36 V High-performance, High-reliability Withstand Voltage Stepping Motor Driver

BD63716AMWV

General Description

BD63716AMWV is a bipolar low-consumption driver that driven by PWM current. Rated power supply voltage of the device is 36 V, and rated output current is 1.5 A. CLK-IN driving mode is adopted for input interface, and excitation mode is corresponding to FULL STEP mode, HALF STEP mode (2 types) and QUARTER STEP mode via a built-in DAC. In the method of current decay, the FAST DECAY/SLOW DECAY ratio can set without any limitation, and all available modes can be controlled in the most appropriate way. In addition, the power supply can be driven by one single system, which simplifies the design.

Features

- Rated Output Current (DC)1.5 A
- Low ON Resistance DMOS output
- CLK-IN Drive Mode
- PWM Constant Current (the other excitation method)
- Built-in Spike Noise Blanking Function (external noise filter is unnecessary)
- Full-, Half (two kinds)-, Quarter-step Functionality
- Free Timing Excitation Mode Switch
- Current Decay Mode Switch Function (linearly variable FAST/SLOW DECAY ratio)
- Normal Rotation and Reverse Rotation Switching Function
- Power Save Function
- Built-in Logic Input Pull-down Resistor
- Power-on Reset Function
- Thermal Shutdown Circuit (TSD)
- Over-current Protection Circuit（OCP）
- Under Voltage Lock Out Circuit (UVLO)
- Over Voltage Lock Out Circuit (OVLO)
- Ghost Supply Prevention (protects against malfunction when power supply is disconnected)
- Adjacent Pins Short Protection
- Micro Miniature, Ultra-thin and High Heat-radiation (exposed metal type) Package

Application

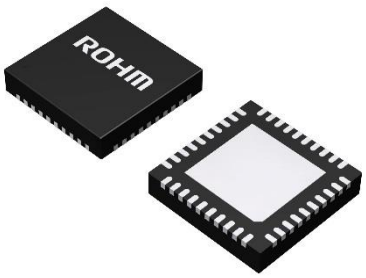
- PPC, Multi-function Printer, Laser Beam Printer, Ink-jet Printer, Monitoring Camera, WEB Camera, Sewing Machine, Photo Printer, FAX, Scanner, Mini Printer, Toy and Robot

Key Specifications

- Range of Power Supply Voltage 8 V to 28 V
- Rated Output Current (continuous) 1.5 A
- Rated Output Current (peak value) 2.0 A
- Range of Operating Temperature -25 °C to +85 °C
- Output ON Resistance 0.85 Ω (Typ)
  (total of upper and lower resistors)

Package
UQFN040V5050

W (Typ) x D (Typ) x H (Max)
5.0 mm x 5.0 mm x 1.0 mm



Typical Application Circuit

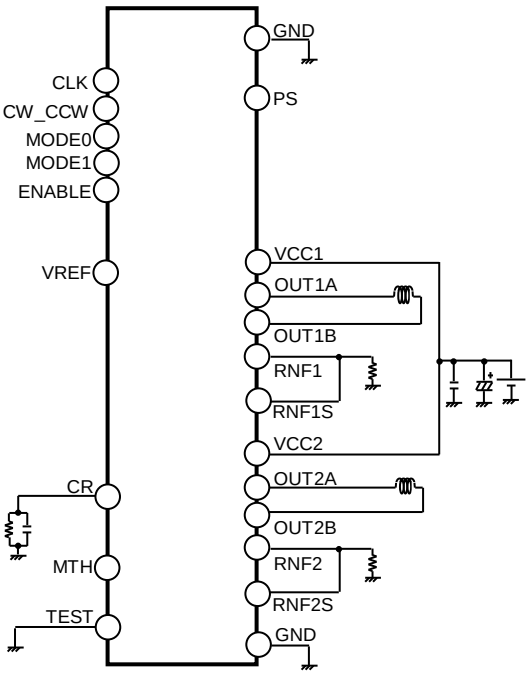


Figure 1. BD63716AMWV Application Circuit Diagram

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Pin Configuration

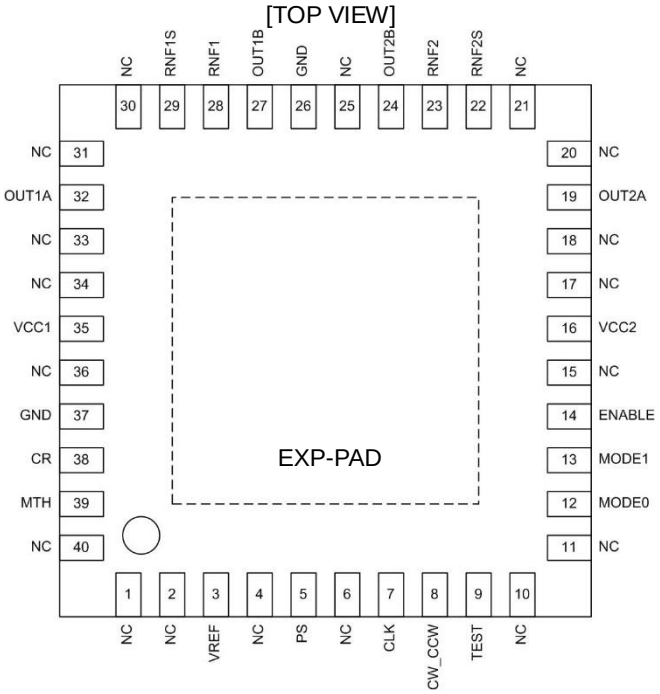


Figure 2. Pins Configuration Diagram

Bock Diagram

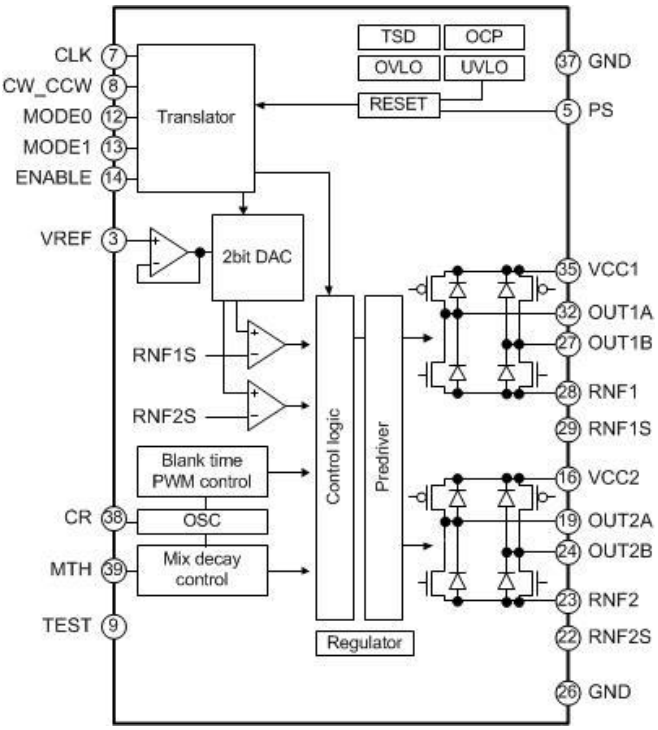


Figure 3. BD63716AMWV Block Diagram

Pin Description

Pin No.	Pin name	Function	Pin No.	Pin name	Function
1	NC	Non connection	21	NC	Non connection
2	NC	Non connection	22	RNF2S	Input pin of current detection comparator
3	VREF	Output current value setting pin	23	RNF2	Connection pin of resistor for output current detection
4	NC	Non connection	24	OUT2B	H bridge output pin
5	PS	Power save pin	25	NC	Non connection
6	NC	Non connection	26	GND	Ground pin
7	CLK	Clock input pin for advancing the electrical angle.	27	OUT1B	H bridge output pin
8	CW_CCW	Motor rotating direction setting pin	28	RNF1	Connection pin of resistor for output current detection
9	TEST	Pin for testing (Used by connecting with GND)	29	RNF1S	Input pin of current detection comparator
10	NC	Non connection	30	NC	Non connection
11	NC	Non connection	31	NC	Non connection
12	MODE0	Motor excitation mode setting pin	32	OUT1A	H bridge output pin
13	MODE1	Motor excitation mode setting pin	33	NC	Non connection
14	ENABLE	Output enable pin	34	NC	Non connection
15	NC	Non connection	35	VCC1	Power supply pin
16	VCC2	Power supply pin	36	NC	Non connection
17	NC	Non connection	37	GND	Ground pin
18	NC	Non connection	38	CR	Connection pin of CR for setting chopping frequency
19	OUT2A	H bridge output pin	39	MTH	Current decay mode setting pin
20	NC	Non connection	40	NC	Non connection
-	EXP-PAD	The EXP-PAD is connected to GND.	-	-	-

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Absolute Maximum Rating (Ta = 25°C)

Item	Symbol	Rated Value	Unit
Supply Voltage	V_{CC1}, V_{CC2}	-0.2 to +36.0	V
Input Voltage for Control Pin	V_{IN}	-0.2 to +5.5	V
RNF Maximum Voltage	V_{RNF}	0.7	V
Maximum Output Current (DC)	I_{OUT}	1.5*(Note 1)*	A/Phase
Maximum Output Current (PEAK) *(Note 2)*	$I_{OUTPEAK}$	2.0*(Note 1)*	A/Phase
Storage Temperature Range	Tstg	-55 to +150	°C
Maximum Junction Temperature	Tjmax	+150	°C

(Note 1) Do not, however exceed Tjmax = 150°C.
(Note 2) Pulse width tw≤1ms, duty 20 %.

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 Condition

Item	Symbol	Min	Typ	Max	Unit
Operating Temperature Range	Topr	-25	+25	+85	°C
Supply Voltage	V_{CC1}, V_{CC2}	+8	+24	+28	V
Maximum Output Current (DC)	I_{OUT}	-	-	+1.2*(Note 3)*	A/Phase

(Note 3) Not exceeding Tj =150°C.

Thermal Resistance*(Note 4)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s*(Note 6)*	2s2p*(Note 7)*	
UQFN040V5050				
Junction to Ambient	θ_{JA}	95.2	31.7	°C/W
Junction to Top Characterization Parameter*(Note 5)*	Ψ_{JT}	7	4	°C/W

(Note 4) Based on JESD51-2A(Still-Air).
(Note 5) 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 6) Using a PCB board based on JESD51-3.
(Note 7) 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 8)*	
			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 8) This thermal via connects with the copper pattern of all layers.

