36 V High-Performance High-Reliability Withstand Voltage Stepping Motor Driver

BD63717MUV

General Description

BD63717MUV is a bipolar low-consumption driver that is driven by PWM current. Rated power supply voltage rating of 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 (2 types), HALF STEP mode (2 types), QUARTER STEP mode, 1/8 STEP mode and 1/16 STEP mode via a built-in DAC. Constant current control is possible without using an external sense resistor, and the board area can be reduced. In the method of current decay, the SLOW DECAY or AUTO DECAY can be set. 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 Control
- Resistance is Unnecessary for Current Detection (current accuracy ±4.5 %)
- Built-in Spike Noise Blanking Function (external noise filter is unnecessary)
- FULL STEP (2 types), HALF STEP (2 types), QUARTER STEP, 1/8 STEP, 1/16 STEP Functionality
- Free Timing Excitation Mode Switch
- Current Decay Mode Switch Function
- Normal Rotation & Reverse Rotation Switching Function
- Power Save Function
- Built-in Logic Input Pull-down Resistor
- Power-on Reset Function
- Temperature 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)
- Microminiature, Ultra-thin, High Heat-radiation (exposed metal type) Package

Application

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

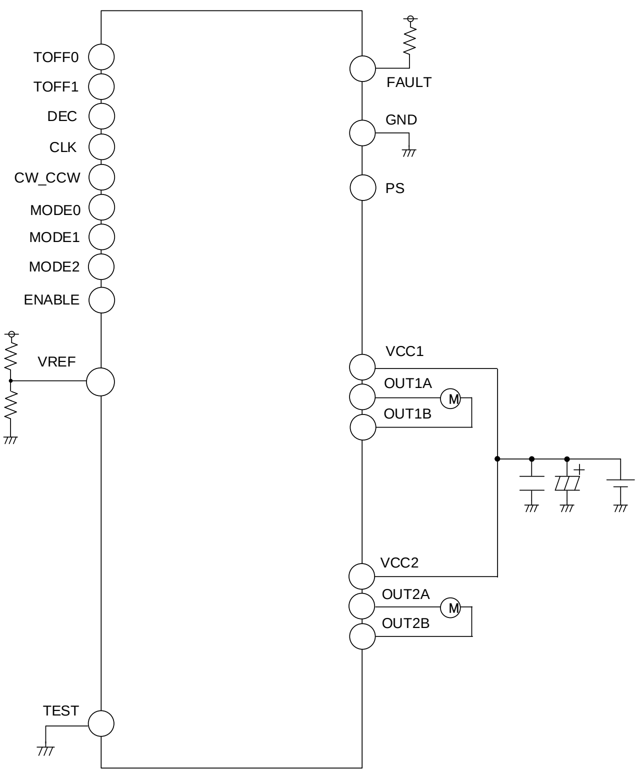
Key Specifications

Range of Power Supply Voltage	19 V to 26.4 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 (total of upper and lower resistors)	0.90 Ω (Typ)

Package

Package	W (Typ) x D (Typ) x H (Max)
VQFN24AV4040	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.

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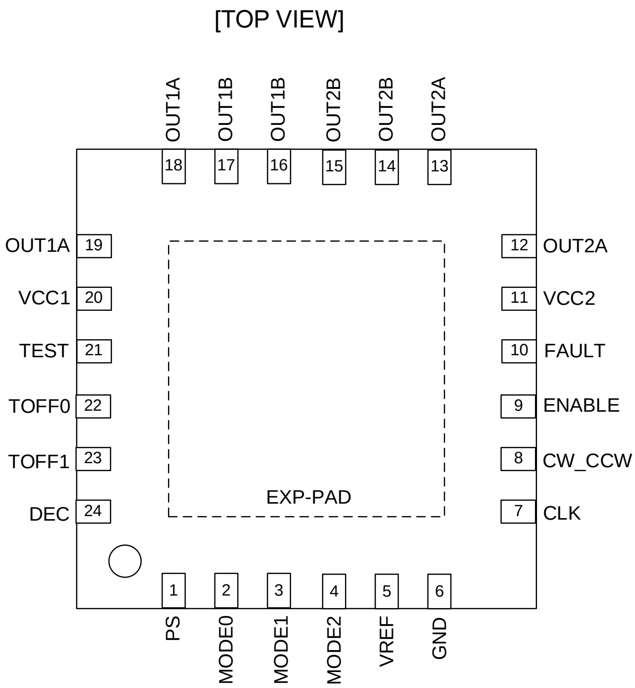
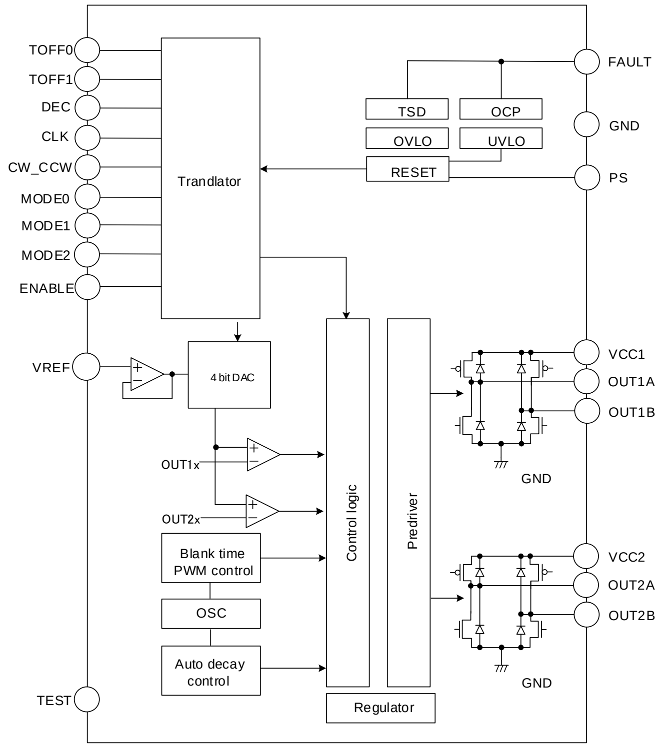
Pin Configuration



Block Diagram



Pin Description

No.	Pin Name	Function	No.	Pin Name	Function
1	PS	Power save pin	13	OUT2A	H bridge output pin
2	MODE0	Motor excitation mode setting pin	14	OUT2B	H bridge output pin
3	MODE1	Motor excitation mode setting pin	15	OUT2B	H bridge output pin
4	MODE2	Motor excitation mode setting pin	16	OUT1B	H bridge output pin
5	VREF	Output current value setting pin	17	OUT1B	H bridge output pin
6	GND	Ground pin	18	OUT1A	H bridge output pin
7	CLK	CLK input pin for advancing the electrical angle	19	OUT1A	H bridge output pin
8	CW_CCW	Motor rotating direction setting pin	20	VCC1	Power supply pin
9	ENABLE	Output enable pin	21	TEST	Pin for testing (Used by connecting with GND)
10	FAULT	Abnormal state output pin	22	TOFF0	Current decay time setting pin
11	VCC2	Power supply pin	23	TOFF1	Current decay time setting pin
12	OUT2A	H bridge output pin	24	DEC	Current decay mode setting pin
-	EXP-PAD	Power ground The EXP-PAD connect to GND.			

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Function Explanation

1 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 is picked up at the CLK pin, so design the pattern in such a way that there is no noise plunging in.

2 MODE0, MODE1, MODE2/Motor Excitation Mode Setting Pin
Sets the motor excitation mode.

MODE0	MODE1	MODE2	Excitation Mode
L	L	L	FULL STEP A
H	L	L	HALF STEP A
L	H	L	HALF STEP C
H	H	L	QUARTER STEP
L	L	H	FULL STEP B
H	L	H	1/8 STEP
L	H	H	1/16 STEP
H	H	H	1/16 STEP

Please refer to pages 12, 13 and 14 for the timing charts and motor torque vector diagrams of various excitation modes.
Unrelated to CLK, change of setting is forcibly reflected. (refer to page 16).

3 CW_CCW/Motor Rotating Direction Setting Pin
Sets the motor's rotating direction. Change in setting is reflected immediately after the rising edge of CLK (refer to page 15).

CW_CCW	Rotating Direction
L	Clockwise (CH2's current is outputted with a phase lag of 90° with regards to CH1's current.)
H	Counterclockwise (CH2's current is outputted with a phase lead of 90° with regards to CH1's current.)

4 ENABLE/Output Enable Pin
Forcibly turn off all the output transistors (motor output OPEN).
When ENABLE = L, CLK input is blocked, and phase advance operation of internal translator circuit is stopped.
However, if the the excitation mode (MODE0, MODE1, MODE2) is switched during ENABLE = L, the switched mode is valid in the excitation mode when the ENABLE returns from Low to High (refer to page 16).

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

5 PS/Power Save Pin
PS can make the circuit in standby state and make motor output OPEN.
In standby state, the translator circuit is RESET (initialized) and the electrical angle is initialized.
Be careful because there is a delay of 100 μs (Max), as PS = L→H, until it is returned from standby state to normal state and the motor output becomes ACTIVE (refer to page 11).

