Ordering number : ENA1563

SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

LV8746V — Bi-CMOS LSI PWM Constant-Current Control Stepping Motor Driver

Overview

The LV8746V is a stepping motor driver corresponding to the W1-2 aspect excitation drive that the selection of CLK-IN input and a parallel input is possible. It is ideally suited for driving brushed DC motors and stepping motors used in office equipment and amusement applications.

Features

- PWM current control stepping motor driver incorporated.
- BiCDMOS process IC
- Low on resistance (upper side : 0.84Ω ; lower side : 0.7Ω ; total of upper and lower : 1.54Ω ; Ta = 25°C, I_O = 1A)
- Excitation mode can be set to 2-phase, 1-2 phase Full torque, 1-2 phase, or W1-2 phase
- CLK-IN input and a parallel input can be selected.
- Motor current selectable in four steps
- Output short-circuit protection circuit (selectable from latch-type or auto-reset-type) incorporated
- Unusual condition warning output pins
- No control power supply required

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	VM max		38	V
Output peak current	I_O peak	tw ≤ 10ms, duty 20%	1.2	A
Output current	I_O max		1	A
Logic input voltage	V_{IN}		-0.3 to +6	V
EMO input voltage	Vemo		-0.3 to +6	V

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Parameter	Symbol	Conditions	Ratings	Unit
Allowable power dissipation	Pd max	Ta ≤ 85°C *	3.1	W
Operating temperature	Topr		-20 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

* Specified circuit board : 90.0mm×90.0mm×1.6mm, glass epoxy 2-layer board, with backside mounting.

Allowable Operating Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range	VM		9 to 35	V
Logic input voltage	V_{IN}		0 to 5.5	V
VREF input voltage range	VREF		0 to 3	V

Electrical Characteristics at Ta = 25°C, VM = 24V, VREF = 1.5V

Parameter		Symbol	Conditions	Ratings			Unit
				min	typ	max	
Standby mode current drain		IMst	ST = "L"		190	300	μA
Current drain		IM	ST = "H", OE = "L", with no load		3.3	5	mA
VREG5 output voltage		Vreg5	I_O = -1mA	4.5	5	5.5	V
Thermal shutdown temperature		TSD	Design guarantee	150	180	210	°C
Thermal hysteresis width		ΔTSD	Design guarantee		40		°C
Motor driver							
Output on resistance		Ronu	I_O = 1A, Upper-side on resistance		0.84	1.1	Ω
		Rond	I_O = 1A, Lower-side on resistance		0.7	0.9	Ω
Output leakage current		$I_O$leak				50	μA
Diode forward voltage		VD	ID = -1A		1.0	1.3	V
Logic pin input current(ST)		I_{IN}L	V_{IN} = 0.8V	3	8	15	μA
		I_{IN}H	V_{IN} = 5V	50	78	110	μA
Logic pin input current(other ST)		I_{IN}L	V_{IN} = 0.8V	3	8	15	μA
		I_{IN}H	V_{IN} = 5V	30	50	70	μA
Logic high-level input voltage		V_{IN}H		2.0			V
Logic low-level input voltage		V_{IN}L				0.8	V
Current setting comparator threshold voltage (CLK-IN input)	W1-2-phase drive	Vtdac0_W	Step 0 (When initialized : channel 1 comparator level)	0.29	0.3	0.31	V
		Vtdac1_W	Step 1 (Initial state+1)	0.29	0.3	0.31	V
		Vtdac2_W	Step 2 (Initial state+2)	0.185	0.2	0.215	V
		Vtdac3_W	Step 3 (Initial state+3)	0.09	0.1	0.11	V
	1-2 phase drive	Vtdac0_M	Step 0 (When initialized : channel 1 comparator level)	0.29	0.3	0.31	V
		Vtdac2_M	Step 2 (Initial state+1)	0.185	0.2	0.215	V
	1-2 phase drive (Full torque)	Vtdac0_H	Step 0 (When initialized : channel 1 comparator level)	0.29	0.3	0.31	V
		Vtdac2_H	Step 2 (Initial state+1)	0.29	0.3	0.31	V
	2 phase drive	Vtdac2_F	Step 2	0.29	0.3	0.31	V
Current setting comparator threshold voltage (parallel input)		Vtdac11	I01 = H , I11 = H	0.29	0.3	0.31	V
		Vtdac01	I01 = L , I11 = H	0.185	0.2	0.215	V
		Vtdac10	I01 = H , I11 = L	0.09	0.1	0.11	V
Current setting comparator threshold voltage (current attenuation rate switching)		Vtatt00	ATT1 = L, ATT2 = L	0.29	0.3	0.31	V
		Vtatt01	ATT1 = H, ATT2 = L	0.185	0.2	0.215	V
		Vtatt10	ATT1 = L, ATT2 = H	0.135	0.15	0.165	V
		Vtatt11	ATT1 = H, ATT2 = H	0.09	0.1	0.11	V
Chopping frequency		Fchop	Rchop = 20KΩ	45	62.5	75	kHz
VREF pin input current		Iref	VREF = 1.5V	-0.5			μA

