resolution is 8 bit (256 steps, 0.39 % per step). SST pin sets the step up time of duty increment.

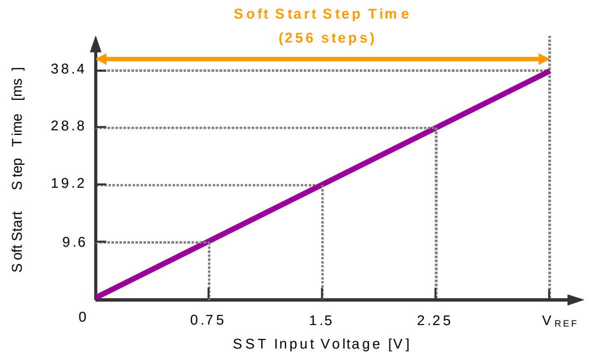
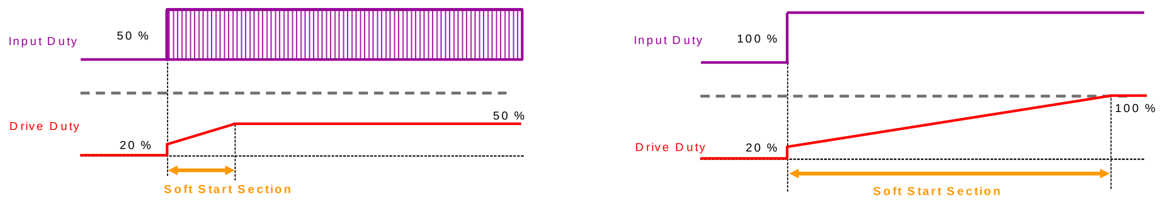


Figure 35. Relations of SST Pin Voltage and Soft Start Step Up Time

Duty transition time is

(Difference of current duty and Target duty (output duty after SLP/ADJ calculation)) x (step time)

When soft start time is set for a long time, lock protection may be detected without enough motor torque when motor start up from 0 % duty. Therefore start up duty is set to approximately 20 % (50 / 256).



Start with Input Duty 50 % Start with Input Duty 100%

Figure 36. Soft Start Operation Image from Motor Stop Condition

When SST pin voltage = REF pin voltage, and 100 % duty is input on motor stop condition, output duty arrives at 100 % after progress the time of 38.4 ms x (256 - 50 step) = 7.91 seconds

Soft start functions always work when the change of input duty as well as motor start up. In addition, it works when duty goes down from high duty. Duty step down time is the half of duty step up time.

6. Start Duty Assist

It is the function that enable the motor to start even if drive duty output is low, when the soft start function is not used. When input duty is within 50 % at motor stop condition, 50 % duty is output till four times of hall signal change are detected. Operational image is shown in Figure 37.

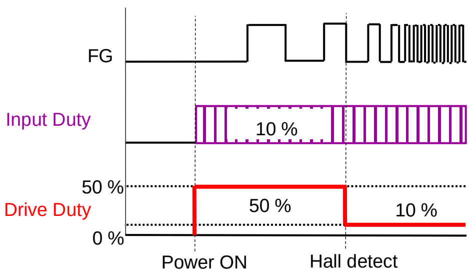


Figure 37. Start Duty Assist Operation at Input Duty 10 %

Functional Description – continued

7. **Standby Function (only for PWM control application)**
When PWMIN pin input duty is less than 1.5 % (input PWM frequency 25 kHz), IC shut off the circuit to reduce current consumption in motor stop state. Because circuit current of IC oneself is cut with the standby mode, and the voltage output of the REF pin stops, the power consumption that a hall device uses and the power consumption to use by resistance for the input setting of the A/D converter can be reduced.

Standby function is effective in STBEN = open, and can invalidate standby function in STBEN = GND short.

This IC processes input duty from PWMIN pin through the filter in logic circuit. Therefore the time to shift standby mode varies according to input PWM duty before inputting PWM = L. When PWM = L is input, relations of the input duty till then and the time to detect 0 % are shown in Figure 39.