PS	State
L	Standby (RESET)
H	ACTIVE

The electrical angle (initial electrical angle) of each excitation mode immediately after RESET is as follows (refer to pages 12, 13, 14).

Excitation Mode	Initial Electrical Angle
FULL STEP A	45°
HALF STEP A	45°
HALF STEP C	45°
QUARTER STEP	45°
FULL STEP B	45°
1/8 STEP	45°
1/16 STEP	45°

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Function Explanation - continued

6 VCCx(Note 1)/Power Supply Pin

The motor's drive current is flowing in this pin, so design the wire to be thick, short and has low impedance. VCC voltage may have large fluctuations, due to motor back electromotive force, PWM switching noise, etc., so arrange the bypass capacitor (100 μF to 470 μF) as close to the pin as possible and adjust in such a way to stabilize the VCC voltage. Increase the capacitance as needed especially when a large current is used or those motors that have a large back electromotive force are used.
In addition, for the purpose of reducing the power supply's impedance in wide frequency band, it is recommended to set parallel connection of multi-layered ceramic capacitor of 0.01 μF to 0.1 μF. Extreme care must be used to make sure that the VCC voltage does not exceed the rating even for a short period of time. Although VCCx are shorted inside the IC, be sure to short it externally as well. If used without shorting, malfunction or destruction may occur because of concentration of current routes etc.
Furthermore, the power supply pin has a built-in clamp component for preventing electrostatic destruction. When a steep pulse signal or voltage such as a surge that exceeds the absolute maximum rating is applied, the clamp component operates, as a result there is a danger of destruction, so be sure that the absolute maximum rating must not be exceeded. It is also effective to mount a Zener diode of about the absolute maximum rating. Moreover, the diode for preventing electrostatic destruction is inserted between VCCx pin and GND pin, as a result there is the danger of IC destruction if reverse voltage is applied between VCCx pin and GND pin, so be careful.
(Note 1) x = 1 or 2

7 GND/Ground Pin

To reduce the noise caused by switching current and to stabilize the internal reference voltage of the IC, the wiring impedance from this pin should be made as low as possible to achieve the lowest electrical under any operating conditions. Moreover, please design the patterns so that it does not have any common impedance with other GND patterns.

8 OUT1A, OUT1B, OUT2A, OUT2B/H Bridge Output Pin

The motor's drive current is flowing in this pin, so design the wire to be thick, short and has low impedance.
It is also effective to add a Schottky diode if output has large positive or negative fluctuations when a large current is used, for example when the back electromotive force is large. When a steep pulse signal or voltage such as a surge exceeding the absolute maximum rating is applied, as a result there is a danger of destruction, so be sure that the absolute maximum rating must not be exceeded.

9 VREF/Output Current Value Setting Pin

This is the pin to set the output current value. It can be set by VREF voltage.

$$I_{OUT} = \frac{VREF}{2} \quad \text{[A]}$$

I_{OUT} : is the Output Current
$VREF$: is the Output Current Value- Setting Pin Voltage

Avoid using the VREF pin open, because when it is open, the input is unstable, and the VREF voltage increases and there is a possibility of such malfunctions as the setting current increases and a large current flow etc. Keep to the input voltage range, because if a voltage exceeding 3 V is applied to the VREF pin, there is a danger that a large current flows in the output and so OCP or TSD will operate.
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.

10 TOFF0 and TOFF1/Current Decay Time Setting Pin

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

TOFF0	TOFF1	Current Decay Time
L	L	6 μs
H	L	12 μs
L	H	20 μs
H	H	32 μs

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Function Explanation - continued

11 DEC/Current Decay Mode Setting Pin

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

DEC	Current Decay Mode
L	SLOW DECAY
H	AUTO DECAY

12 FAULT/Abnormal Status Output Pin

Abnormal detection signal is output when the Over Current Protection (OCP) or Thermal Shutdown circuit (TSD) activates, the FAULT pin output goes Low. Even if the Under Voltage Lock Out function (UVLO) and Over Voltage Lock Out function (OVLO) operate, no abnormality detection signal is output. This signal can be connected to a microcontroller to shutdown the system. Fault pin is an open drain pin, so use a 5 kΩ to 100 kΩ resistor to pull it up to a power supply of 7 V or less (for example, a 5 V or 3.3 V power supply). When this pin is not used, it should be connected to GND.

13 TEST/Pin for Testing

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.

14 IC Back Metal

The VQFN24AV4040 package has a heat dissipation metal at the back of the IC, and it is assumed that this metal will be heat-treated before use, so be sure to connect it to the GND plane on the board with solder and make the GND pattern as wide as possible to ensure sufficient heat dissipation area.
In addition, the back side metal is shorted with IC chip's back side and becomes a GND potential, so there is 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

1 **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 will automatically return to normal operation. However, even when TSD is in operation, if heat is continuously applied externally, heat overdrive can lead to destruction.
In addition, although it is basically unnecessary in normal applications, please consider connecting a Schottky diode between the motor output pin to GND pin, to reduce the heat generated in the IC when it is used under extreme thermal conditions, in particular.

2 **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 to each other or VCC-motor output or motor output-GND is shorted. This circuit latches the motor output to OPEN state when the regulated current flows for 3 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 due to over current in irregular conditions such as motor output shorts and is not meant as protection or security for the set. Therefore, sets should not be designed to take advantage of this circuit's functions.
After OCP operating, if irregular situations continue and the return by power reactivation or a reset by the PS pin, then OCP operates repeatedly, and the IC may generate heat or otherwise deteriorate. When the L value of the wiring is large, due to long wiring, the motor outputs is shorted to each other or VCC-motor output is shorted or motor output-GND is shorted, if the output pin voltage jumps up and the absolute maximum rating is exceeded after the over current has flowed, there is a possibility of destruction. Also, if a current above the output current rating and less than or equal to the OCP detection current flows, the IC will generate heat, and if Tjmax = 150 °C is exceeded, the IC can deteriorate, therefore do not apply current that exceeds the output current rating.

3 **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 voltage applied to VCCx pin becomes 15 V (Typ) or less, the motor output becomes OPEN. This switching voltage has a hysteresis of 1 V (Typ) 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.

4 **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 VCCx pin goes beyond 32 V (Typ), the motor output is set to OPEN.
This switching voltage has a hysteresis of 1 V (Typ), and a 3 µs (Typ) mask time to false operation by noise etc. Furthermore, although the IC has a built-in over voltage locked out circuit, there is a possibility of destruction if the absolute maximum rating of the power supply voltage is exceeded. Therefore, the absolute maximum rating should not be exceeded. Be aware that this circuit does not operate during power save mode.

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

If a control signal[(Note 1)] 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 electrostatic destruction prevention diode from these control input pins to the VCCx pin. Therefore, there is no malfunction of the circuit even when voltage is supplied to these input pins when there is no power supply.
(Note 1) Control Signal = PS, ENABLE, CLK, CW_CCW, MODE0, MODE1, MODE2, TOFF0, TOFF1, DEC, VREF

6 **Operation Under Strong Electromagnetic Field**

The IC is not designed for use 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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Absolute Maximum Rating (Ta = 25°C)

Parameters	Signal	Rating	Unit
Supply Voltage	V_{CC1}, V_{CC2}	-0.2 to +36.0	V
Input Voltage for Control Pin(Note 1)	V_{IN}	-0.2 to +5.5	V
Output Current (Continuous)	I_{OUT}	1.5(Note 2)	A/Phase
Output Current (Peak)	$I_{OUTPEAK}$	2.0(Note 2)	A/Phase
FAULT Pin Voltage	V_{FAULT}	-0.2 to +36.0	V
FAULT Pin Current	I_{FAULT}	6	mA
Storage Temperature Range	Tstg	-55 to +150	°C
Maximum Junction Temperature	Tjmax	+150	°C

(Note 1) Control Input = PS, ENABLE, CLK, CW_CCW, MODE0, MODE1, MODE2, TOFF0, TOFF1, DEC, VREF
(Note 2) Do not exceed Tjmax = 150 °C
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

Parameters	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{CC1}, V_{CC2}	19	24	26.4	V
Operating Temperature	Topr	-25	+25	+85	°C
Maximum Output Current (continuous)	I_{OUT}	-	-	1.2(Note 3)	A/Phase

(Note 3) Do not exceed Tjmax = 150 °C

Thermal Resistance (Note 4)

Parameters	Symbol	Thermal Resistance (Typ)		Unit
		1s(Note 6)	2s2p(Note 7)	
VQFN24AV4040				
Junction to Ambient	θ_{JA}	107.7	37.7	°C/W
Junction to Top Characterization Parameter(Note 5)	Ψ_{JT}	11	8	°C/W

(Note 4) Based on JESD51-2A (Still-Air)
(Note 5) 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 connect with the copper pattern of layers 1,2, and 4. The placement and dimensions obey a land pattern.