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Electrical Characteristics (Unless otherwise specified Ta = 25 °C, V_{CC1}, V_{CC2} = 24V)

Item	Symbol	Specification			Unit	Condition
		Min	Typ	Max		
[Whole]						
Circuit Current at Standby	I_{CCST}	-	0	10	µA	PS = L
Circuit Current	I_{CC}	-	2.0	5.0	mA	PS = H, VREF = 3 V
[Control Input]						
H-level Input Voltage	V_{INH}	2.0	-	-	V	
L-level Input Voltage	V_{INL}	-	-	0.8	V	
H-level Input Current	I_{INH}	35	50	100	µA	V_{IN} = 5V
L-level Input Current	I_{INL}	-10	0	-	µA	V_{IN} = 0V
[Output]						
Output ON Resistance	R_{ON}	-	0.85	1.15	Ω	I_{OUT} = ±1.0 A (total of upper and lower resistors)
Output Leak Current	I_{LEAK}	-	-	10	µA	
[Current Control]						
RNFxS Input Current*(Note 9)*	I_{RNFS}	-2.0	-0.1	-	µA	RNFxS = 0 V
RNFx Input Current*(Note 9)*	I_{RNF}	-80	-40	-	µA	RNFx = 0 V
VREF Input Current	I_{VREF}	-2.0	-0.1	-	µA	VREF = 0 V
VREF Input Voltage Range	V_{VREF}	0	-	3.0	V	
MTH Input Current	I_{MTH}	-2.0	-0.1	-	µA	MTH = 0 V
MTH Input Voltage Range	V_{MTH}	0	-	3.5	V	
Minimum ON Time (Blank time)	t_{ONMIN}	0.3	0.7	1.5	µs	C = 1000 pF, R = 39 kΩ
Comparator Threshold	V_{CTH}	0.579	0.600	0.621	V	VREF = 3 V

(Note 9) x = 1 or 2

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Function Explanation

CLK/Clock input Pin for advancing the electrical angle

CLK is working on rising edge. The Electrical angle advances by one for each CLK input.
Motor's misstep will occur if noise gets mixed with the CLK pin, so design the pattern there is no noise plunging.

MODE0, MODE1/Motor Excitation Mode Setting Pin

Set the motor excitation mode

MODE0	MODE1	Excitation Mode
L	L	FULL STEP
H	L	HALF STEP A
L	H	HALF STEP B
H	H	QUARTER STEP

Refer to the P.13, 14 for the timing chart and motor torque vector of various excitation modes.
Unrelated to CLK, change of setting is forcibly reflected. (refer to P.16).

CW_CCW Pin/Motor rotating direction setting Pin

Set the motor's rotating direction. Change of setting is reflected by the CLK rising edge immediately after that. (refer to P.15)

CW_CCW	Rotating Direction
L	Clockwise (CH2's current is outputted with a phase lag of 90°on the basis of CH1's current)
H	Counter Clockwise (CH2's current is outputted with a phase lead of 90°on the basis of CH1's current)

ENABLE Pin/Output enable Pin

Turn off forcibly all the output transistors (motor output is open).
When ENABLE = L, input to CLK is blocked, and phase advance operation of internal translator circuit is stopped.
However, when the excitation mode (MODE 0, MODE 1) is switched in the ENABLE = L periode, The switched mode is valid in the excitation mode when the ENABLE pin returns from Low to High. (refer to P.16)

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

PS/Power save Pin

PS can make circuit standby state and motor output OPEN. In standby state, translator circuit is reset (initialized) and electrical angle is initialized.
Be careful because there is a delay of 40µs (Max), as PS = L→H, until it is returned from standby state to normal state and the motor output becomes ACTIVE (refer to P.12).

PS	Status
L	Standby State (RESET)
H	ACTIVE

The electrical angle (initial electrical angle) of each excitation mode immediately after RESET is as follows.
(refer to P.13, 14)

Excitation Mode	Initial Electrical Angle
FULL STEP	45°
HALFSTEP A	45°
HALFSTEP B	45°
QUARTER STEP	45°

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Function Explanation – continued

VCC1, VCC2/Power supply Pin

Motor's drive current is flowing in it, so the wire is thick, short and has low impedance. Voltage VCC may have great fluctuation, so arrange the bypass capacitor of about 100 µF to 470 µF as close to the pin as possible and adjust the voltage VCC is stable. Increase the capacity as needed especially, when a large current is used or those motors that have great back electromotive force are used.

In addition, for the purpose of reducing of power supply's impedance in wideband, it is recommended to set parallel connection of multi-layered ceramic capacitor of 0.01 µF to 0.1 µF etc. Extreme care must be used to make sure that the voltage VCC does not exceed the rating even for a moment. VCC1 and VCC2 are shorted inside IC, but be sure to short externally VCC1 and VCC2 when using. If used without shorting, malfunction or destruction may occur because of concentration of current routes etc. Still more, in the power supply pin, there is built-in clamp component for preventing of electrostatic destruction. When a steep pulse signal or voltage such as a surge exceeding the absolute maximum rating is applied, this clamp component operates, as a result there is the danger of destruction, so be sure that the absolute maximum rating must not be exceeded. It is effective to mount a Zener diode of about the absolute maximum rating. Moreover, the diode for preventing of electrostatic destruction is inserted between VCC pin and GND pin, as a result there is the danger of IC destruction if reverse voltage is applied between VCC pin and GND pin, so be careful.

GND/Ground Pin

In order to reduce the noise caused by switching current and to stabilize the internal reference voltage of IC, the wiring impedance from this pin is made as low as possible to achieve the lowest electrical potential no matter what operating state it may be. Moreover, please design patterns not to have any common impedance with other GND patterns.

OUT1A, OUT1B, OUT2A, OUT2B/H Bridge output Pin

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

RNF1, RNF2/Connection Pin of resistor for detecting of output current

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

RNF1S, RNF2S/Input Pin of current detection comparator

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

VREF/Output current value setting Pin

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

$$I_{OUT} = \frac{VREF}{5} / RNF \qquad [A]$$

Where:

I_{OUT} is the output current.
$VREF$ is the voltage of output current value-setting pin.
RNF is the current-detecting resistor.

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

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Function Explanation – continued

CR/Connection pin of CR for setting chopping frequency

This is the pin to set the chopping frequency of output. Connect the external C (470 pF to 1500 pF) and R (10 kΩ to 200 kΩ) to GND. Refer to P9, 10.

Interconnect from external components to GND not to have a common impedance with other GND patterns. In addition, carry out the wire pattern design it keeps away such steep pulses as square wave etc. and has little noise plunging. Mount the two components of C and R if being used by PWM constant current control because normal PWM constant current control becomes impossible if CR Pin is open or it is biased externally.

MTH/Current decay mode-setting Pin

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

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

Connect to GND if using at SLOW DECAY mode.

Avoid using with MTH pin open because if MTH pin is open, the input is unsettled, and then there is the danger that PWM operation becomes unstable. Besides, select the resistance value in consideration of the outflow current (Max 2 μA) if it is inputted by resistance division.

TEST/Pin for inspection

This pin is used for delivery inspection on IC, and shall be grounded before use.

In addition, malfunctions may be caused by application without grounding.

NC

This pin is unconnected electrically with IC internal circuit.

IC Back Metal

For UQFN040V5050 package, the heat-radiating metal is mounted on IC's back side, and on the metal the heat-radiating treatment is performed when in use, which becomes the precondition to use, secure sufficiently the heat-radiating area by surely connecting by solder with the GND plane on the board and getting as wide GND pattern as possible. Moreover, the back side metal is shorted with IC chip's back side and becomes the GND potential, so there is the danger of malfunction and destruction if shorted with potentials other than GND, therefore please absolutely do not design patterns other than GND through the IC's back side.

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Protection Circuits

Thermal Shutdown (TSD)

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

Over Current Protection (OCP)

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

Under Voltage Lock Out (UVLO)

This IC has a built-in under voltage lock out function to prevent false operation such as IC output during power supply under voltage. When the applied voltage to the VCC pin goes 5 V (Typ) or less, the motor output is set to OPEN. This switching voltage has a 1 V (Typ) hysteresis to prevent false operation by noise etc. Be aware that this circuit does not operate during power save mode. Also, the electrical angle is reset when the UVLO circuit operates.

Over Voltage Lock Out (OVLO)

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

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

If a signal (logic input, MTH, VREF) is input when there is no power supplied to this IC, there is a function which prevents a malfunction where voltage is supplied to power supply of this IC or other IC in the set via the electrostatic destruction prevention diode from these input pins to the VCC. Therefore, there is no malfunction of the circuit even when voltage is supplied to these input pins while there is no power supply.

Operation Under Strong Electromagnetic Field

The IC is not designed for using in the presence of strong electromagnetic field. Be sure to confirm that no malfunction is found when using the IC in a strong electromagnetic field.

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PWM Constant Current Control

1) Current Control Operation

The output current increases due to the output transistor turned on. When the voltage on the RNF pin, the output current is converted it due to connect the external resistance to RNF pin, reaches the voltage value set by the internal 2-bit DAC and the VREF input voltage, the current limit comparator engages and enters current decay mode. Thereafter the output turned on again after a period of time determined the CR pin. The process repeats itself constantly.

2) Noise-masking Function

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

3) CR Timer

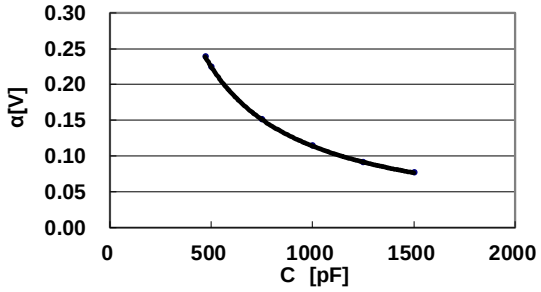
The CR pin is repeatedly charged and discharged between the V_{CRH} and V_{CRL} levels by connected the external capacitor and resistor. The CR pin voltage decides in IC and it is V_{CRL} = 0.4 V, V_{CRH} = 1.0 V respectively. The detection of the current detection comparator is masked while charging from V_{CRL} to V_{CRH}. (As mentioned above, this period defines the minimum ON-time of the motor output transistor.) The CR pin begins discharging once the voltage reaches V_{CRH}. When the output current reaches the current limit during this period, then the IC enters decay mode. The CR continues to discharge during this period until it reaches V_{CRL}, at which point the IC output is switched back ON. The current output and CR pin begin charging simultaneously.