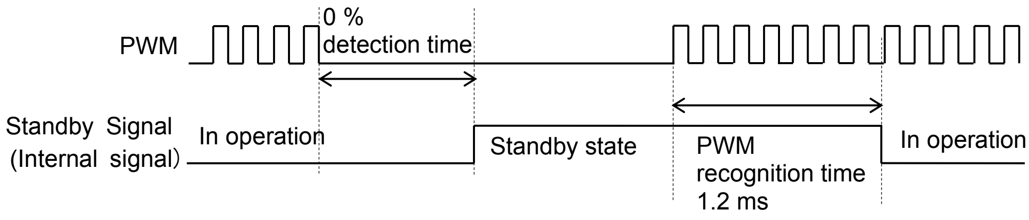


Figure 38. Standby Detection Time and Recover Time

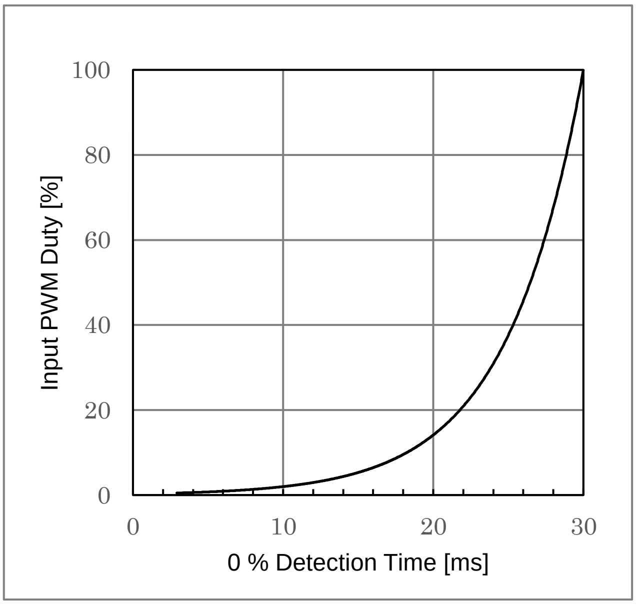


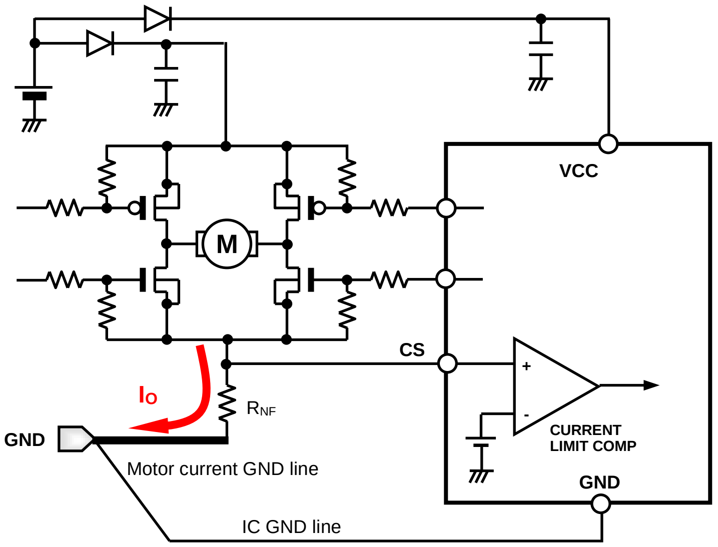
Figure 39. Input PWM Duty vs 0 % Detection Time

When the soft start time is set, it takes more time to duty fall down except the filter time of Figure 39.

Functional Description – continued

8. Current Limit

Current limit function turns off the output when the current flow through the motor coil is detected exceeding a set value. The working current value of the limit is determined by current limit voltage V_{CL} and CS pin voltage.
In Figure 40, current flow in motor coil is Io, resistor to detect Io is R_{NF} = 0.1 Ω, power consumption of R_{NF} is P_R, current limit voltage V_{CL} = 160 mV (Typ), current limit value and power consumption of R_{NF} can be calculated below expression.
When current limit function is not used, please short CS pin to GND



I_O [A] = V_{CL} [V] / R_{NF} [Ω]
= 160 [mV] / 0.1 [Ω]
= 1.6 [A]

P_R [W] = V_{CL} [V] x I_O [A]
= 160 [mV] x 1.6 [A]
= 0.256 [W]

Figure 40. Current Limit Setting and GND Line

9. Lock Protection and Automatic Restart

Motor rotation is detected by hall signal period. IC detects motor rotation is stop when the period becomes longer than the time set up at the internal counter, and IC turns off the output. Lock detection ON time (t_{ON}) and lock detection OFF time (t_{OFF}) are set by the digital counter based on internal oscillator. Therefore the ratio of ON/OFF time is always constant. Timing chart is shown in Figure 41. AL signal is output in SSEL pin = GND, and FG signal is output in SSEL pin = open.