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

Item	Symbol	Specification			Unit	Condition
		Min	Typ	Max		
[Whole]						
Circuit Current at Standby	I_{CCST}	-	0	10	μA	PS = L
Circuit Current	I_{CC}	-	4.0	6.0	mA	PS = H, VREF = 3 V
[Control Logic Input*(Note 1)*]						
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} = 5 V
L-level Input Current	I_{INL}	-10	0	-	μA	V_{IN} = 0 V
[DEC Input]						
H-level Input Voltage	V_{DINH}	2.0	-	-	V	
L-level Input Voltage	V_{DINL}	-	-	0.8	V	
H-level Input Current	I_{DINH}	70	100	200	μA	V_{IN} = 5 V
L-level Input Current	I_{DINL}	-10	0	-	μA	V_{IN} = 0 V
[Output*(Note 2)*]						
Output On Resistance	R_{ON}	-	0.90	1.19	Ω	I_{OUT} = ±1.2 A (total of upper and lower resistors)
Output Leak Current	I_{LEAK}	-	-	10	μA	
[Abnormal Detection Signal Output*(Note 3)*]						
Output L Voltage	V_{FAULT}	-	430	800	mV	FAULT = 6 mA
Output Leak Current	I_{LEAK_FAULT}	-	-	10	μA	FAULT = 5 V
[Current Control]						
VREF Input Current	I_{VREF}	-1.0	0	+1.0	μA	VREF = 0 V
VREF Input Voltage Range	V_{VREF}	0	-	3.0	V	
Minimum ON Time (Cancel Time)	t_{ONMIN}	1.4	2.0	2.6	μs	
OFF Time 1	t_{OFF1}	3	6	9	μs	TOFF0 = L, TOFF1 = L
OFF Time 2	t_{OFF2}	7	12	17	μs	TOFF0 = H, TOFF1 = L
OFF Time 3	t_{OFF3}	12	20	28	μs	TOFF0 = L, TOFF1 = H
OFF Time 4	t_{OFF4}	19	32	45	μs	TOFF0 = H, TOFF1 = H
Output Current Accuracy 1 (100 %-71.7 %)	ΔICL1	-4.5	0	+4.5	%	VREF = 3 V
Output Current Accuracy 2 (63.4 %-38.3 %)	ΔICL2	-10	0	+10	%	VREF = 3 V
Output Current Accuracy 3 (29.0 %-9.8 %)	ΔICL3	-15	0	+15	%	VREF = 3 V

(Note 1) Control Logic Input = PS, ENABLE, CLK, CW_CCW, MODE0, MODE1, MODE2, TOFF0, TOFF1
(Note 2) Output = OUT1A, OUT1B, OUT2A, OUT2B
(Note 3) Abnormal Detection Signal Output = FAULT

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PWM Constant Current Control

1 Current Control Operation

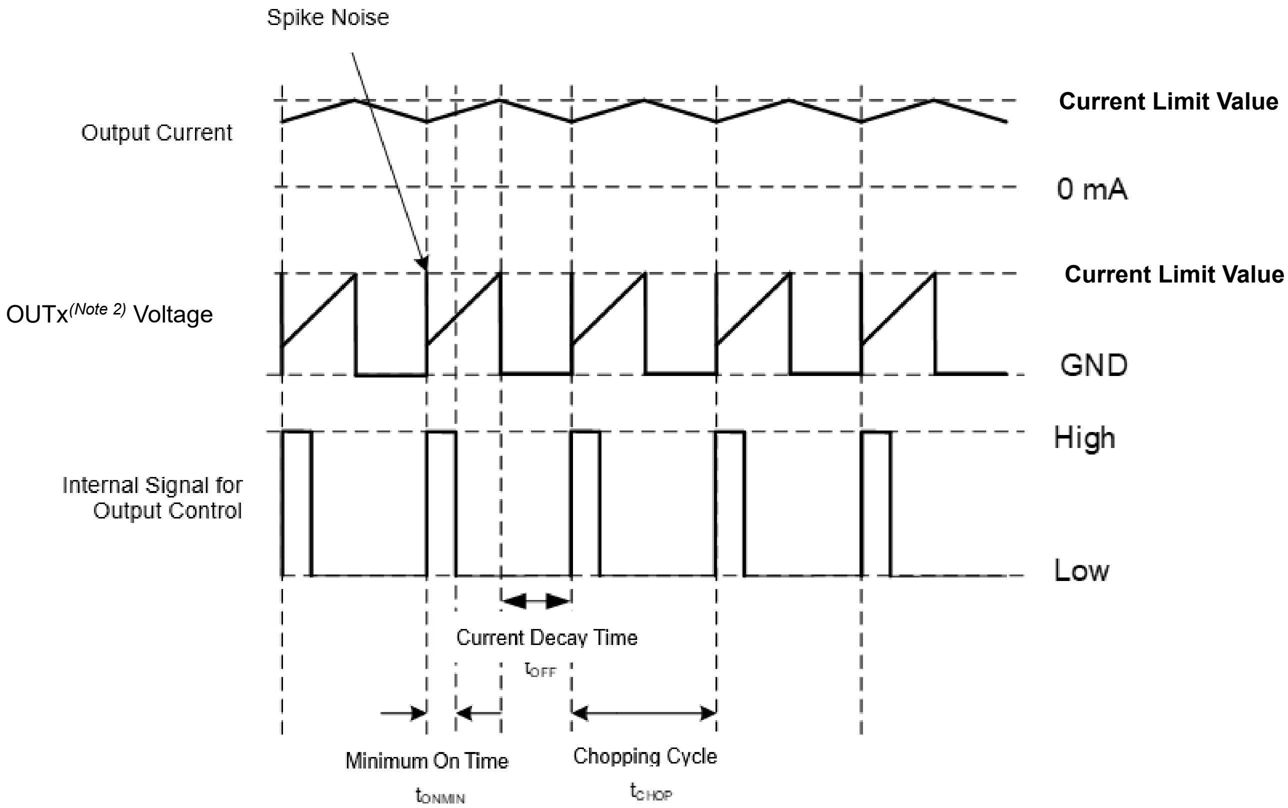
The output current increases due to the output transistor being turned on. When it reaches the current value determined by the VREF input voltage, the current limit comparator operates, and enters current decay mode. Thereafter the output turned on again after OFF (Current Decay) time t_{OFF} determined by TOFFx*(Note 1)*. The process repeats itself with chopping period (t_{CHOP}).

(Note 1) x = 1 or 2

2 Noise Masking Function

To avoid misdetection of current limit comparator due to spike noise that occurs when the output turns on, the IC has the minimum ON time t_{ONMIN} (Blank time: 2 μs (Typ)). The current limit detection is invalid from the output transistor turned on to minimum ON time. This allows for constant current drive without the need for an external filter.

3 Timing Chart of Output Current



(Note 2) x = 1A, 1B, 2A, 2B

Figure 1. Timing Chart of Output Current, Output Voltage, and Internal Signal for Output Control

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PWM Constant Current Control - continued

4 Current Decay Mode

In PWM Constant Current Control, the current decay mode can be set to SLOW DECAY/AUTO DECAY. The following diagrams show the state of each output transistor and the motor regenerative current path during the current decay for each decay mode.

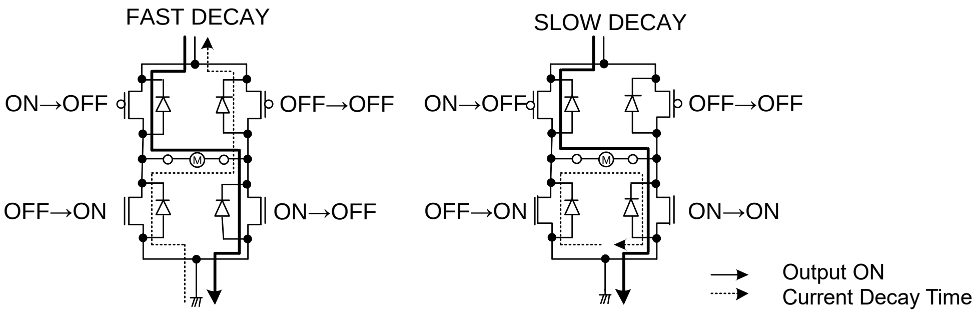

Figure 2. Regenerative Current Path during Current Decay

The merits of each decay mode are as follows.

4.1 SLOW DECAY

The voltage of the motor coils is small, and the regenerative current decreases slowly. So, the output current ripple is small, and this is favorable for keeping the motor torque high. However, output current increases according to fall-off current characteristic deterioration in low-current region and it is easily influenced by EMF when pulse rate is high. As a result, the current waveform is not able to follow the change in current limit and the distortion and motor vibration increases in HALF STEP, QUARTER STEP, 1/8 STEP, and 1/16 STEP modes. Thus, this decay mode is most suited for FULL STEP mode or low-pulse rate driven HALF STEP, QUARTER STEP, 1/8 STEP, and 1/16 STEP modes.

4.2 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 cases two problems (1)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 (2)the power loss of 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 driven HALF STEP, QUARTER STEP, 1/8 STEP, and 1/16 STEP modes.