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

$$t_{ONMIN} \fallingdotseq C \times \frac{R' \times R}{R' + R} \times ln\left(\frac{V_{CR} - 0.4}{V_{CR} - 1.0}\right) \quad [s]$$

Where:

t_{ONMIN}	is the minimum ON-time.
C	is the capacitance of the CR Pin.
R	is the resistance of the CR Pin.
R'	is the CR Pin internal impedance 5 kΩ (Typ)
V_{CR}	is the CR Pin voltage.



$$V_{CR} = V \times \frac{R}{R' + R} \quad [V]$$

Where:

V	is the internal regulator voltage 5 V (Typ).

$$t_{DISCHARGE} \fallingdotseq C \times R \times ln\left(\frac{1+\alpha}{0.4}\right) \quad [s]$$

Where:

$t_{DISCHARGE}$	is the CR discharge time.
α	refer to the right graph.

$$t_{CHOP} = t_{ONMIN} + t_{DISCHARGE} \quad [s]$$

Where:

t_{CHOP}	is the chopping period.

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3)CR Timer – continued

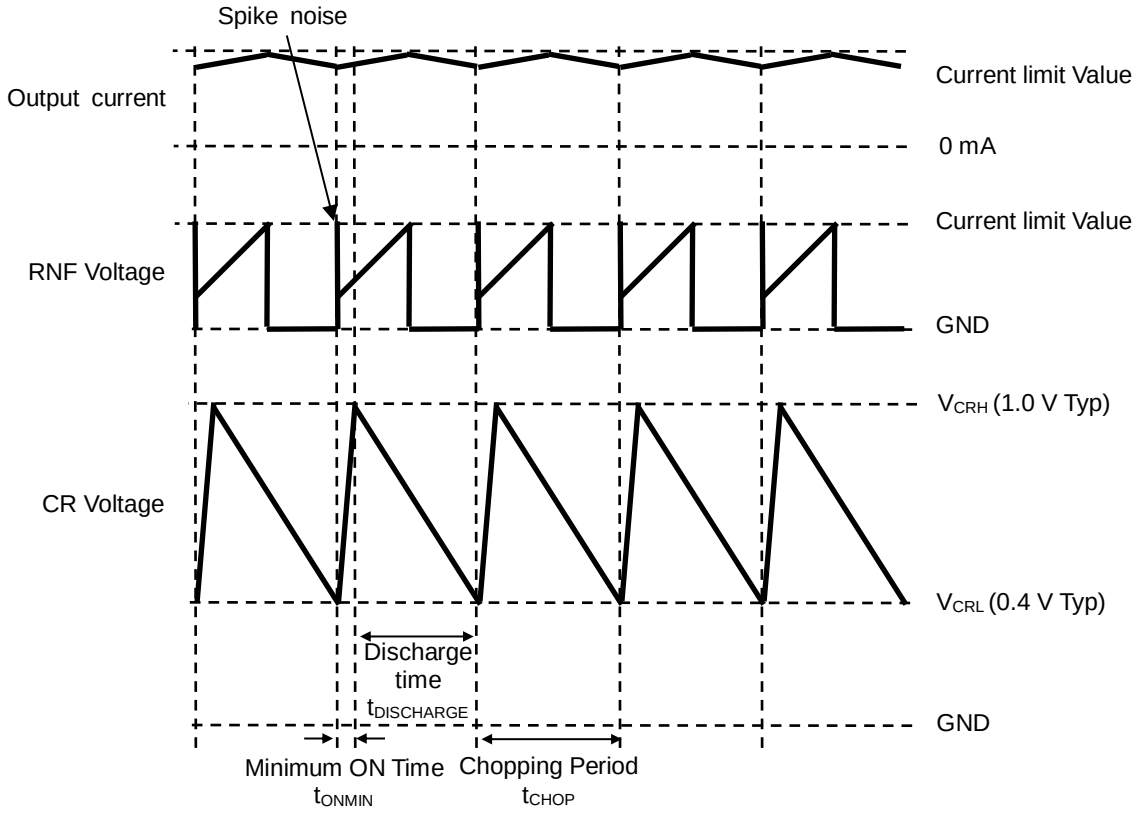


Figure 4. Timing Chart of CR Voltage, RNF Voltage and Output Current

Attach a resistor of at least 10 kΩ to the CR Pin (10 kΩ to 200 kΩ recommended) as lower values may keep the CR from reaching the V_{CRH} voltage level. A capacitor in the range of 470 pF to 1500 pF is also recommended. As the capacitance value is thousands or more, however, the noise-masking period (t_{ONMIN}) also increases, and there is a risk that the output current may exceed the current setting value due to the internal L and R components of the output motor coil. Also, ensure that the chopping period (t_{CHOP}) is not set longer than necessary, as doing so will increase the output ripple, thereby decreasing the average output current and yielding lower output rotation efficiency. Select optimal value so that motor drive sound, and distortion of output current waveform can be minimized.

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PWM Constant Current Control – continued

Current Decay Mode

PWM Constant Current Control can be optionally set the current decay mode in which the ratio of fast and slow decay. The following diagrams show the state of each transistor and the regenerative current path during the current decay for each decay mode:

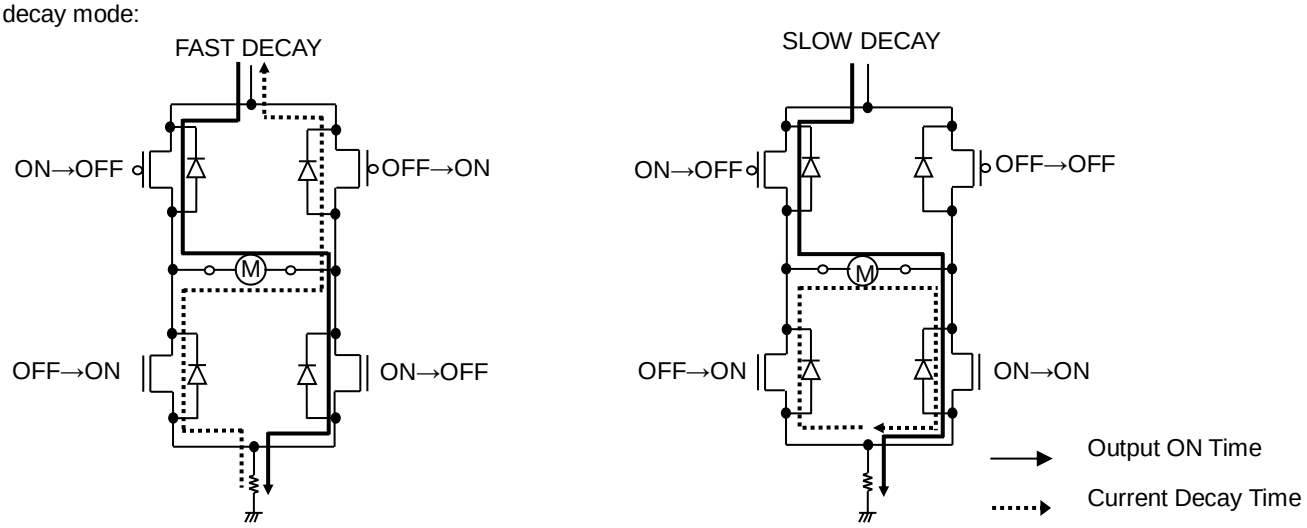


Figure 5. Route of Regenerated Current during Current Decay

The merits of each decay mode are as follows:

SLOW DECAY

The voltage of motor coils is small and the regenerative current decreases slowly. So the output current ripple is small and this is favorable for keeping motor torque high. However, output current is increasing according to fall-off current characteristic deterioration in the low-current region and it is easily influenced by EMF when pulse late is high. As a result, the waveform is distortion and motor oscillation is increasing in half-step or quarter-step modes. Thus, this decay mode is most suited to full-step modes or low-pulse-rate as half-step or quarter-step modes.

FAST DECAY

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

Additionally, this IC allows for a mixed decay mode that can help to improve upon problems that arise from using fast or slow decay. In this mode, the current control characteristic improves without increasing the output current ripple by switching the IC between slow and fast decay. The time ratio of fast to slow decay can be changed via the voltage input to the MTH pin; therefore, it is possible for each motor to be realized the optimal control state. During mixed decay mode about chopping cycle, the first X % (t1 to t2) of which operates the IC in slow decay mode, and the remainder (t2 to t3) of which operates in fast decay mode. However, if the output current (i.e., the voltage on the RNF pin) does not reach the set current limit during the first X % (t1 to t2) decay period, the IC operates in fast decay mode only.