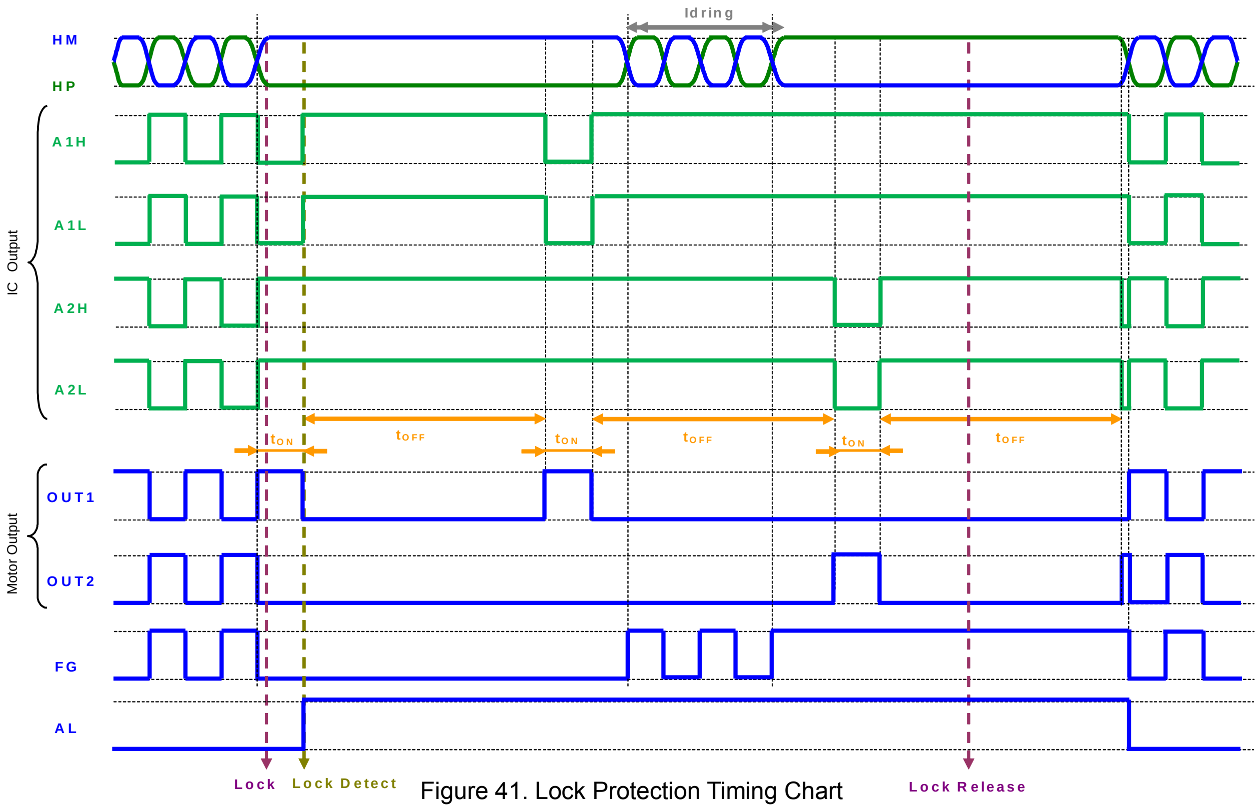


Figure 41. Lock Protection Timing Chart

Functional Description – continued

10. High-speed Detection and Protection

When a hall input signal is abnormally fast (more than 1.525 kHz, 45,750 rpm as 4 pole motor), the lock protection operation works. When noise is easy to appear in a hall input signal, please put a capacitor between hall input pins like C1 of Figure 43.

11. Hall Input Setting

The rotation detection sensor output of the motor corresponds to both the 2-pin output of the Hall element and the 1-pin output of the Hall IC. In either case, input the voltage level of the input signal so that the intermediate potential (reference potential) of the amplitude falls within the "Hall Common Mode Input Voltage" range.

If the output voltage of the Hall element or Hall IC swings between 0 V and 3.0 V, it can be detected if the reference voltage of either the HP/HM pin is within the “Hall Common Mode Input Voltage” range. One of the HP/HM pins, the other pin that does not connect to the Hall IC output divides the voltage of the REF pin (3.0 V constant voltage output), and inputs a voltage such as 1/2 x 3.0 V = 1.5 V.

In order to detect the rotation of the motor, the amplitude of "Hall Input Hysteresis" or more is required. Set the Hall output amplitude so that a potential difference of at least 50 mV or more is given between the HP/HM pins.

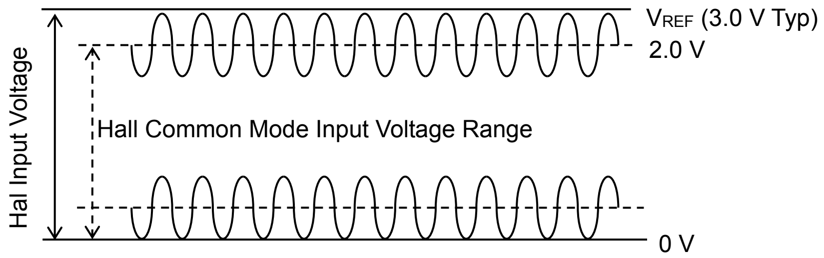


Figure 42. Hall Input Voltage Range

○Reducing the Noise of Hall Signal

Hall element may be affected by V_{CC} noise or the like depending on the wiring pattern of board. In this case, place a capacitor like C1 in Figure 43. In addition, when wiring from the hall element output to IC hall input is long, noise may be loaded on wiring. In this case, place a capacitor like C2 in Figure 43.