The AUTO DECAY method is a way to improve the problems that occur in the above SLOW DECAY and FAST DECAY.

4.3 AUTO DECAY

Current control capability can still be improved without making the current ripple big by using SLOW DECAY and switches only to MIX DECAY only when rapid decay is required. Decay modes becomes MIX DECAY only when output current reaches current limit value during the minimum ON time. The time ratio is 67 % for SLOW DECAY and 33 % for FAST DECAY with respect to the OFF time t_{OFF}.

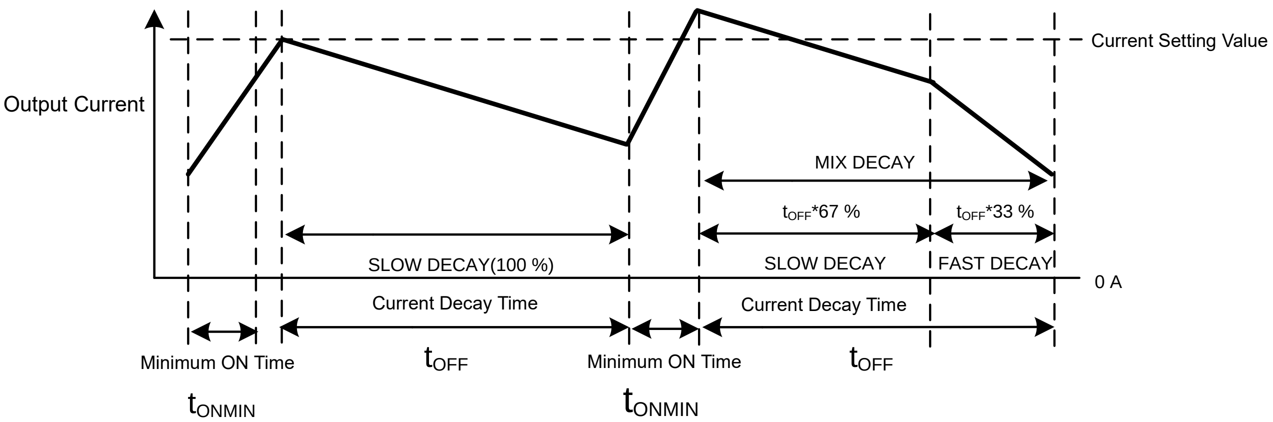

Figure 3. Output Current during AUTO DECAY

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Translator Circuit Operation in CLK-IN Drive Mode

It has a built-in translator circuit and can drive a stepping motor using the CLK-IN mode.
The operation of the translator circuit in CLK-IN drive mode is described below.

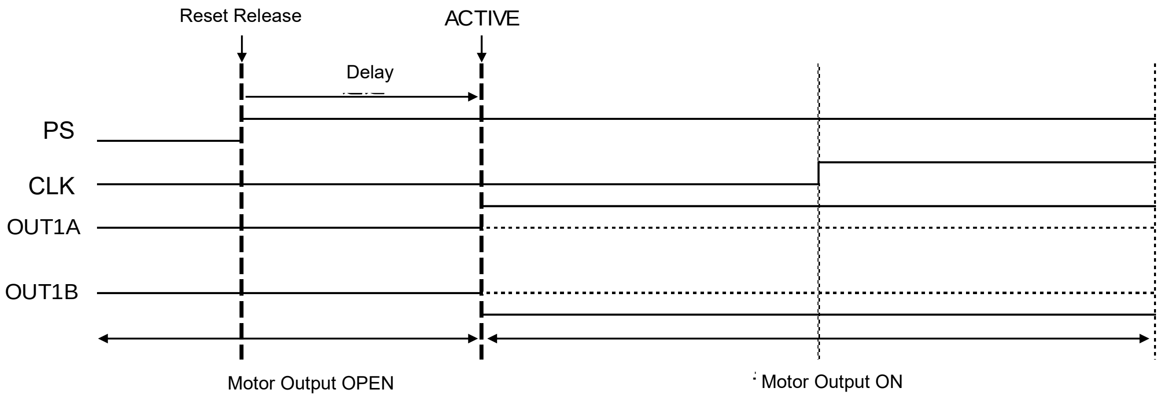
1 Reset Operation

The translator circuit is initialized by power ON reset function and PS pin.

1.1 Initializing operation when power supply is turned on

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

When the power supply is turned on, the power ON reset function operates in IC and initialized, but as long as PS = L, the motor output is in the OPEN state. After the power supply is turned on, because of changing PS = L→H, the motor output becomes ACTIVE state, and 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 100 µs (Max) until the motor output becomes ACTIVE state.



1.1.2 If power supply is turned on at PS = H

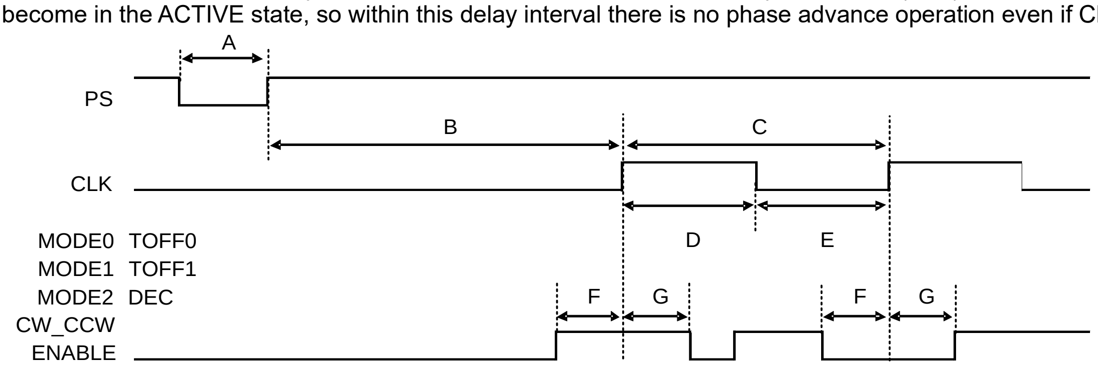
When the power supply is turned on, the power ON reset function in IC operates, and be initialized before the motor output becomes ACTIVE state during ENABLE = H, and excitation is started at the initial electrical angle.

1.2 Initializing operation during motor operation

When initializing the translator circuit during motor operation, input a reset signal to the PS pin (refer to page 15). But at the time of PS = L→H, it returns from standby state to normal state and there is a delay of 100 µs (Max) until the motor output becomes ACTIVE state, so within this delay interval there is no phase advance operation even if CLK is inputted.

2 Control Input Timing

Shown below is the operation of the translator circuit at the rising edge of the CLK signal. Not following this timing and input, then there is a possibility that the translator circuit does not operate as expected. In addition, at the time of PS = L→H, it returns from standby state to normal state and there is a delay of 100 µs (Max) until the motor output has become in the ACTIVE state, so within this delay interval there is no phase advance operation even if CLK is inputted.



A: PS minimum input L pulse width …. 20 µs
B: PS rising edge to CLK rising edge input possible maximum delay time …. 100 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, MODE2, CW_CCW, ENABLE, TOFF0, TOFF1, DEC set-up time …. 1 µs
G: MODE0, MODE1, MODE2, CW_CCW, ENABLE, TOFF0, TOFF1, DEC hold time …. 1 µs