MTH Pin input Voltage [V]	Current Decay Mode
0 to 0.3	SLOW DECAY
0.4 to 1.0	MIX DECAY
1.5 to 3.5	FAST DECAY

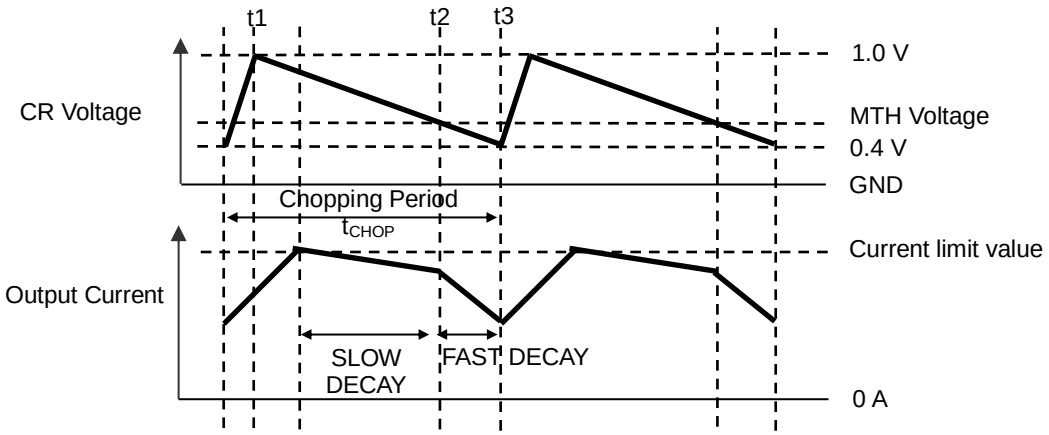


Figure 6. CR Pin Voltage and Output Current during Mixed Decay

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Translator Circuit

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

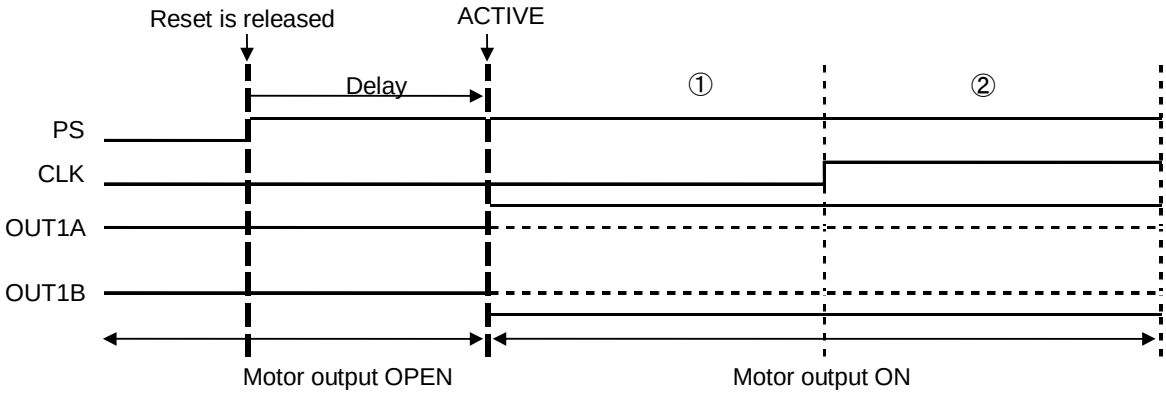
Reset operation

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

Initializing operation when power supply is turned on

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

When power supply is turned on, the power ON reset function operates in IC and initialized, but as long as it is PS = L, the motor output is the OPEN state. After power supply is turned on, because of the changing of PS = L→H, the motor output becomes the ACTIVE state, and the excitation is started at the initial electrical angle.
But at the time of PS = L→H, it returns from the standby state to the normal state and there is a delay of 40 µs (Max) until the motor output has become the ACTIVE state.



②If power supply is turned on at PS = H

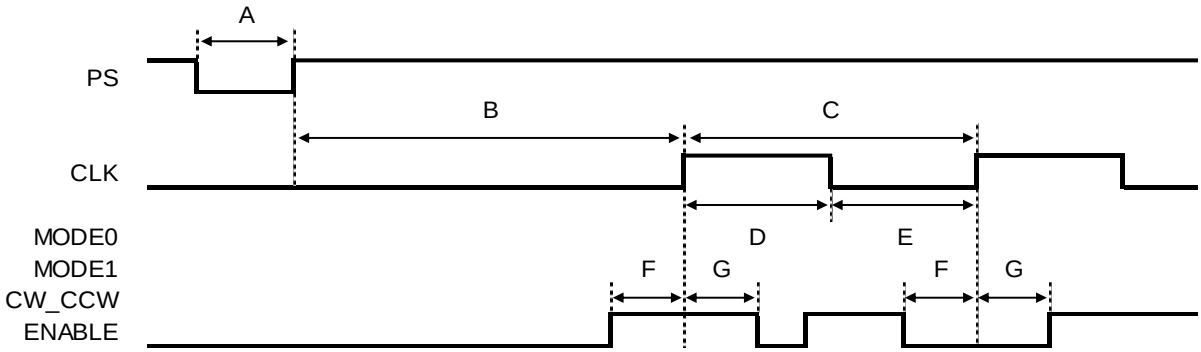
When power supply is turned on, the power ON function in IC operates, and be initialized before the motor output becomes the ACTIVE state during EN = H, and the excitation is started at the initial electrical angle.

Initializing operation during motor operating

Input the reset signal to PS pin when the translator circuit is initialized during motor fundamentally operating. (Refer to P.15) But at the time of PS = L→H, it returns from the standby state to the normal state and there is a delay of 40 µs (Max) until the motor output has become the ACTIVE state, so be careful.

Control Input Timing

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



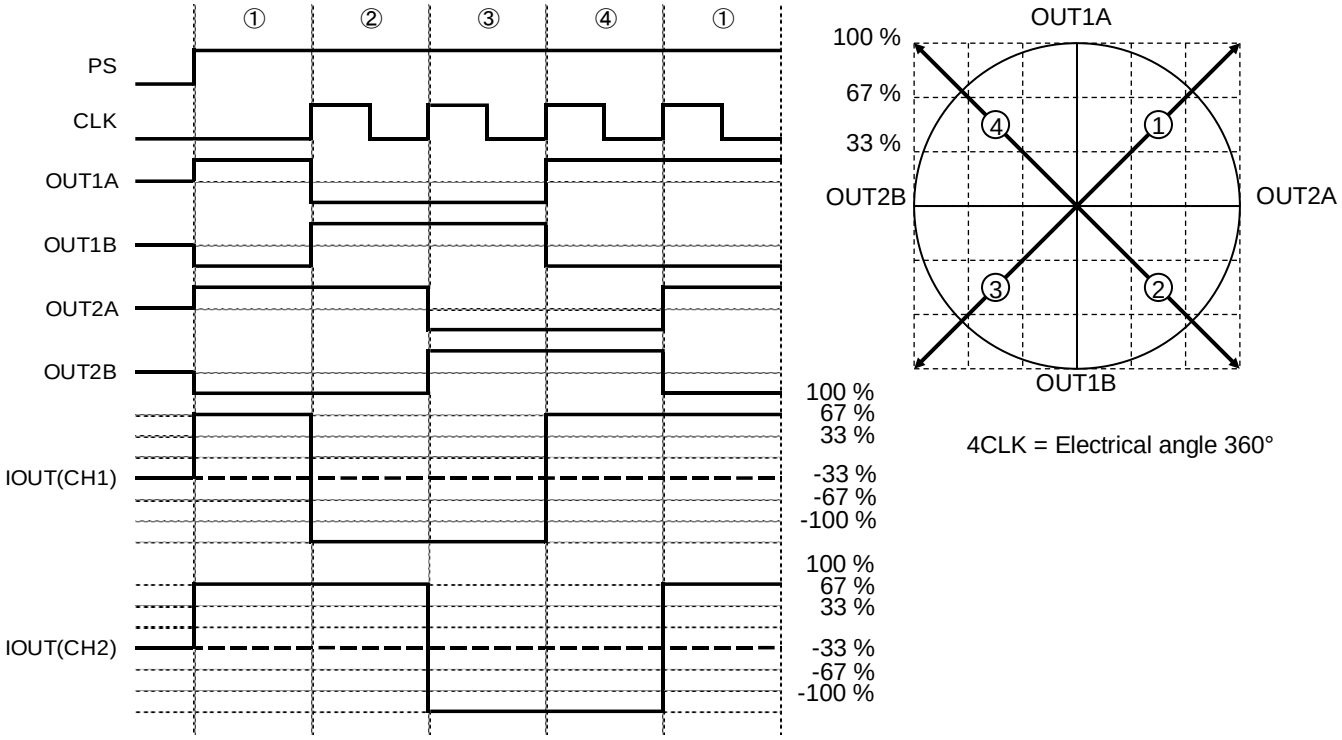
A: PS minimum input pulse width • • • • 20 µs
B: PS rising edge to CLK rising edge input possible maximum delay time • • • • 40 µs
C: CLK minimum period • • • • 4 µs
D: CLK minimum input H pulse width • • • • 2 µs
E: CLK minimum input L pulse width • • • • 2 µs
F: MODE0, MODE1, CW_CCW, ENABLE set-up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

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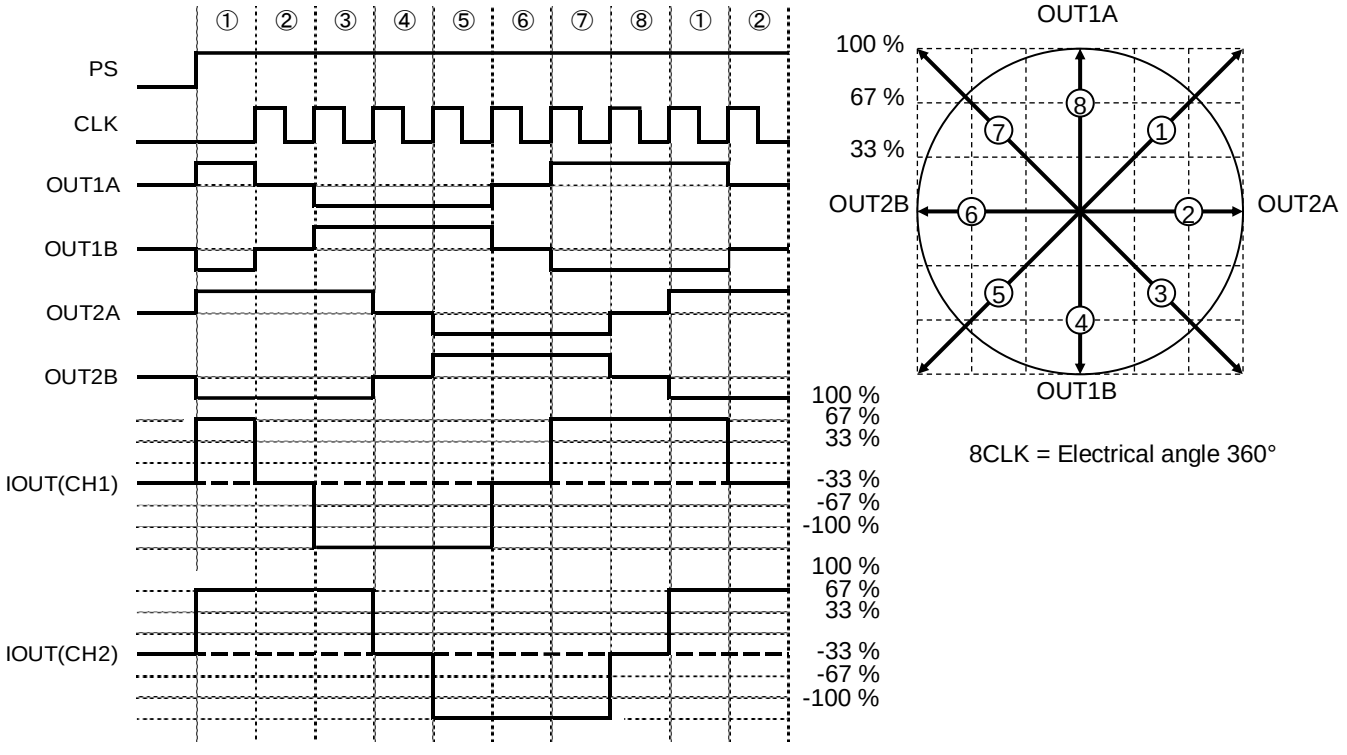
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Translator Circuit – continued