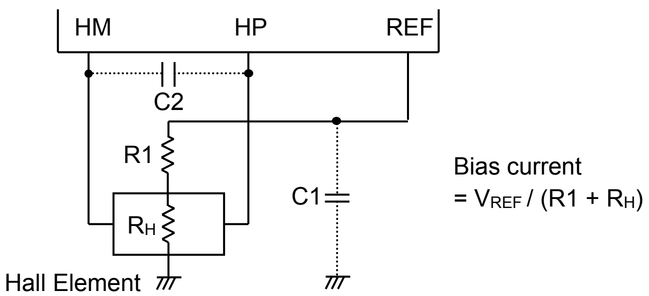


Figure 43. Application near of Hall Signal

11. Hall Input Setting – continued

○Relationship Between Hall Amplitude and Phase
Hysteresis is set in the input circuit that receives the Hall signal to remove noise. When the amplitude of the Hall signal is small, the timing at which the IC recognizes it as a Hall signal switching is delayed compared to when the amplitude is large.

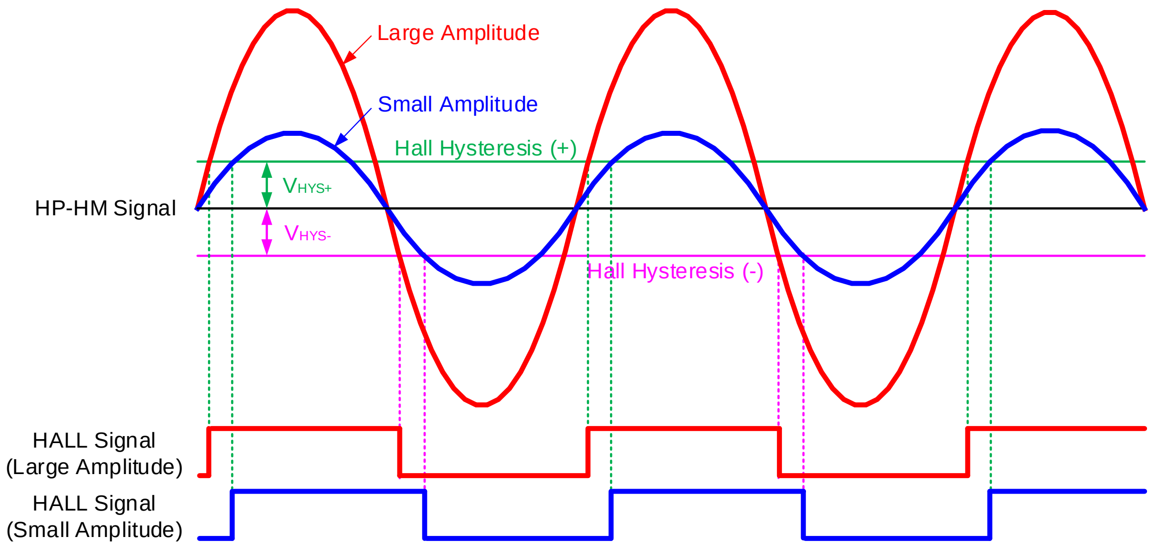
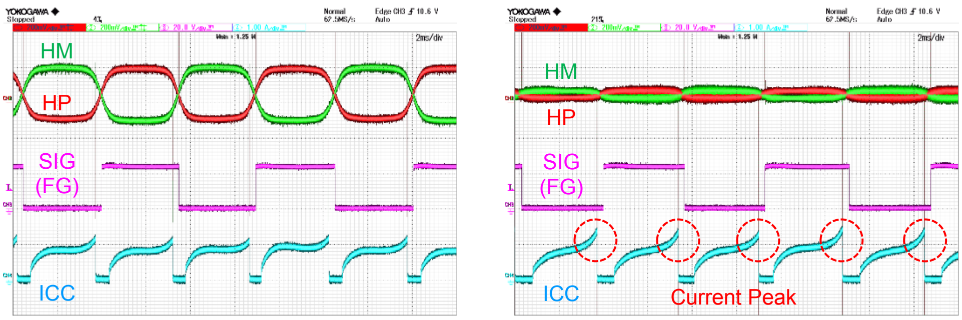


Figure 44. Relationship Between Hall Amplitude and Phase

Depending on the drive waveform settings, a timing shift in the Hall signal can lead to a phase delay in the current, as shown in Figure 45. Depending on the characteristics of the Hall element, the amplitude changes due to temperature changes can be very large. Please carefully check the effect that Hall amplitude changes have on motor characteristics within the temperature range in which you will use it, and then decide on the setting constants.