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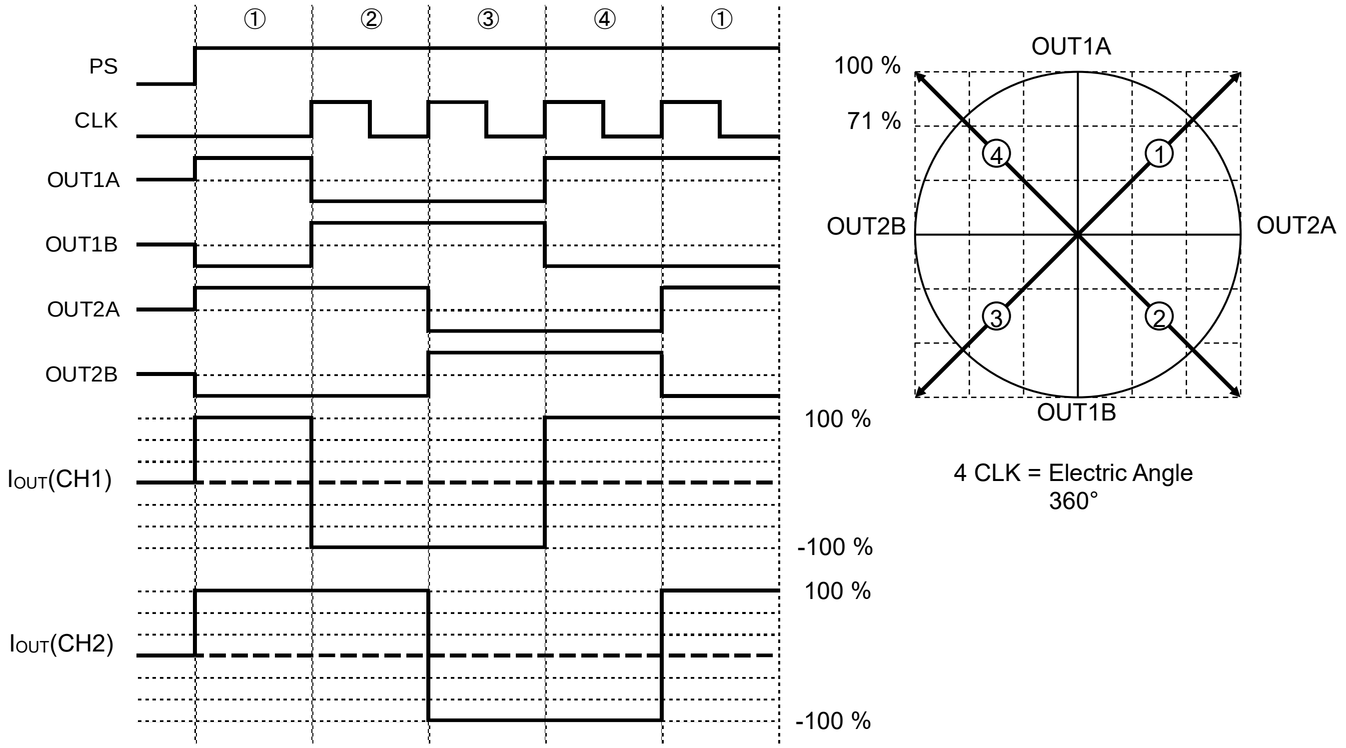
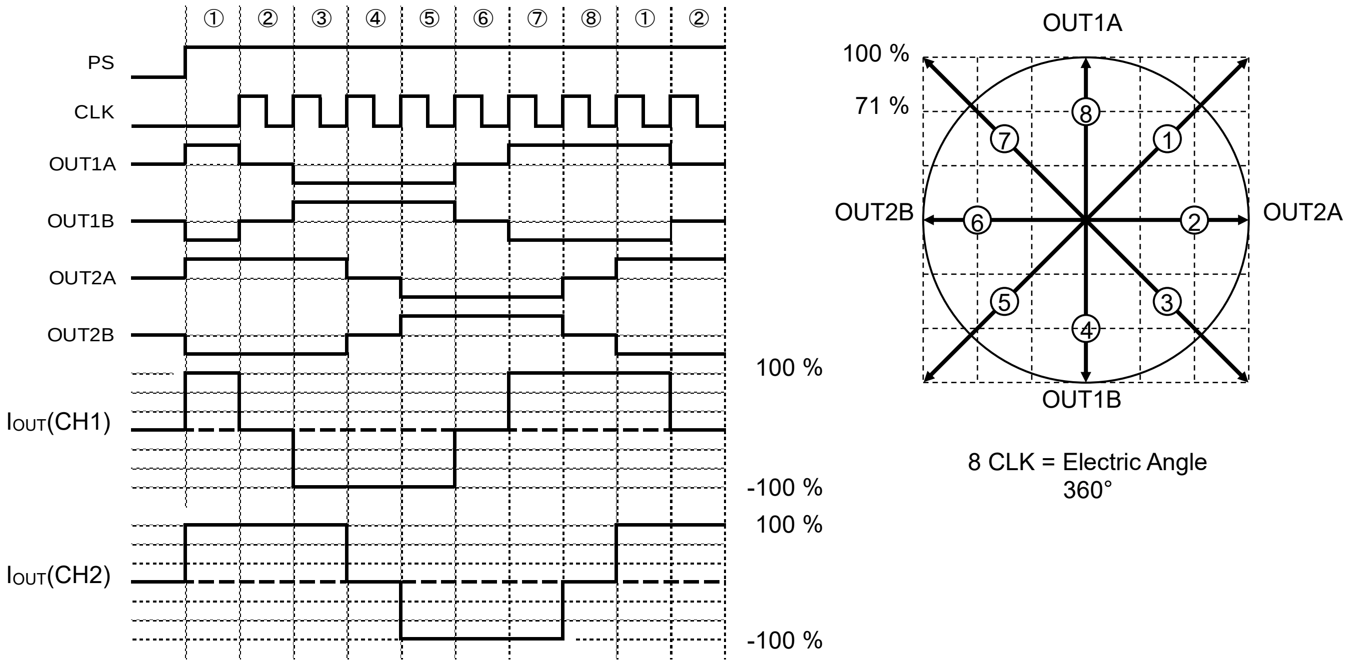
Translator Circuit Operation in CLK-IN Drive Mode – continued

3 FULL STEP A (MODE0 = L, MODE1 = L, MODE2 = L, CW_CCW = L, ENABLE = H, TOFF0 = L, TOFF1 = L, DEC = L)



4 HALF STEP A (MODE0 = H, MODE1 = L, MODE2 = L, CW_CCW = L, ENABLE = H, TOFF0 = L, TOFF1 = L, DEC = L)



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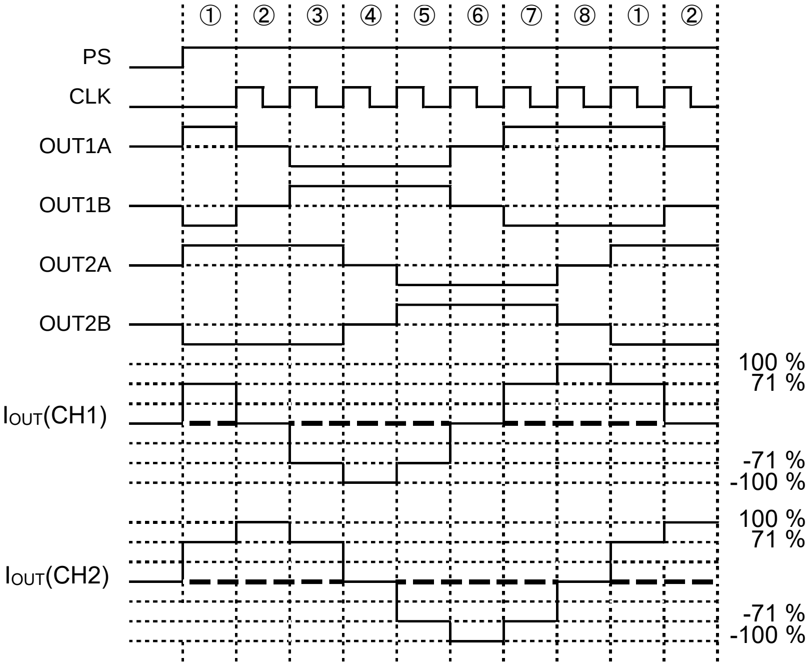
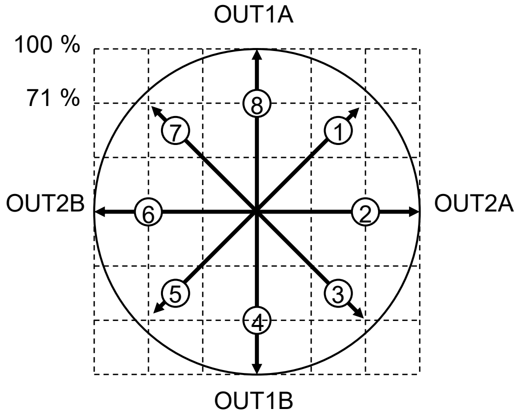
Translator Circuit Operation in CLK-IN Drive Mode – continued

5 **HALF STEP C (MODE0 = L, MODE1 = H, MODE2 = L, CW_CCW = L, ENABLE = H, TOFF0 = L, TOFF1 = L, DEC = L)**





8 CLK = Electric Angle 360°

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Translator Circuit Operation in CLK-IN Drive Mode – continued