FULL STEP (MODE0 = L, MODE1 = L, CW_CCW = L, ENABLE = H)



HALF STEP A (MODE0 = H, MODE1 = L, CW CCW = L, ENABLE = H)

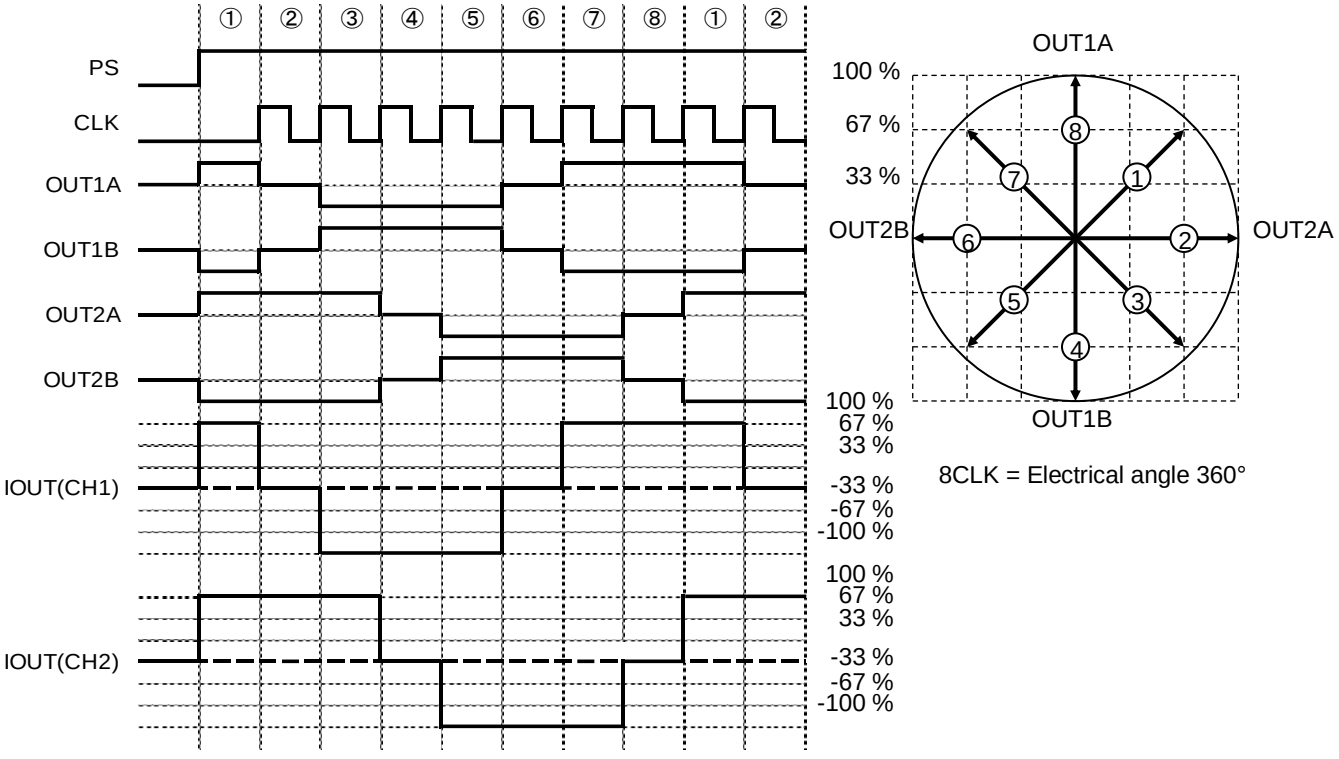


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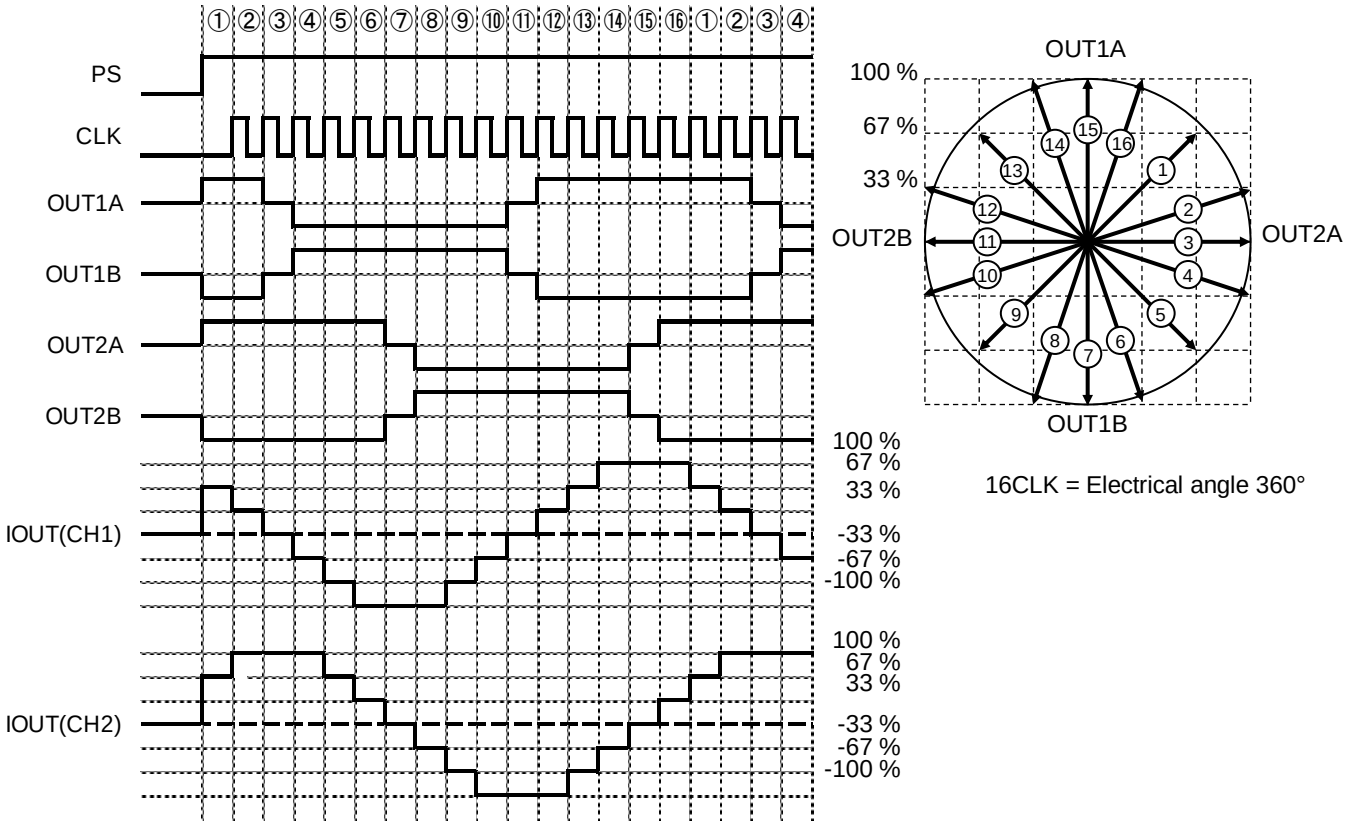
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Translator Circuit – continued

HALF STEP B (MODE0 = L, MODE1 = H, CW_CCW = L, ENABLE = H)



QUARTER STEP (MODE0 = H, MODE1 = H, CW_CCW = L, ENABLE = H)