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Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Charge pump						
VG output voltage	VG		28	28.75	30	V
Rise time	tONG	VG = 0.1μF			0.5	mS
Oscillator frequency	Fosc	Rchop = 20KΩ	90	125	150	kHz
Output short-circuit protection						
EMO pin saturation voltage	Vsatemo	Iemo = 1mA		80	160	mV
CEM pin charge current	Icem	Vcem = 0V	7	10	13	μA
CEM pin threshold voltage	Vthcem		0.8	1.0	1.2	V

Package Dimensions

unit : mm (typ)

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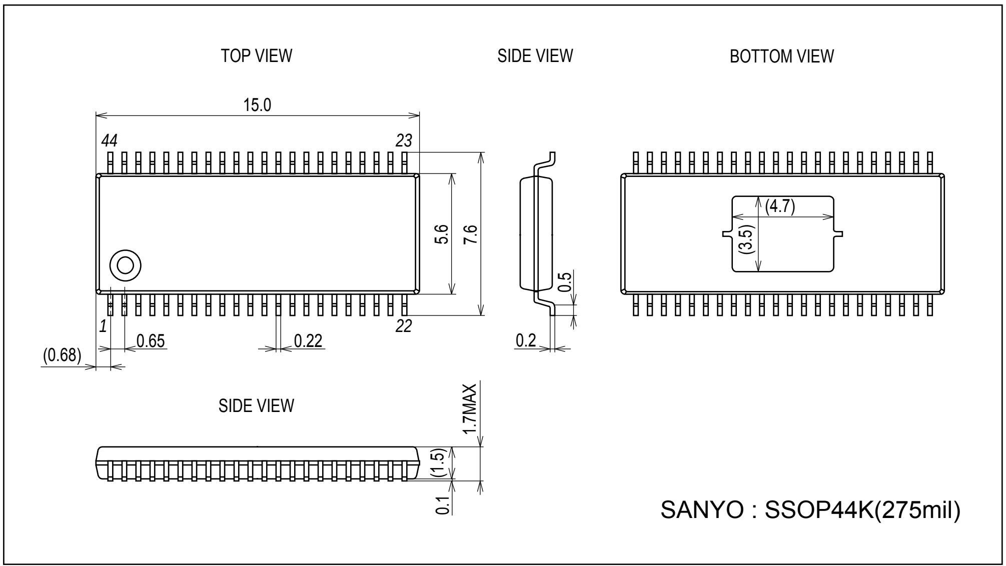
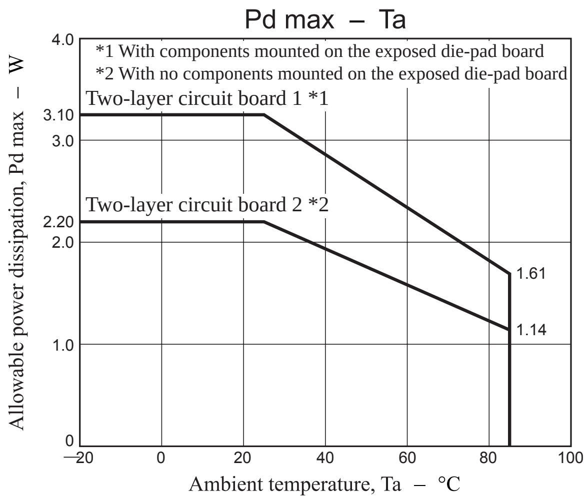
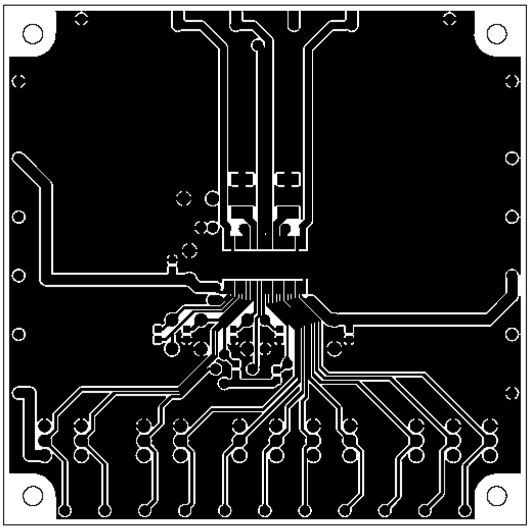
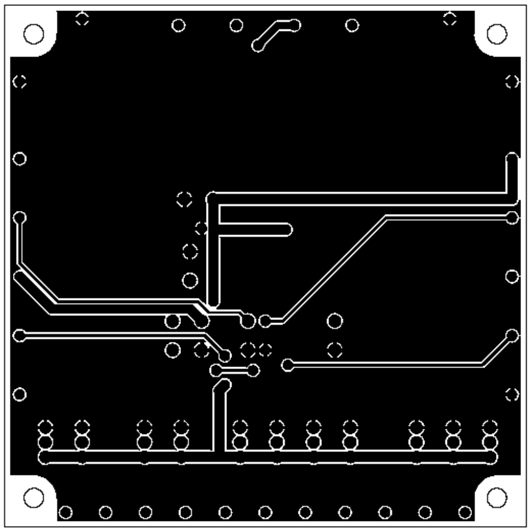