6 Step Sequence Table (MODE2 = H, CW_CCW = L, initial electrical angle = step angle 45°)

	FULL STEP B	QUARTER STEP	1/8 STEP	1/16 STEP	CH1 CURRENT[%]	CH2 CURRENT[%]	STEP ANGLE[°]
		15	29	57	100.00	0.00	0.0
				58	99.52	9.80	5.6
			30	59	98.08	19.51	11.3
				60	95.69	29.03	16.9
		16	31	61	92.39	38.27	22.5
				62	88.19	47.14	28.1
			32	63	83.15	55.56	33.8
				64	77.30	63.44	39.4
Initial electrical angle→	1	1	1	1	71.71	71.71	45.0
				2	63.44	77.30	50.6
			2	3	55.56	83.15	56.3
				4	47.14	88.19	61.9
		2	3	5	38.27	92.39	67.5
				6	29.03	95.69	73.1
			4	7	19.51	98.08	78.8
				8	9.80	99.52	84.4
		3	5	9	0.00	100.00	90.0
				10	-9.80	99.52	95.6
			6	11	-19.51	98.08	101.3
				12	-29.03	95.69	106.9
		4	7	13	-38.27	92.39	112.5
				14	-47.14	88.19	118.1
			8	15	-55.56	83.15	123.8
				16	-63.44	77.30	129.4
	2	5	9	17	-71.71	71.71	135.0
				18	-77.30	63.44	140.6
			10	19	-83.15	55.56	146.3
				20	-88.19	47.14	151.9
		6	11	21	-92.39	38.27	157.5
				22	-95.69	29.03	163.1
			12	23	-98.08	19.51	168.8
				24	-99.52	9.80	174.4
		7	13	25	-100.00	0.00	180.0
				26	-99.52	-9.80	185.6
			14	27	-98.08	-19.51	191.3
				28	-95.69	-29.03	196.9
		8	15	29	-92.39	-38.27	202.5
				30	-88.19	-47.14	208.1
			16	31	-83.15	-55.56	213.8
				32	-77.30	-63.44	219.4
	3	9	17	33	-71.71	-71.71	225.0
				34	-63.44	-77.30	230.6
			18	35	-55.56	-83.15	236.3
				36	-47.14	-88.19	241.9
		10	19	37	-38.27	-92.39	247.5
				38	-29.03	-95.69	253.1
			20	39	-19.51	-98.08	258.8
				40	-9.80	-99.52	264.4
		11	21	41	0.00	-100.00	270.0
				42	9.80	-99.52	275.6
			22	43	19.51	-98.08	281.3
				44	29.03	-95.69	286.9
		12	23	45	38.27	-92.39	292.5
				46	47.14	-88.19	298.1
			24	47	55.56	-83.15	303.8
				48	63.44	-77.30	309.4
	4	13	25	49	71.71	-71.71	315.0
				50	77.30	-63.44	320.6
			26	51	83.15	-55.56	326.3
				52	88.19	-47.14	331.9
		14	27	53	92.39	-38.27	337.5
				54	95.69	-29.03	343.1
			28	55	98.08	-19.51	348.8
				56	99.52	-9.80	354.4

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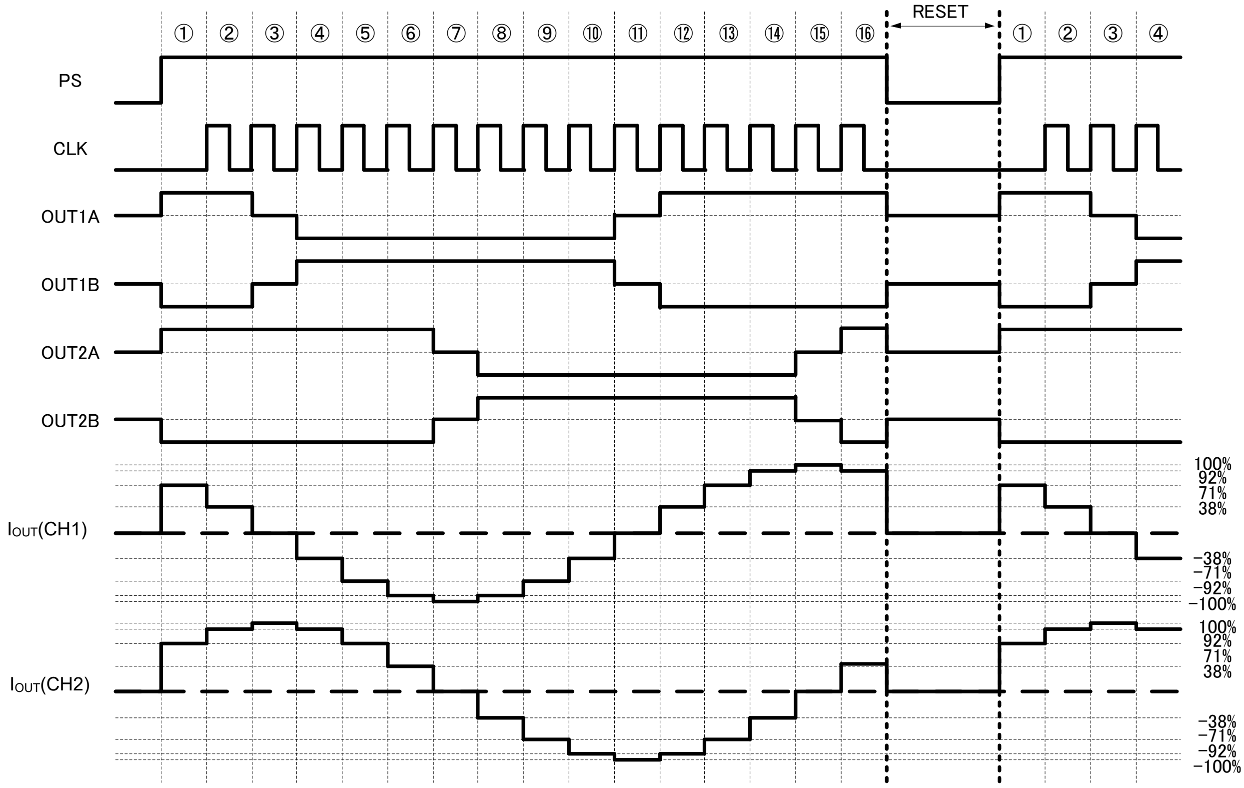
Translator Circuit Operation in CLK-IN Drive Mode – continued

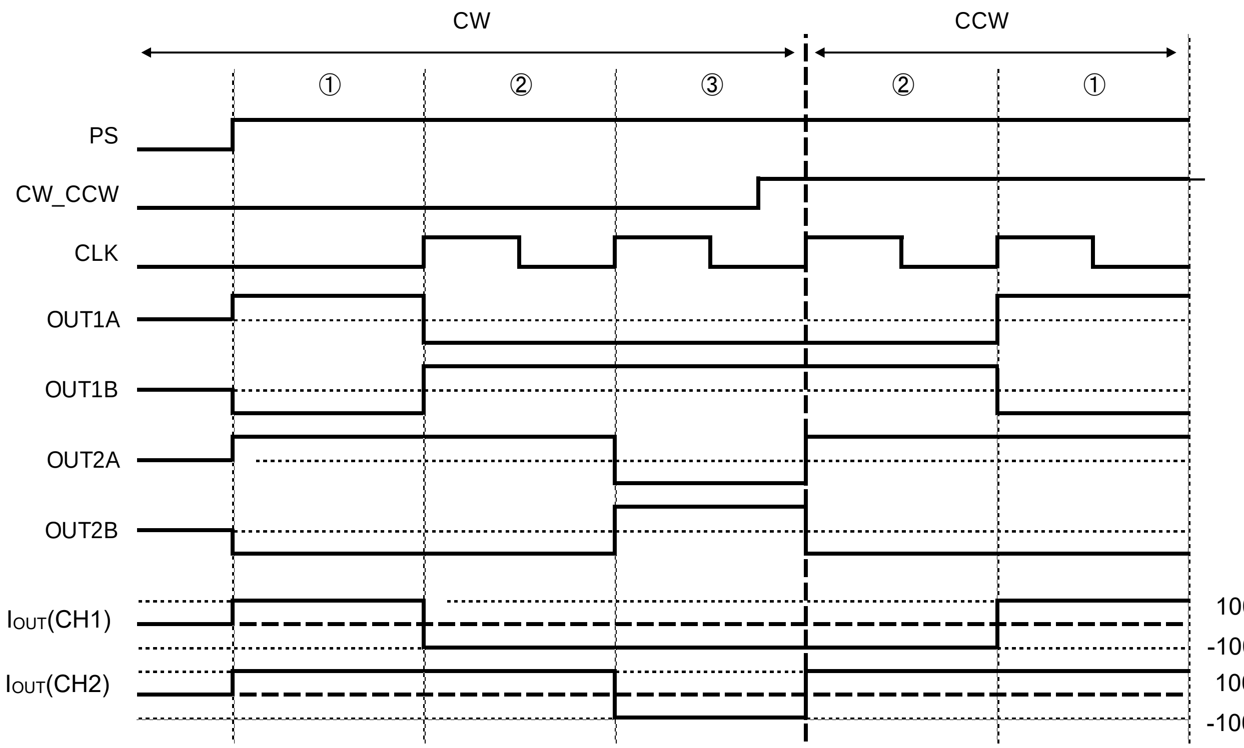
7 Reset Timing Chart (QUARTER STEP, CW_CCW = L, ENABLE = H)

To reset the translator circuit during motor operation regardless of the other input signals, make the PS pin input to L. At this time, the IC internal circuit enters standby mode and makes the motor output OPEN.



8 CW_CCW Switching Timing Chart (FULL STEP A, ENABLE = H)

The switch of CW_CCW is reflected by the rising edge of CLK that comes immediately after CW_CCW signal has changed. However, due to the operation state of motor during switch, motor may not act following control on driver IC side control and thereby lead to out-of-step or misstep, so evaluate the sequence of the switch enough.