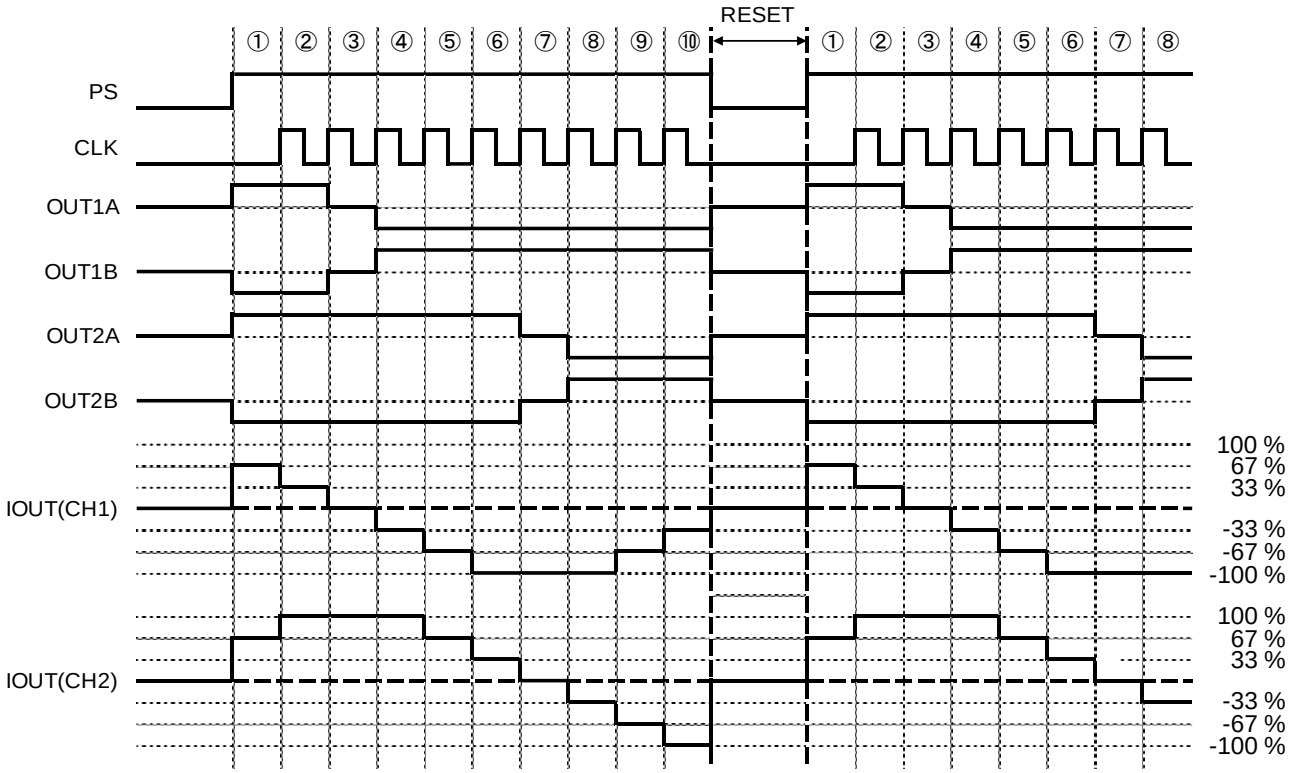
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Translator Circuit – continued

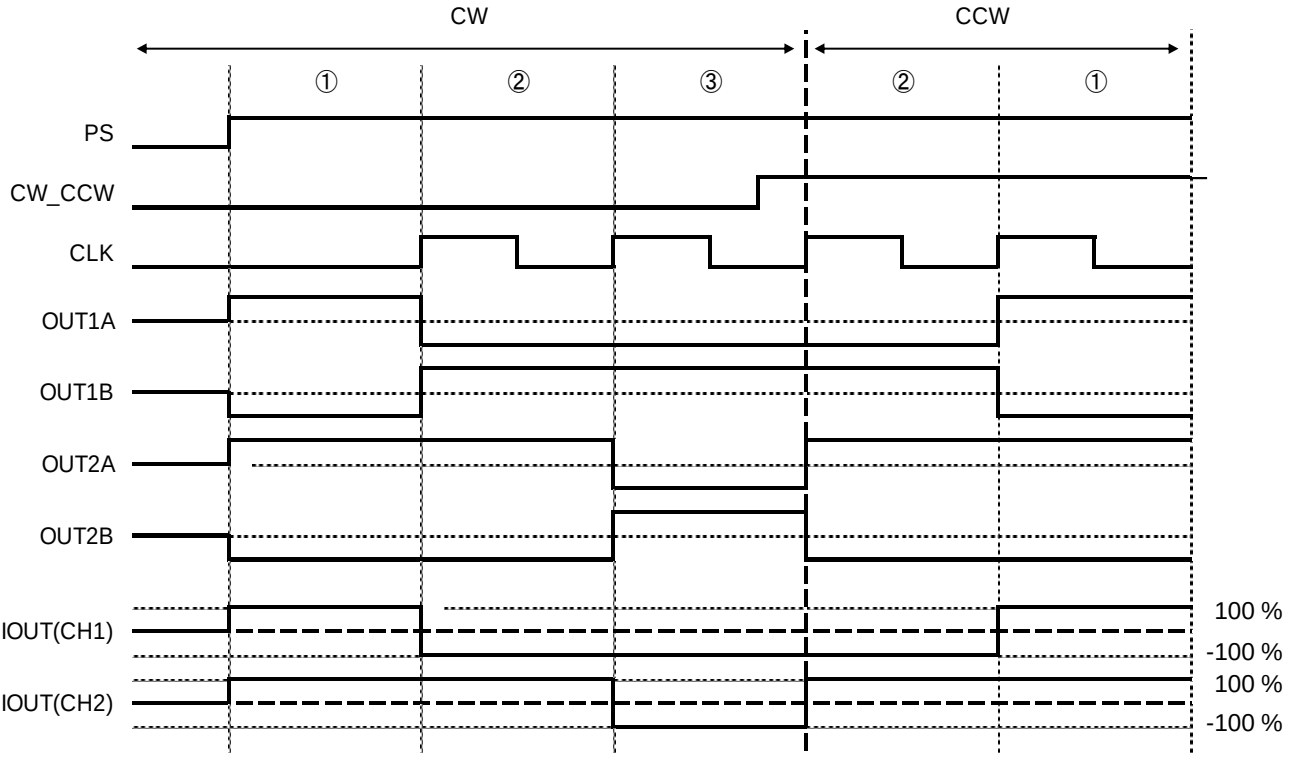
Reset Timing Chart (QUARTER STEP, MODE0 = H, MODE1 = H, CW_CCW = L, ENABLE = H)

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



CW_CCW Switch Timing Chart (FULL STEP, MODE0 = L, MODE1 = L, ENABLE = H)

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



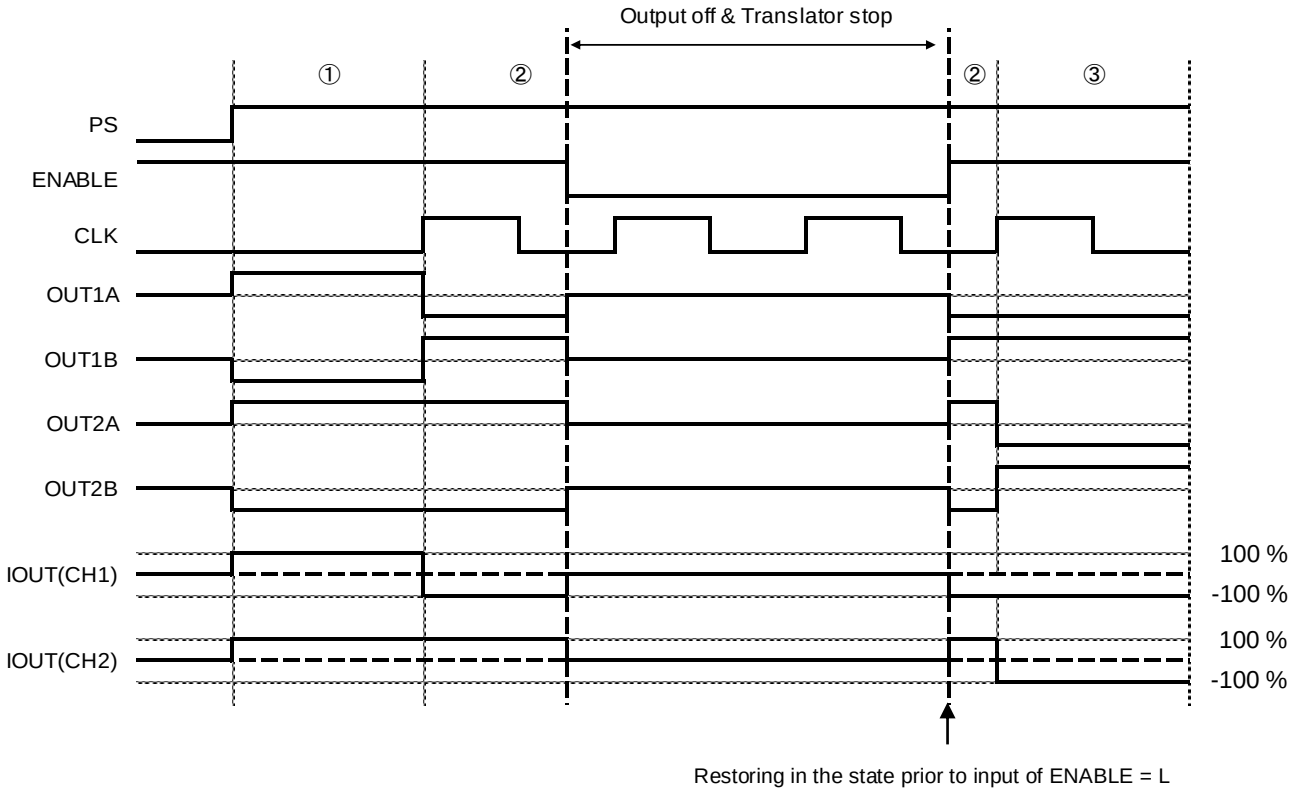
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Translator Circuit – continued

ENABLE Switch Timing Chart (FULL STEP, MODE0 = L, MODE1 = L)

The switch of the ENABLE signal is reflected by the change in the ENABLE signal with regardless of other input signals. In the section of ENABLE = L, the motor output becomes OPEN and the electrical angle doesn't advance. Because the translator circuit stop and CLK input is canceled. Therefore, the progress of ENABLE = L→H is completed before the input of ENABLE = L. Excitation mode (MODE0, MODE1) also switches within ENABLE = L interval. Where excitation mode switched within ENABLE = L interval, restoring of ENABLE = L→H was done in the excitation mode after switch.



About the Switch of the Motor Excitation Mode

The switch of the excitation mode can be done with regardless of the CLK signal at the same time as changing of the signal MODE0 and MODE1. The following built-in function can prevent motor out-of-step caused by discrepancies of torque vector of transitional excitations during switch between excitation modes. However, depending on the state of operation of the motor at the switch the motor cannot follow even if the control on driver IC side is correspondent and there are possibilities of step-out and mistake step in motor. Therefore, switch sequence shall be evaluated sufficiently before any decision.