Substrate Specifications (Substrate recommended for operation of LV8746V)

Size	: 90mm × 90mm × 1.6mm (two-layer substrate [2S0P])
Material	: Glass epoxy
Copper wiring density	: L1 = 85% / L2 = 90%


L1 : Copper wiring pattern diagram


L2 : Copper wiring pattern diagram

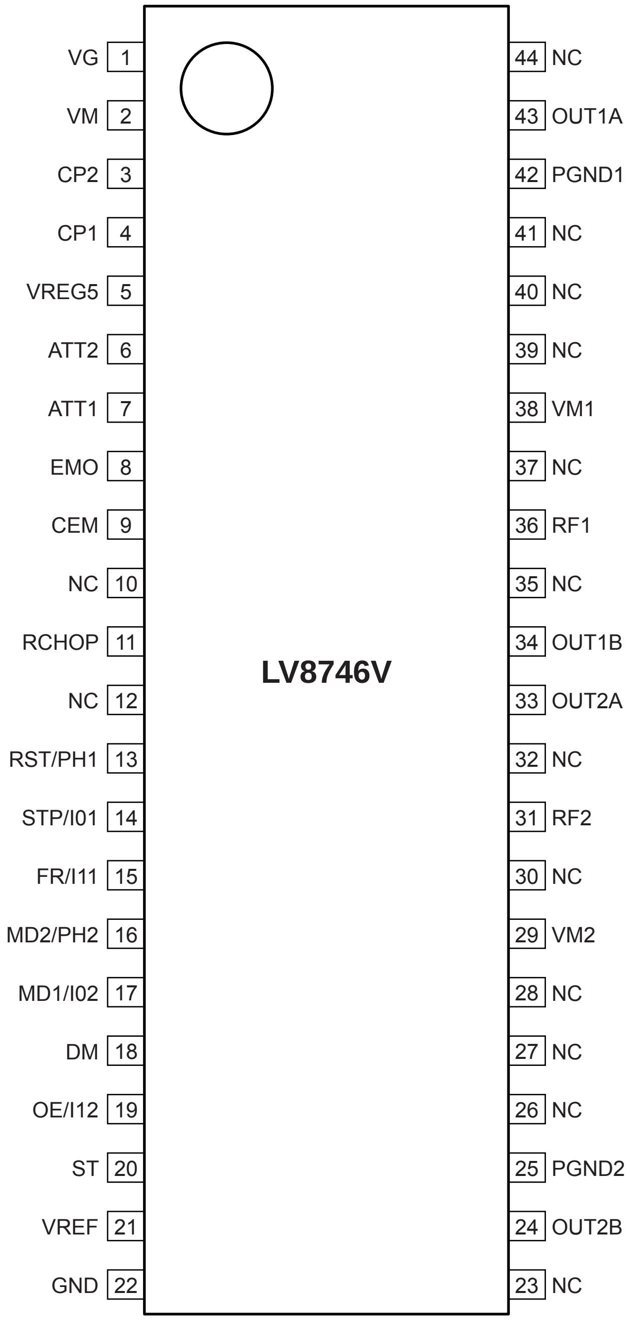
Cautions

1) The data for the case with the Exposed Die-Pad substrate mounted shows the values when 90% or more of the Exposed Die-Pad is wet.