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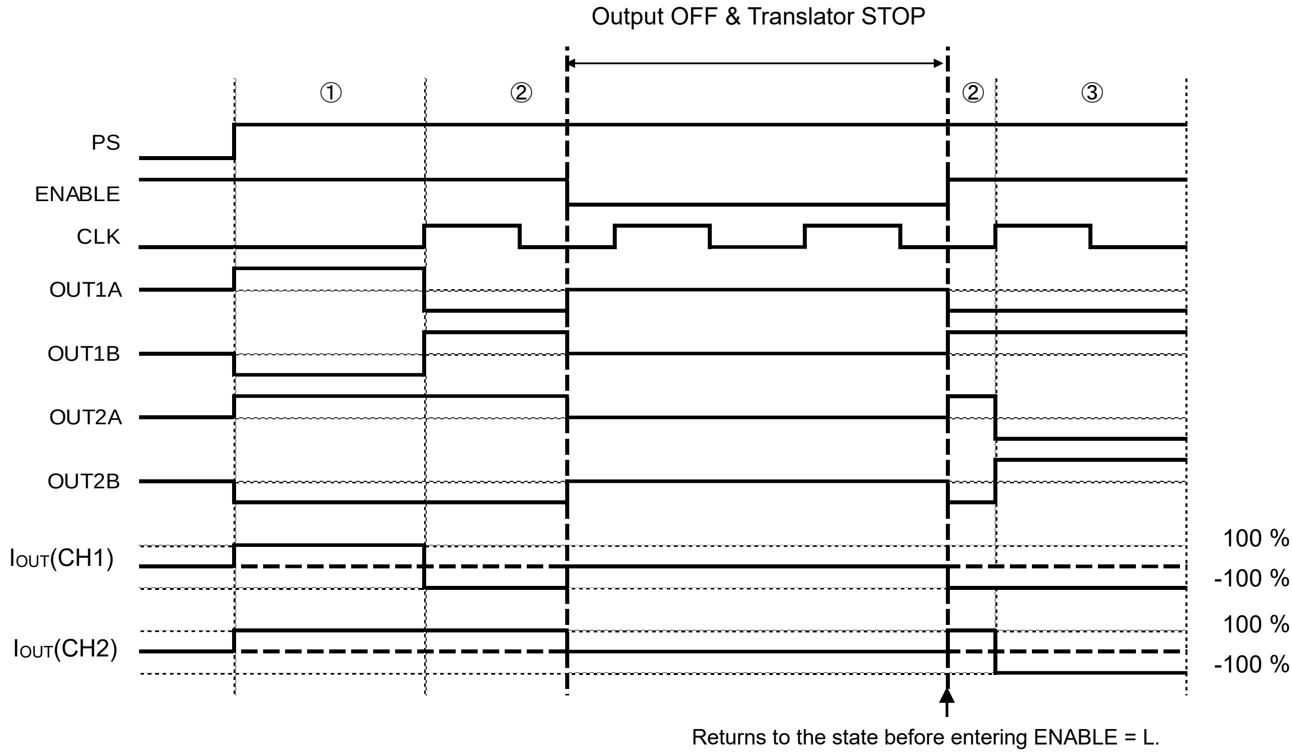
Translator Circuit Operation in CLK-IN Drive Mode – continued

9 ENABLE Switch Timing Chart (FULL STEP A)

The switch of the ENABLE signal is reflected by the change in the ENABLE signal regardless of other input signals. In the section of ENABLE = L, the motor output becomes OPEN and the CLK input is blocked, so translator circuit stops, and the electrical angle doesn't advance. Therefore, when returning from ENABLE = L→H, the output state returns immediately to the last state before the input of ENABLE = L. The excitation mode (MODE0, MODE1, MODE2) also switches within ENABLE = L interval, so if the excitation mode is switched in the ENABLE = L interval, restoring of ENABLE = L→H was done in the excitation mode after switch.



10 About the Switch of the Motor Excitation Mode

The switch of the excitation mode can be done regardless of the CLK signal at the same time as changing of the signal MODE0, MODE1, and MODE2. This product has a built-in function that prevents motor out-of-step caused by discrepancies of torque vector of transition excitations during switch between excitation modes. However, due to the operation state of motor during switch, motor may not act following control on driver IC side control, and thereby lead to out-of-step or misstep. Therefore, switch sequence shall be evaluated thoroughly before making any decision.

11 Precautions when switching both CW_CCW and Excitation Modes (MODE0, MODE1, MODE2)

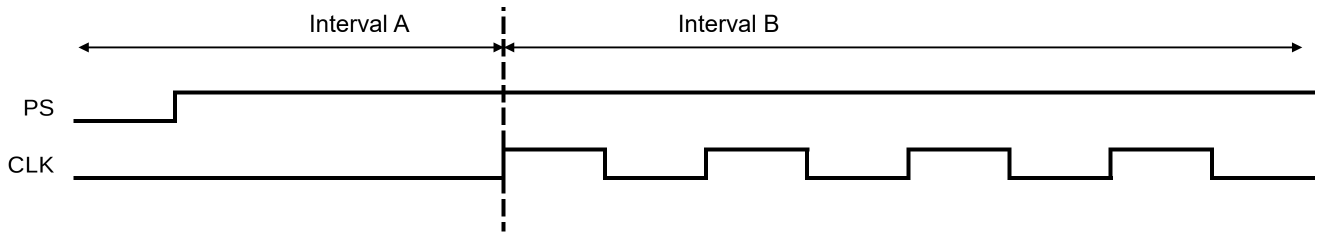
As shown in the figure below, the area between the end of reset release (PS = L→H) and beginning of the first CLK signal input is defined as interval A, while the area from the end of the first CLK signal input is defined as interval B.

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 a misstep (with one extra leading phase) or out-of-step.
Therefore, in case that CW_CCW and excitation mode are switched simultaneously, make sure to input a reset signal to the PS pin. Then start to operate in interval A before carrying out such switching mode.



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Temperature Monitoring Method

BD63717MUV has 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 experimentation purposes 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 for measuring the V_F voltage of the internal diode.

2. Measure the temperature characteristics of this pin voltage. (V_F has a linear negative temperature coefficient with respect to temperature). With the results of these temperature characteristics, chip temperature can be calibrated 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).

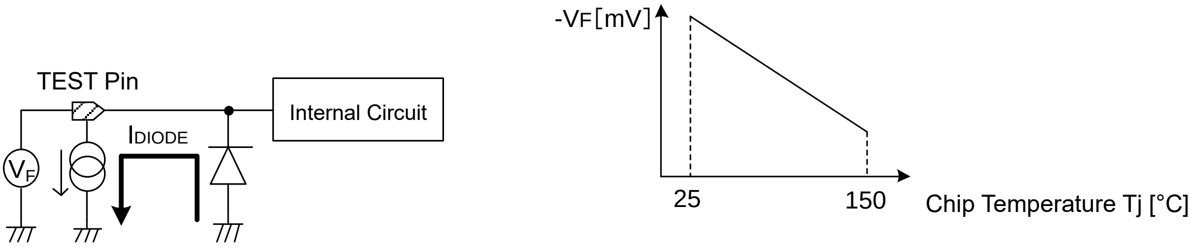

Figure 4. Model Diagram for Measuring Chip Temperature

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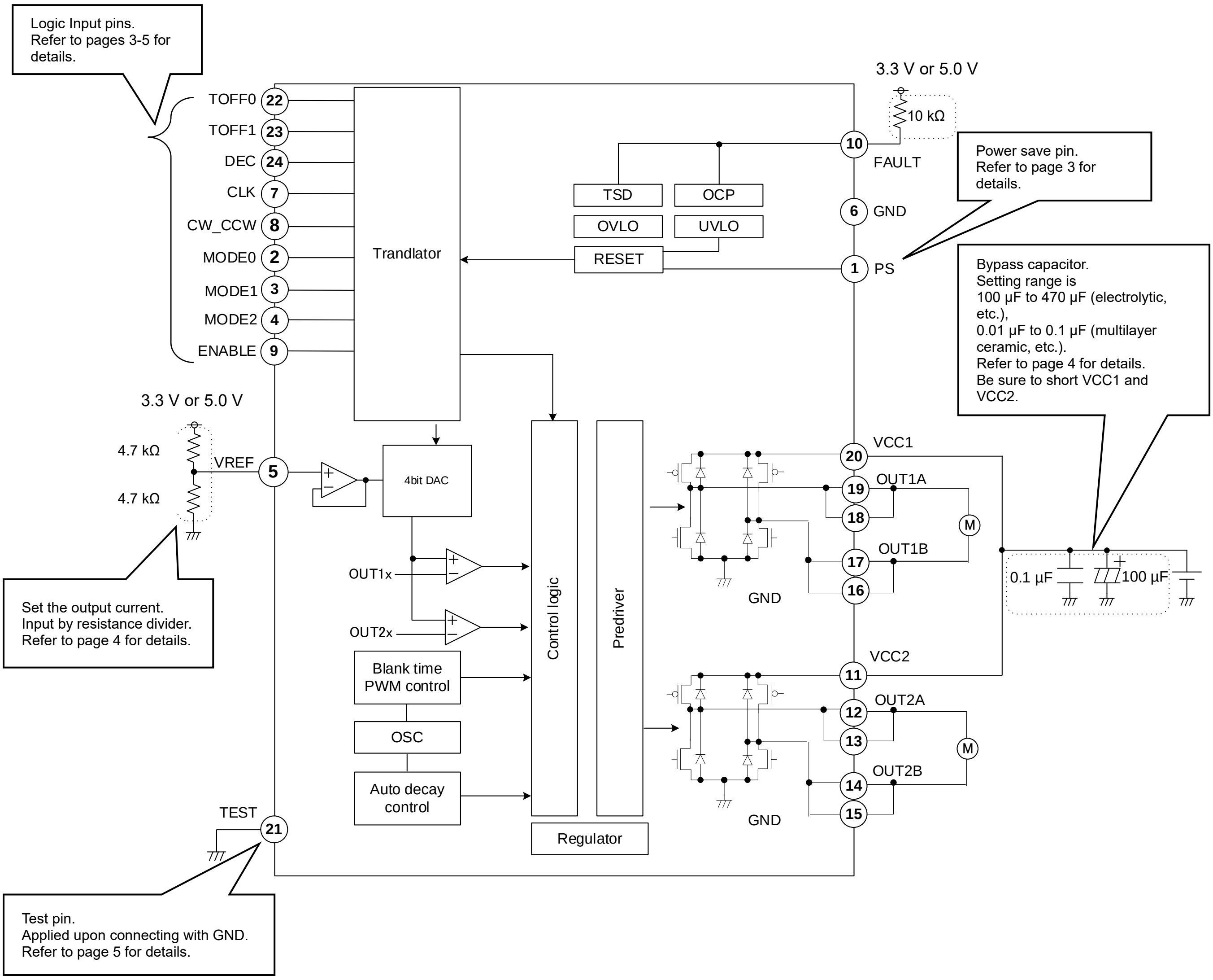
Application Example