Cautions of Bidirectional Switch of CW_CCW and Excitation Modes (MODE0, MODE1)

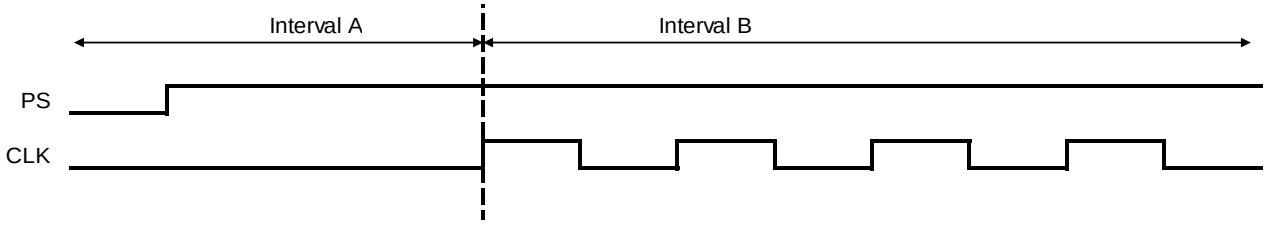
As shown in the figure below, the area between the end of reset discharge (PS = L→H) and beginning of the first CLK signal input is defined as interval A, while the area until the end of the first CLK signal input is defined as interval B.

Interval A

=> For CW_CCW, no limitation is applied on switch of excitation mode.

Interval B

=> In CLK1 period, or within ENABLE = L interval, CW_CCW and excitation mode can't be switched together.
Violation of this restriction may lead to false step (with one extra leading phase) or out-of-step.
Therefore, in case that CW_CCW and excitation modes are switched simultaneously, PS Pin must be input with reset signal. Then start to operate in interval A before carrying out such bidirectional switch.



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Power Dissipation

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

Thermal Calculation

The IC's consumed power can be estimated roughly with the power supply voltage (V_{CC}), circuit current (I_{CC}), output ON resistance (R_{ONH}, R_{ONL}) and motor output current value (I_{OUT}).
The calculation method during FULL STEP drive, SLOW DECAY mode is shown here:

$$W_{VCC} = V_{CC} \times I_{CC} \quad [W]$$

where:

W_{VCC}	is the consumed power of the V_{CC}.
V_{CC}	is the power supply voltage.
I_{CC}	is the circuit current.

$$W_{DMOS} = W_{ON} + W_{DECAY} \quad [W]$$

$$W_{ON} = (R_{ONH} + R_{ONL}) \times {I_{OUT}}^2 \times 2 \times on_duty \quad [W]$$

$$W_{DECAY} = (2 \times R_{ONL}) \times {I_{OUT}}^2 \times 2 \times (1 - on_duty) \quad [W]$$

where:

W_{DMOS}	is the consumed power of the output DMOS.
W_{ON}	is the consumed power during output ON.
W_{DECAY}	is the consumed power during current decay.
R_{ONH}	is the upper P-channel DMOS ON-resistance.
R_{ONL}	is the lower N-channel DMOS ON-resistance.
I_{OUT}	is the motor output current value.
on_duty	PWM on duty $= {t_{ON}}/{t_{CHOP}}$
"2"	is the H bridge A and B.

t_{ON} varies depending on the L and R values of the motor coil and the current set value. Confirm by actual measurement, or make an approximate calculation.
t_{CHOP} is the chopping period, which depends on the external CR. Refer to P.9,10 for details.

IC number	Upper Pch DMOS ON Resistance R_{ONH}[Ω] (Typ)	Lower Nch DMOS ON Resistance R_{ONL}[Ω] (Typ)
BD63716AMWV	0.50	0.35

$$W_total = W_{VCC} + W_{DMOS} \quad [W]$$

$$Tj = Ta + \theta ja \times W_total \quad [°C]$$

where:

W_total	is the consumed total power of IC.
Tj	is the junction temperature.
Ta	is the air temperature.
θja	is the thermal resistance value.

However, the thermal resistance value θja [°C/W] differs greatly depending on circuit board conditions. The calculated values above are only theoretical. For actual thermal design, perform sufficient thermal evaluation for the application board used, and create the thermal design with enough margin to not exceed Tjmax = 150 °C. Although unnecessary with normal use, if the IC is to be used under especially strict heat conditions, consider externally attaching a Schottky diode between the motor output pin and GND to abate heat from the IC.

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Power Dissipation – continued

Temperature Monitoring

In respect of BD63716AMWV, there is a way to directly measure the approximate chip temperature by using the TEST pin with a protection diode for prevention from electrostatic discharge. However, temperature monitor using this TEST pin is only for evaluation and experimenting, and must not be used in actual usage conditions.

(1) Measure the pin voltage when a current of I_{DIODE} = 50 µA flows from the TEST pin to the GND, without supplying VCC to the IC. This is measurement of the V_F voltage inside the diode.

(2) Measure the temperature characteristics of this pin voltage. (V_F has a linear negative temperature factor against the temperature.) With the results of these temperature characteristics, chip temperature can calibrate from the TEST pin voltage.