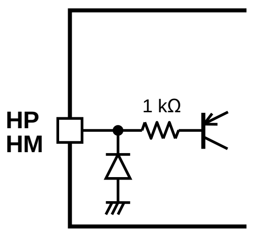


(a) Large Hall Amplitude (b) Small Hall Amplitude

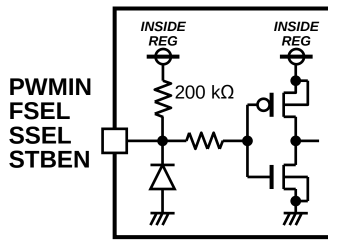
Figure 45. Comparison of Current Waveforms Depending on The Size of Hall Amplitude

I/O Equivalence Circuits

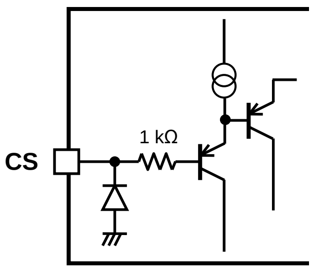
1. HP, HM



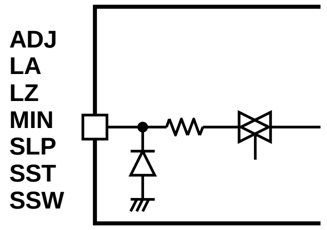
2. PWMIN, FSEL, SSEL, STBEN



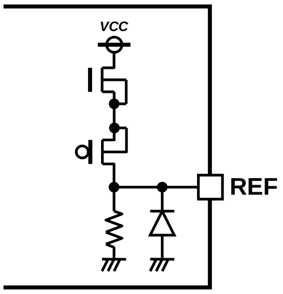
3. CS



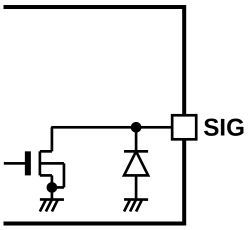
4. A/D converter input



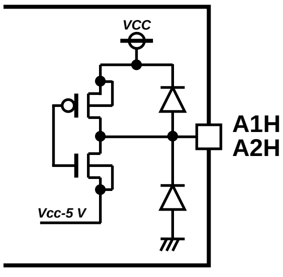
5. REF



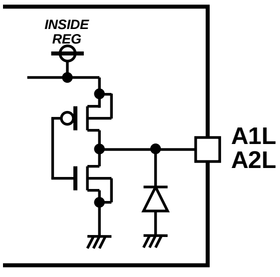
6. SIG



7. A1H, A2H



8. A1L, A2L



Safety Measures

1. **Reverse Connection Protection Diode**
   The reverse connection of the power results in the IC destruction as shown in Figure 46. When the reverse connection is possible, the reverse connection protection diode must be added between the power supply and the VCC.

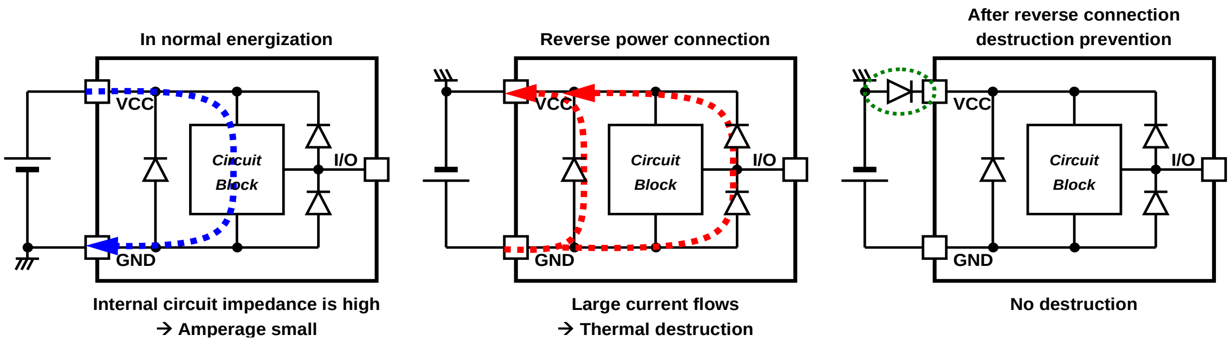


Figure 46. Flow of Current When the Power is Connected Reversely

2. **Problem of GND Line PWM Switching**
   Do not perform the PWM switching of the GND line because the GND pin potential cannot be kept to a minimum.