2) For the set design, employ the derating design with sufficient margin.
Stresses to be derated include the voltage, current, junction temperature, power loss, and mechanical stresses such as vibration, impact, and tension.
Accordingly, the design must ensure these stresses to be as low or small as possible.
The guideline for ordinary derating is shown below :
(1)Maximum value 80% or less for the voltage rating
(2)Maximum value 80% or less for the current rating
(3)Maximum value 80% or less for the temperature rating

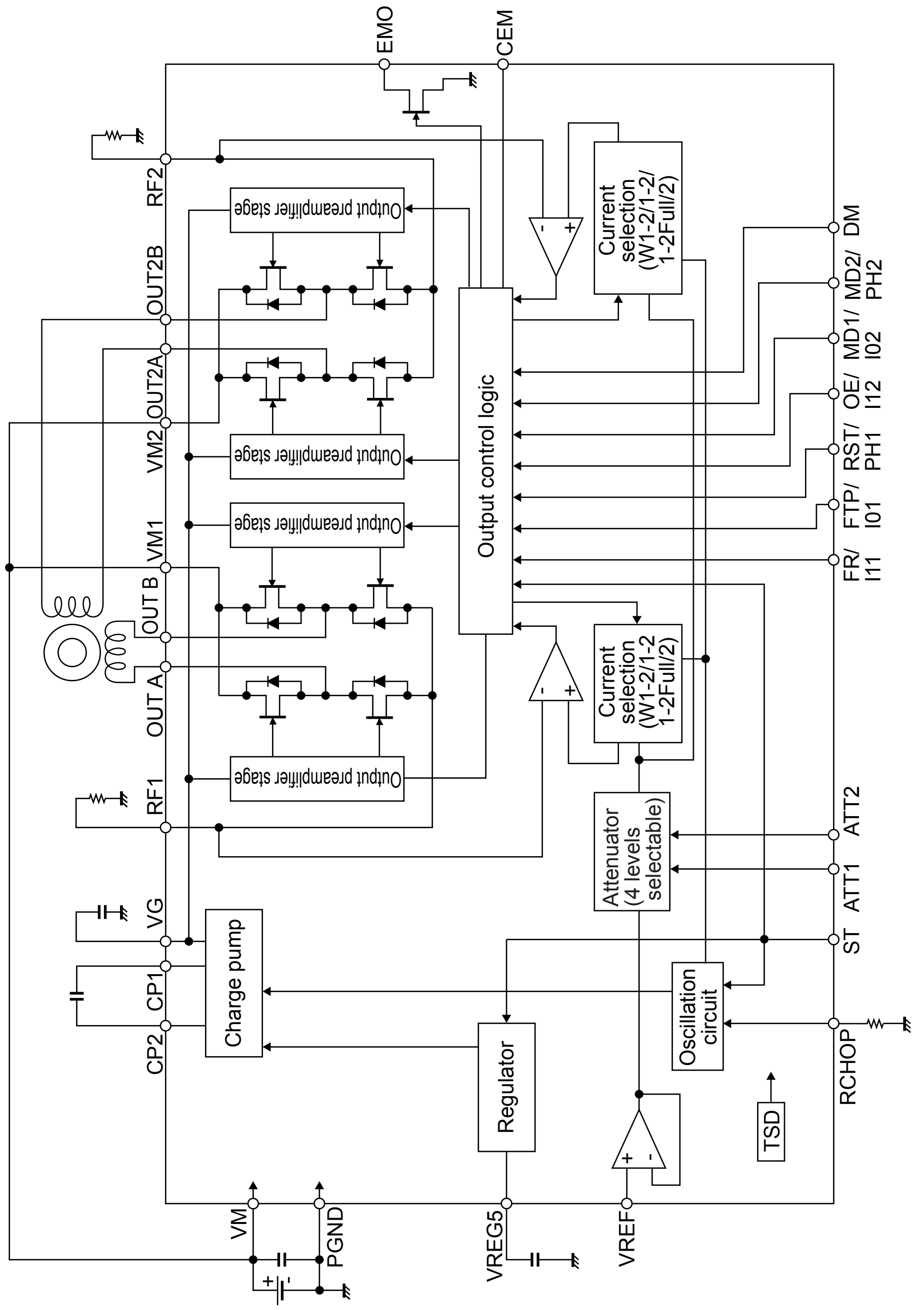
3) After the set design, be sure to verify the design with the actual product.
Confirm the solder joint state and verify also the reliability of solder joint for the Exposed Die-Pad, etc.
Any void or deterioration, if observed in the solder joint of these parts, causes deteriorated thermal conduction, possibly resulting in thermal destruction of IC.