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

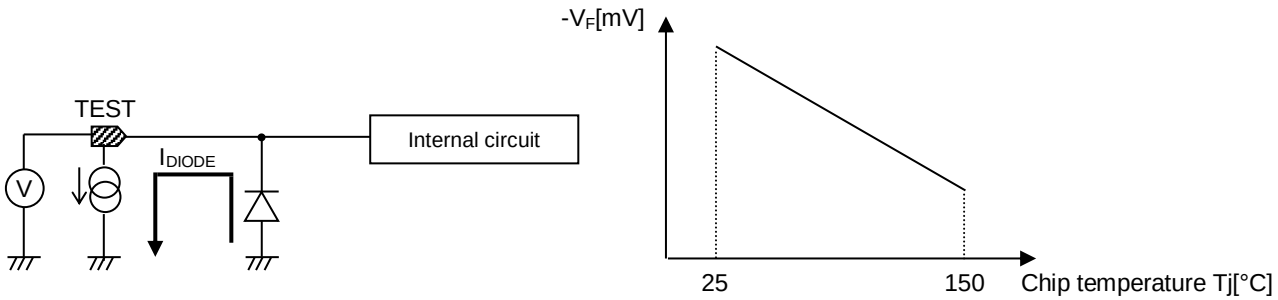


Figure 7. Model Diagram for Measuring Chip Temperature

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Example for Applied Circuit

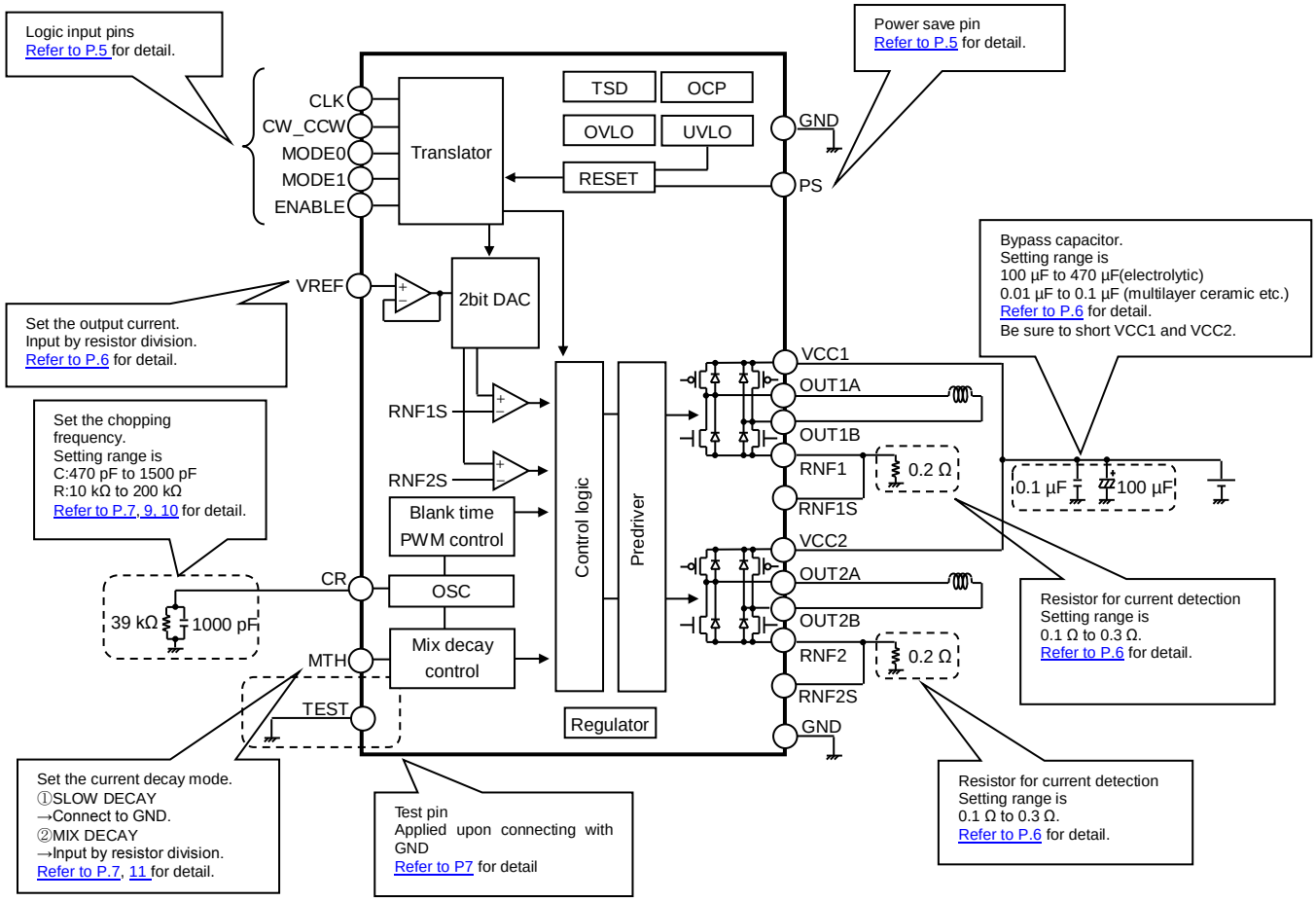


Figure 8. BD63716AMWV Block Diagram and Applied Circuit Diagram

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I/O Equivalence Circuit

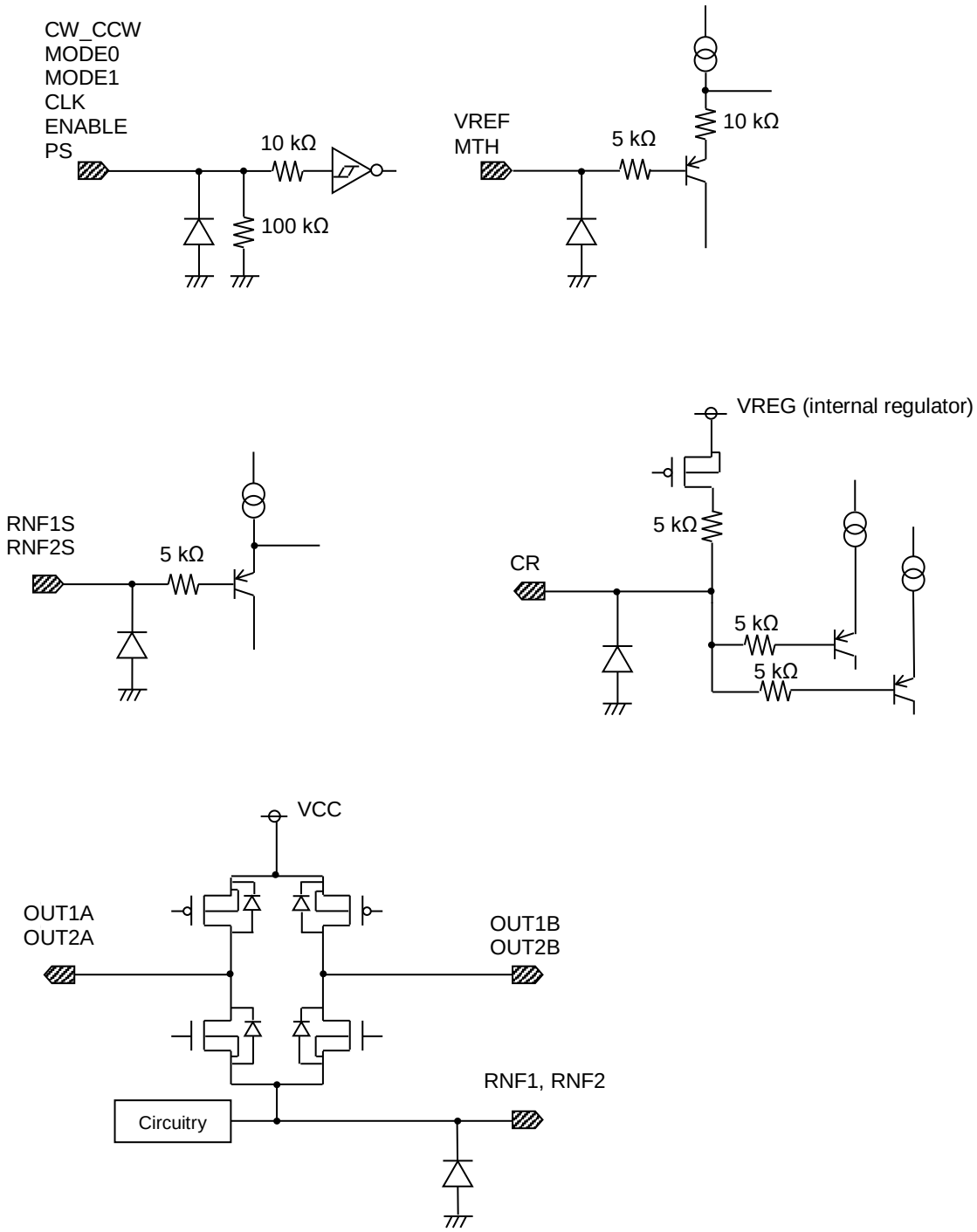


Figure 9. I/O Equivalence Circuit

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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.

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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.

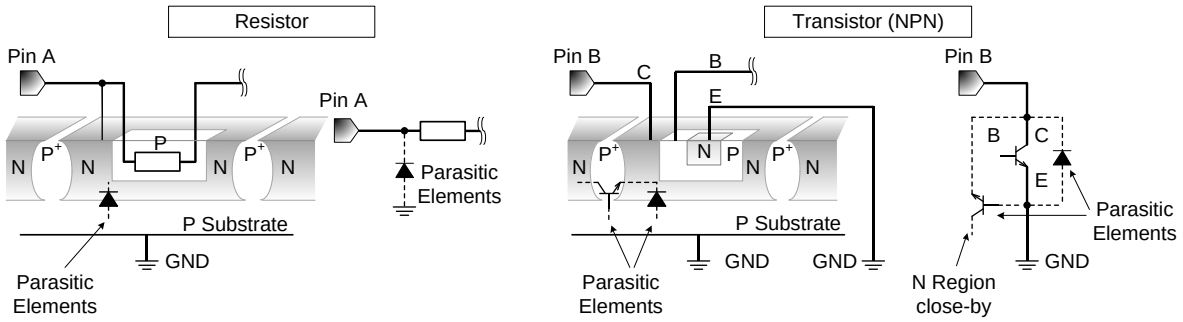


Figure 10. Example of Monolithic IC Structure

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.

12. Thermal Shutdown Circuit (TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF power output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

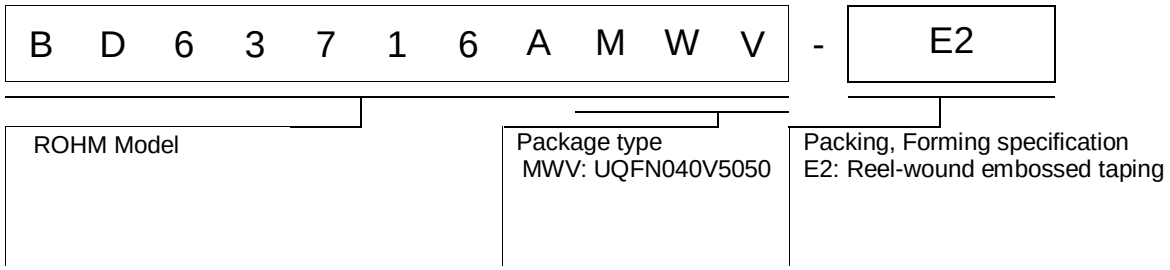
13. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

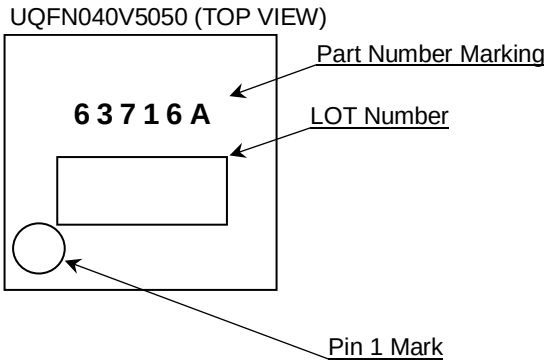
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Ordering Information



Marking Diagram

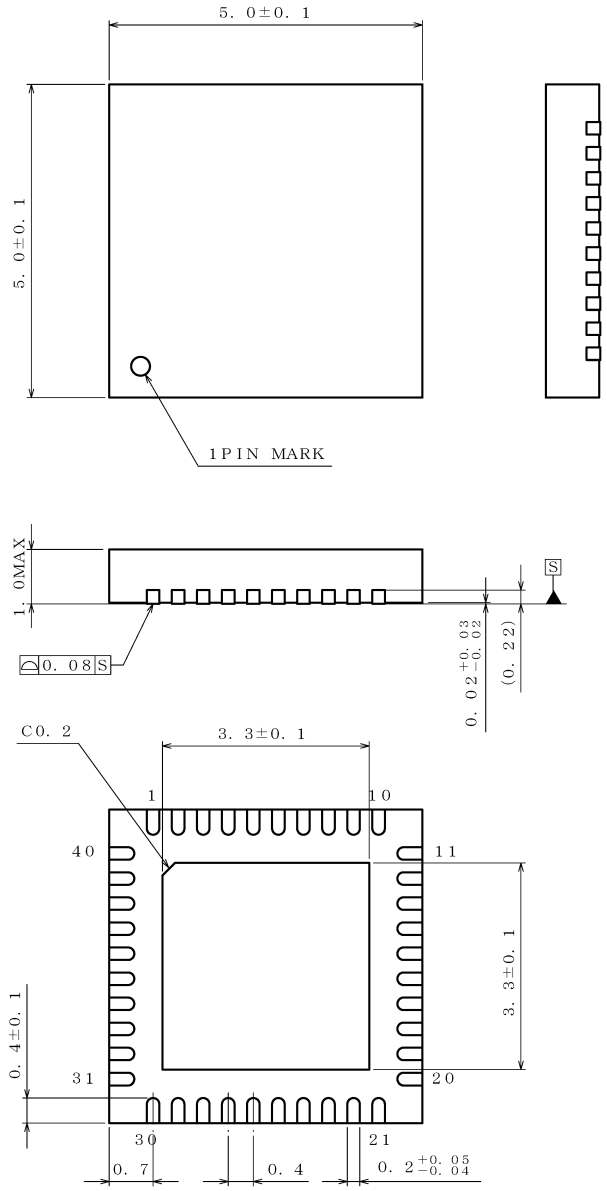


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Physical Dimension and Packing Information

Package Name	UQFN040V5050

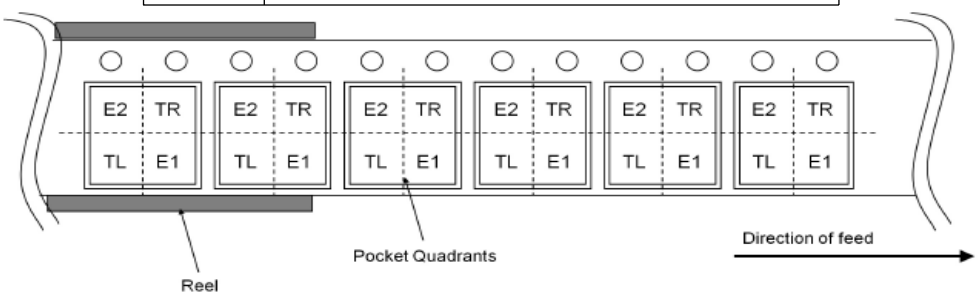


(UNIT : mm)

PKG : UQFN040V5050
Drawing No. EX484-5001-2

<Tape and Reel information>

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



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Revision History

Date	Revision	Changes
28.Jun.2019	001	New Release

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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

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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

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