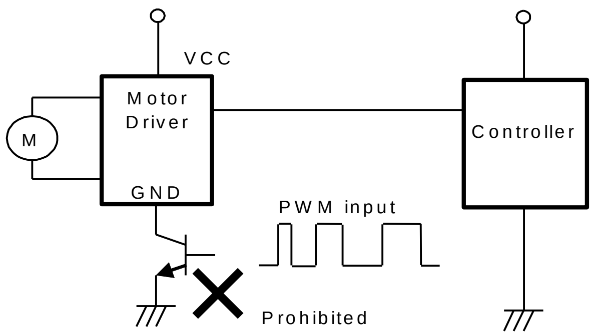


Figure 47. Prohibited the PWM Switching of the GND Line

3. **External Connecting Pin**
   Missconnecting of the external connector from the motor PCB or connecting and disconnecting the hot connector may cause damage to the IC by a rush current or a over voltage surge.

   About the input/output pin except the VCC/GND line, take measures such as a protection resistor so that the IC is not affected by an over voltage, an over current not to intend.
   The SIG pin is an open drain output and requires pull-up resistor. When the SIG pin is directly connected to power supply, over inflow current may damage the IC. By adding protection resister shown in Figure 48, IC is protected from over current.

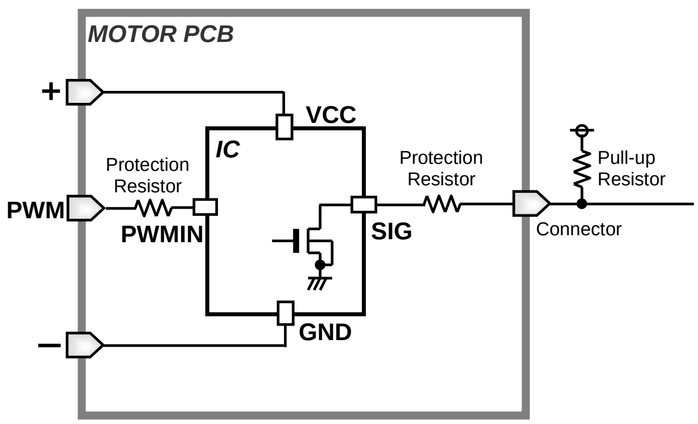


Figure 48. Protection of the PWMIN/SIG Pin

Safety Measures – continued

4. **IC Pin Input**
   When the VCC voltage is not applied to the IC, do not apply voltage to the input pins other than the PWMIN pin. If a voltage above VCC or below GND is applied to the input pin, the parasitic element will operate due to the structure of the IC. The operation of parasitic elements causes mutual interference between circuits, which can lead to malfunction and even destruction. Be careful not to use it in such a way that the parasitic element operates.

5. **Thermal Shutdown Circuit**
   This IC has a built-in thermal shutdown circuit (TSD) to prevent the IC from thermal destruction. The detection temperature is 160 °C (standard value), the release temperature after detection is 140 °C (standard value), and the hysteresis width is 20 °C (standard value). When the IC chip temperature rises and TSD operates, the high side output turns off. The TSD is a circuit that aims to shut off the IC from thermal runaway, and does not aim to protect or guarantee the IC. Never operate this circuit for continuous use and avoid set design that assumes operation.

Power Dissipation

1. **Thermal Resistance**
   Heat generated by consumed power of IC is radiated from the mold resin or lead frame of package. The parameter which indicates this heat dissipation capability (hardness of heat release) is called thermal resistance. Thermal resistance from the chip junction to the ambient temperature is represented in θ_{JA} [°C/W], and thermal characterization parameter from the chip junction to the top center of the outside surface of the component package is represented in Ψ_{JT} [°C/W]. Thermal resistance is divided into the package part and the substrate part. Thermal resistance in the package part depends on the composition materials such as the mold resins and the lead frames. On the other hand, thermal resistance in the substrate part depends on the substrate heat dissipation capability of the material, the size, and the copper foil area etc. Therefore, thermal resistance can be decreased by the heat radiation measures like installing a heat sink etc. in the mounting substrate.

   The thermal resistance model is shown in Figure 49, and equation is shown below.