Pin Assignment

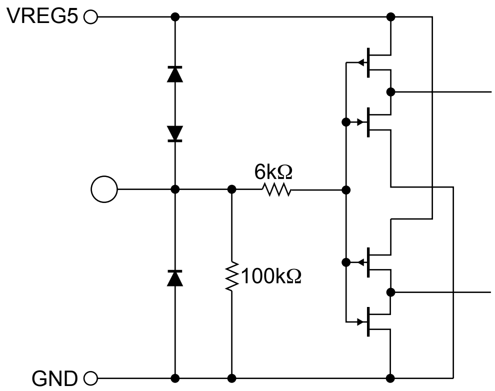
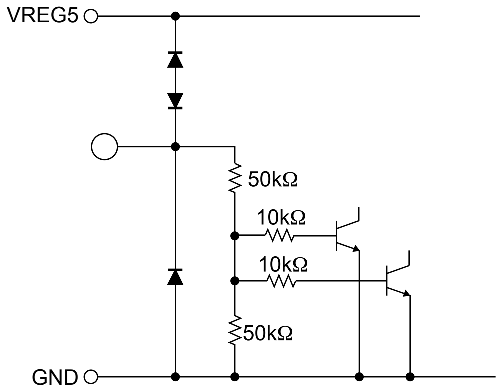
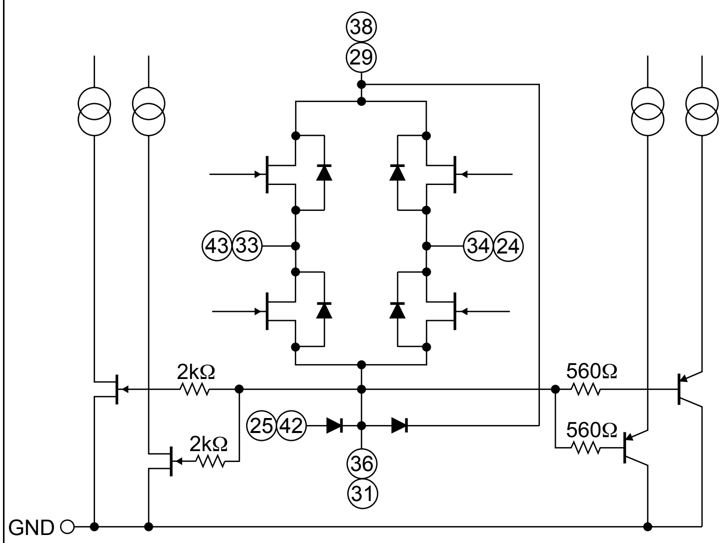


Top view

Block Diagram



Pin Functions

Pin No.	Pin Name	Pin Functction	Equivalent Circuit
6	ATT2	Motor holding current switching pin.	
7	ATT1	Motor holding current switching pin.	
13	RST/PH1	CLK-IN is input , RESET input pin / Parallel is input , Channel 1 forward/reverse rotation pin.	
14	STP/I01	CLK-IN is input , STEP signal input pin / Parallel is input , Channel 1 output control input pin.	
15	FR/I11	CLK-IN is input , forward/reverse signal input pin / Parallel is input , Channel 1 output control input pin.	
16	MD2/PH2	CLK-IN is input , Excitation mode switching pin / Parallel is input , Channel 2 forward/reverse rotation pin.	
17	MD1/I02	CLK-IN is input , Excitation mode switching pin / Parallel is input , Channel 2 output control input pin.	
18	DM	Drive mode switching pin.	
19	OE/I12	CLK-IN is input , output enable signal input pin / Parallel is input , Channel 2 output control input pin.	
20	ST	Chip enable pin.	
24	OUT2B	Channel 2 OUTB output pin.	
25	PGND2	Power system ground pin2.	
42	PGND1	Power system ground pin1.	
29	VM2	Channel 2 motor power supply connection pin.	
31	RF2	Channel 2 current-sense resistor connection pin.	
33	OUT2A	Channel 2 OUTA output pin.	
34	OUT1B	Channel 1 OUTB output pin.	
36	RF1	Channel 1 current-sense resistor connection pin.	
38	VM1	Channel 1 motor power supply pin.	
43	OUT1A	Channel 1 OUTA output pin.	