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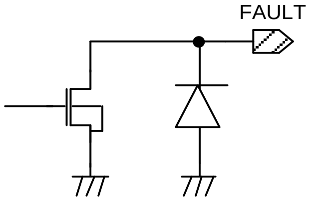
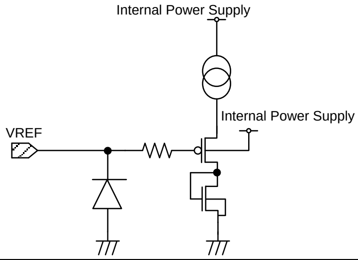
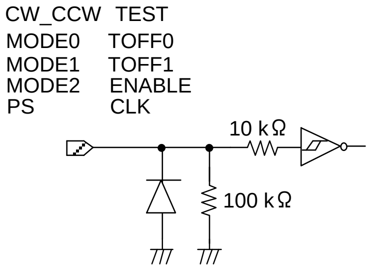
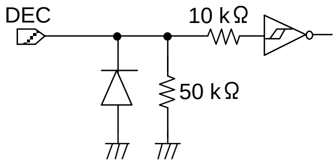
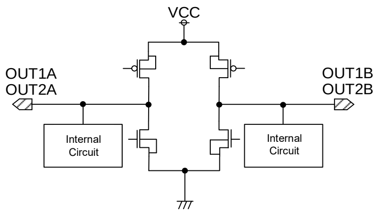
I/O Equivalence Circuit

No.	Pin Name	Equivalence Circuit	No.	Pin Name	Equivalence Circuit
10	FAULT		5	VREF	
1	PS		24	DEC	
7	CLK				
8	CW_CCW				
2	MODE0				
3	MODE1				
4	MODE2				
9	ENABLE				
21	TEST				
22	TOFF0				
23	TOFF1				
18,19	OUT1A				
16,17	OUT1B				
12,13	OUT2A				
14,15	OUT2B				

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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 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.

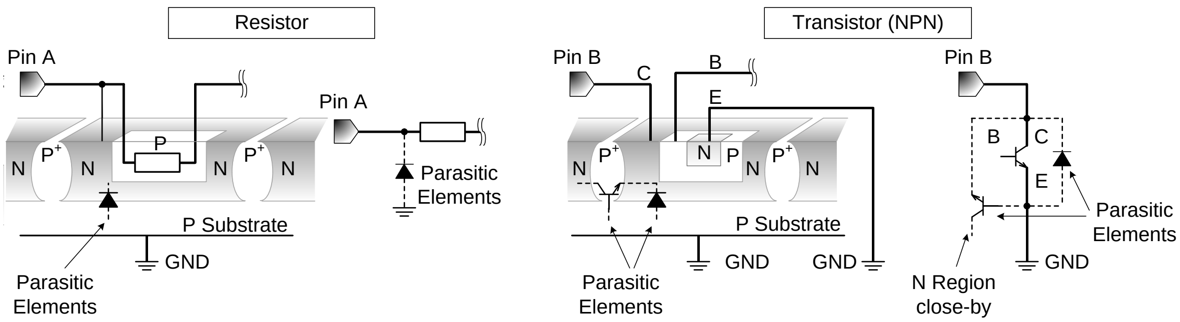

Figure 5. Example of Monolithic IC Structure

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 over current 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

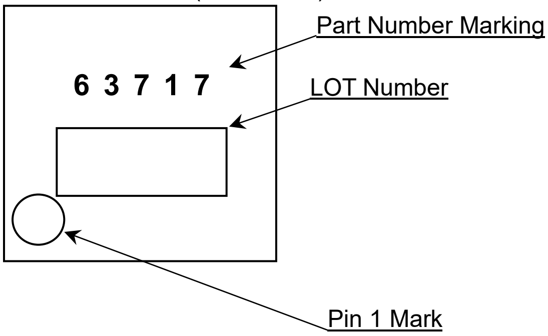
B D 6 3 7 1 7 M U V - E 2

Package
MUV: VQFN24AV4040

Packing and Forming Specification
E2: Embossed tape and reel

Marking Diagram

VQFN24AV4040 (TOP VIEW)



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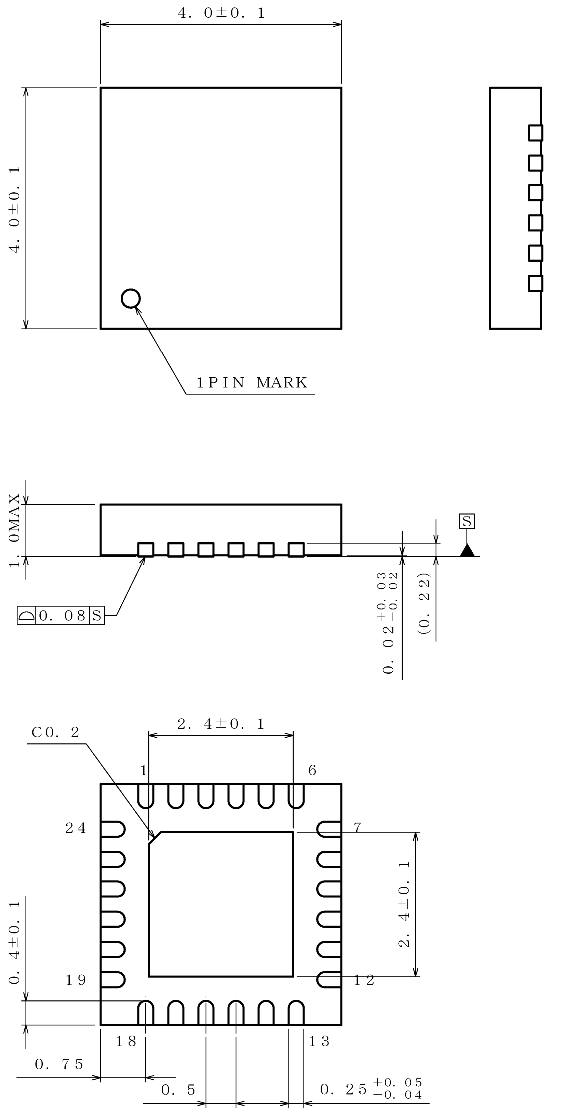
Physical Dimension and Packing Information

Package Name	VQFN24AV4040

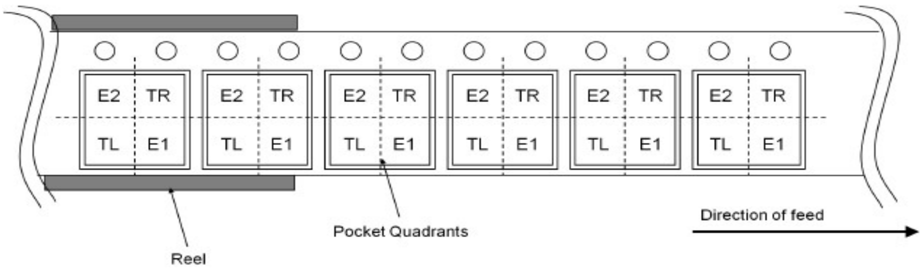


(UNIT : mm)

PKG : VQFN24AV4040
Drawing No. EX443−5001

< 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



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Revision History

Date	Version	Contents of Revision
01.Jul.2024	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.

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