   $\theta_{JA} = (Tj - Ta) / P$ [°C/W]
   $\Psi_{JT} = (Tj - Tt) / P$ [°C/W]

   θ_{JA}: Thermal resistance from junction to ambient [°C/W]
   Ψ_{JT}: Thermal characterization parameter from junction to the top center of the outside surface [°C/W]
   Tj: Junction temperature [°C]
   Ta: Ambient temperature [°C]
   Tt: Package outside surface (top center) temperature [°C]
   P: Power consumption [W]

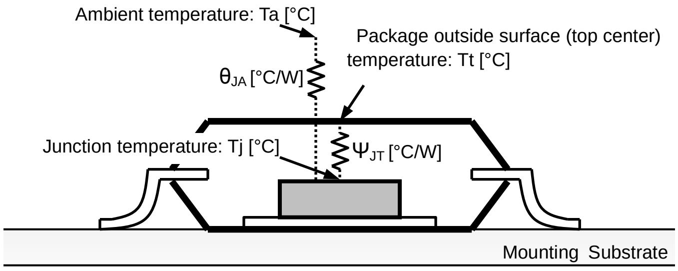


Figure 49. Thermal Resistance Model of Surface Mount

   Even if it uses the same package, θ_{JA} and Ψ_{JT} are changed depending on the chip size, power consumption, and the measurement environments of the ambient temperature, the mounting condition, and the wind velocity, etc.

2. **Thermal De-rating Curve**
   Thermal de-rating curve indicates the power that can be consumed by the IC with reference to ambient temperature. Power that can be consumed by IC begins to attenuate at ambient temperature 25 °C, and becomes 0 W at ambient temperature 150 °C. The inclination is reduced by the reciprocal of thermal resistance θ_{JA}. The thermal de-rating curve under a condition of thermal resistance (P.3) is shown in Figure 50.

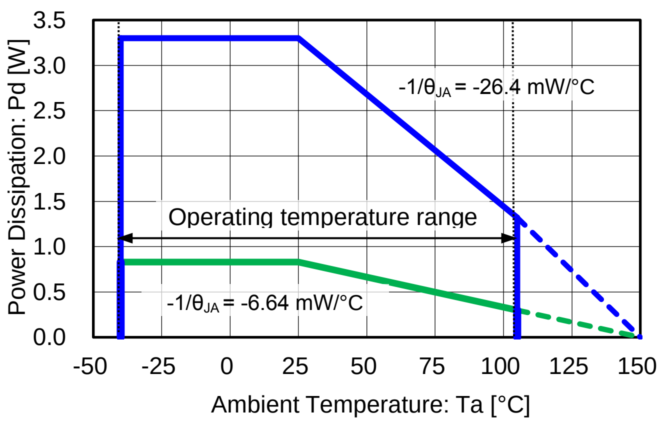


Figure 50. Power Dissipation vs Ambient Temperature

Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Recommended Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

8. **Inter-pin Short and Mounting Errors**
   Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

9. **Unused Input Pins**
   Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

10. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below)

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

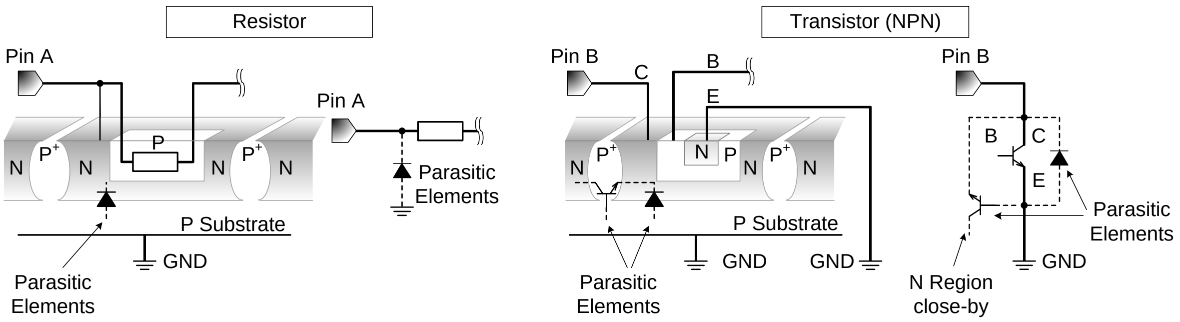


Figure 51. Example of Monolithic IC Structure

11. Ceramic Capacitor

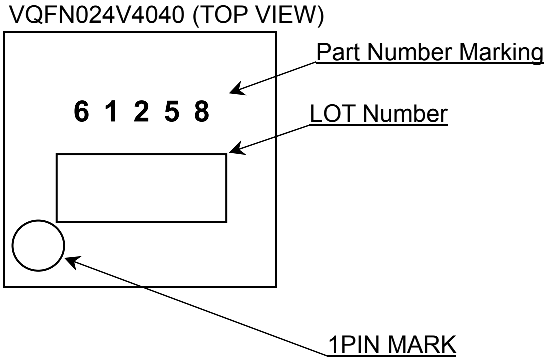
When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