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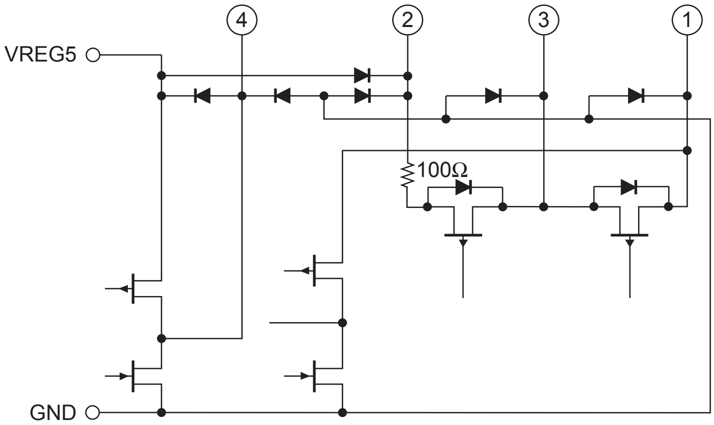
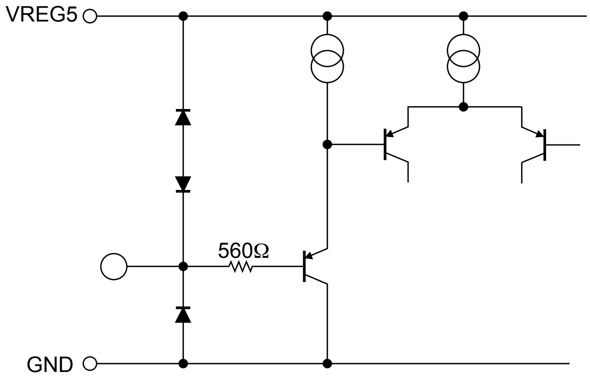
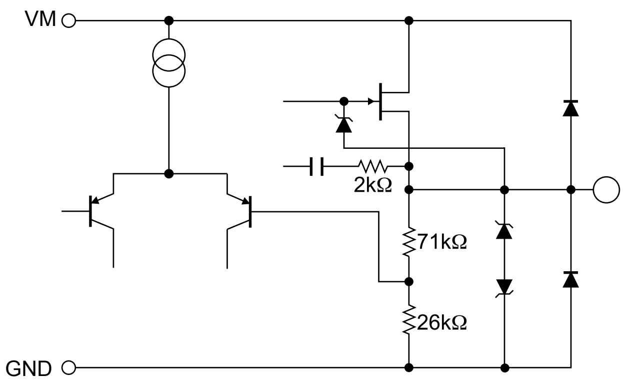
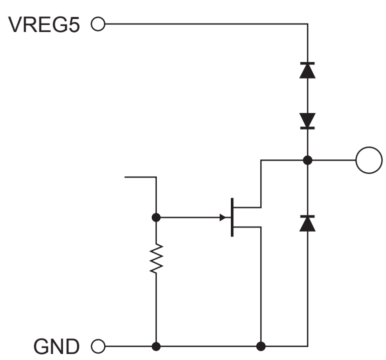
Pin No.	Pin Name	Pin Functtion	Equivalent Circuit
1 2 3 4	VG VM CP2 CP1	Charge pump capacitor connection pin. Motor power supply connection pin. Charge pump capacitor connection pin. Charge pump capacitor connection pin.	
21	VREF	Constant current control reference voltage input pin.	
5	VREG5	Internal power supply capacitor connection pin.	
8	EMO	Output short-circuit state warning output pin.	