Ordering Information

B D 6 1 2 5 8 M U V - E 2

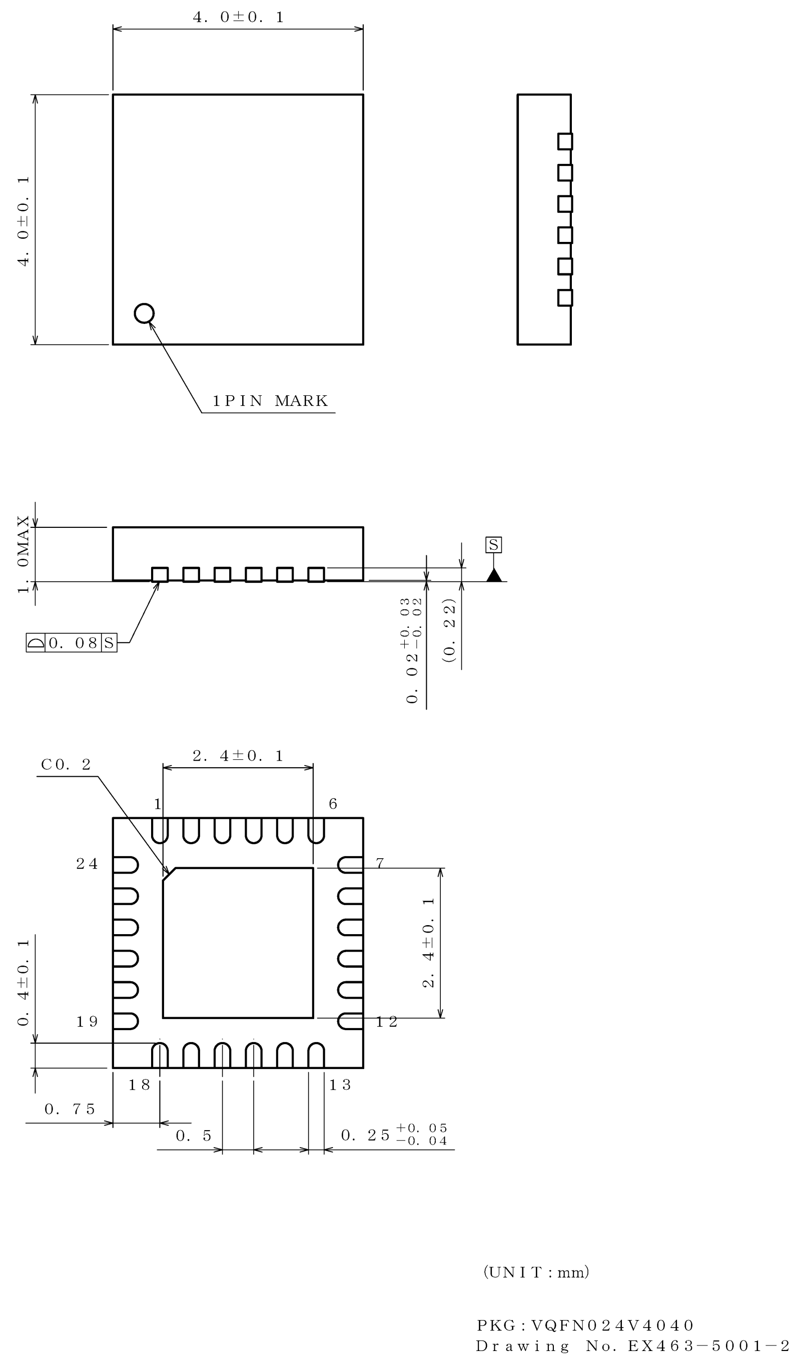
- Part Number
- Package
  MUV: VQFN024V4040
- Packaging and forming specification
  E2: Embossed tape and reel

Marking Diagram



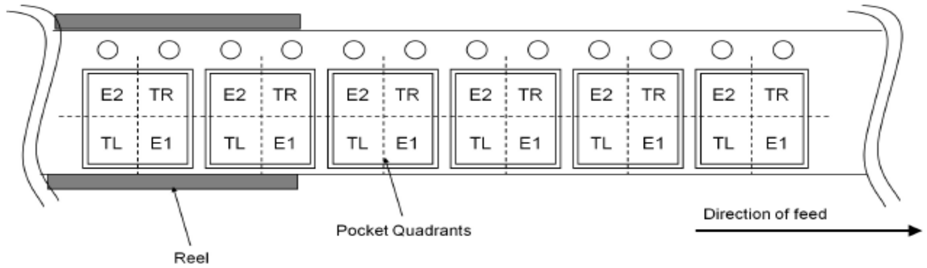
Physical Dimension and Packing Information

Package Name	VQFN024V4040



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 The direction is the pin 1 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



Revision History

Date	Revision	Changes
12.Mar.2024	001	New Release

Notice

Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipment (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data.
2. ROHM shall not have any obligations where the claims, actions or demands arising from the combination of the Products with other articles such as components, circuits, systems or external equipment (including software).
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3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.
4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

General Precaution

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.

2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

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