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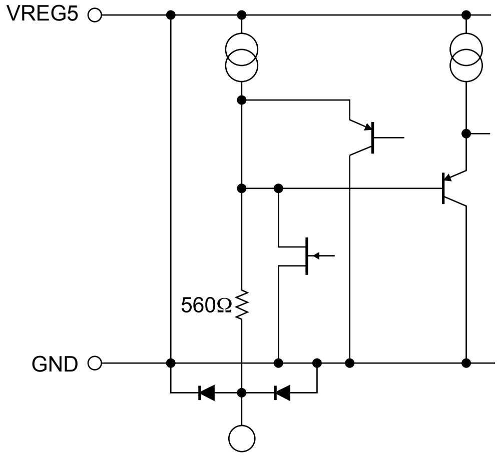
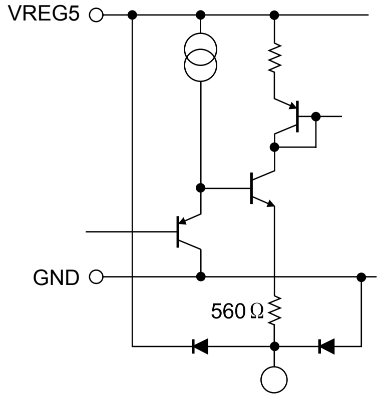
Pin No.	Pin Name	Pin Functtion	Equivalent Circuit
9	CEM	Pin to connect the output short-circuit state detection time setting capacitor.	
11	RCHOP	Chopping frequency setting resistor connection pin.	
22	GND	Ground.	
10,12 23,26 27,28 30,32 35,37 39,40 41,44	NC	No Connection (No internal connection to the IC)	

Description of operation

Input Pin Function

(1) Chip enable function

This IC is switched between standby and operating mode by setting the ST pin. In standby mode, the IC is set to power-save mode and all logic is reset. In addition, the internal regulator circuit and charge pump circuit do not operate in standby mode.

ST	Mode	Internal regulator	Charge pump
Low or Open	Standby mode	Standby	Standby
High	Operating mode	Operating	Operating

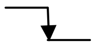
(2) Input control method switching pin function

The IC input control method is switched by setting the DM pin. The CLK-IN input control and the parallel input control can be selected by setting the DM pin.

DM	Input control method
Low or Open	CLK-IN input control
High	Parallel input control

CLK-IN input control (DM = Low or Open)

(1) STEP pin function

Input		Operating mode
ST	STP	
Low	*	Standby mode
High		Excitation step proceeds
High		Excitation step is kept

(2) Excitation mode setting function

MD1	MD2	Excitation mode	Initial position	
			Channel 1	Channel 2
Low	Low	2 phase excitation	100%	-100%
High	Low	1-2 phase excitation (Full torque)	100%	0%
Low	High	1-2 phase excitation	100%	0%
High	High	W1-2 phase excitation	100%	0%

This is the initial position of each excitation mode in the initial state after power-on and when the counter is reset.

(3) Setting constant-current control reference voltage

ATT1	ATT2	Current setting reference voltage
Low	Low	VREF / 5 x 100%
High	Low	VREF / 5 x 67%
Low	High	VREF / 5 x 50%
High	High	VREF / 5 x 33%

The voltage input to the VREF pin can be switched to four-step settings depending on the statuses of the two inputs, ATT1 and ATT2. This is effective for reducing power consumption when motor holding current is supplied.

Set current value calculation method.

The reference voltage is set by the voltage applied to the VREF pin and the two inputs ATT1 and ATT2. The output current (output current at a constant-current drive current ratio of 100%) can be set from this reference voltage and the RF resistance value.

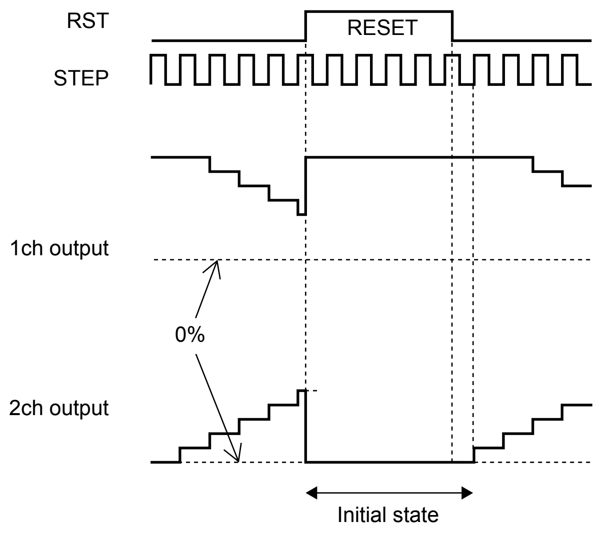
$$I_{OUT} = (VREF/5) \times (\text{current attenuation ratio}) / \text{RF resistance}$$

Example : At VREF of 1.5V, a reference voltage setting of 100% [(ATT1, ATT2) = (L, L)] and an RF resistance of 0.5Ω, the output current is set as shown below.

$$I_{OUT} = 1.5V/5 \times 100\%/0.5\Omega = 0.6A$$

(4) Reset function

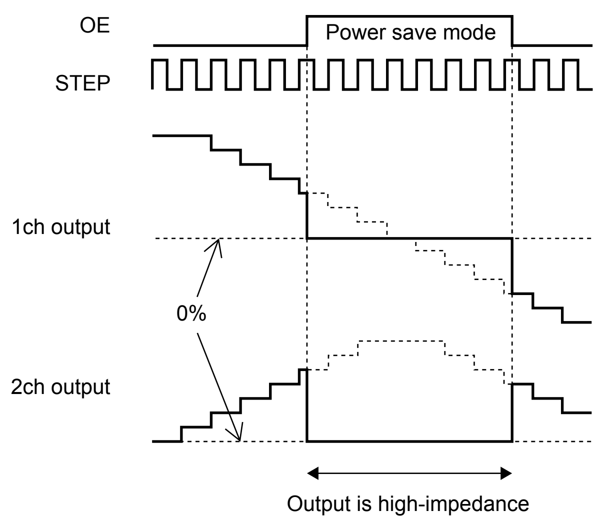
RST	Operating mode
Low	Normal operation
High	Reset state



When the RST pin is set to High, the excitation position of the output is forcibly set to the initial state. When RST is then set to Low, the excitation position is advanced by the next STEP input.

(5) Output enable function

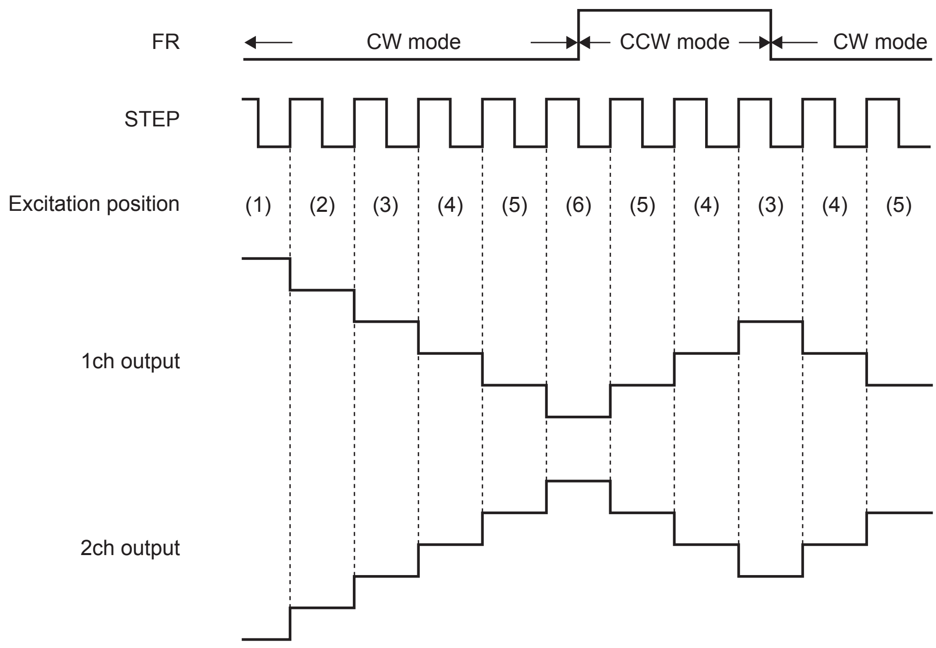
OE	Operating mode
Low	Output ON
High	Output OFF



When the OE pin is set High, the output is forced OFF and goes to high impedance.
However, the internal logic circuits are operating, so the excitation position proceeds when the STEP signal is input. Therefore, when OE is returned to Low, the output level conforms to the excitation position proceeded by the STEP input.

(6) Forward/reverse switching function

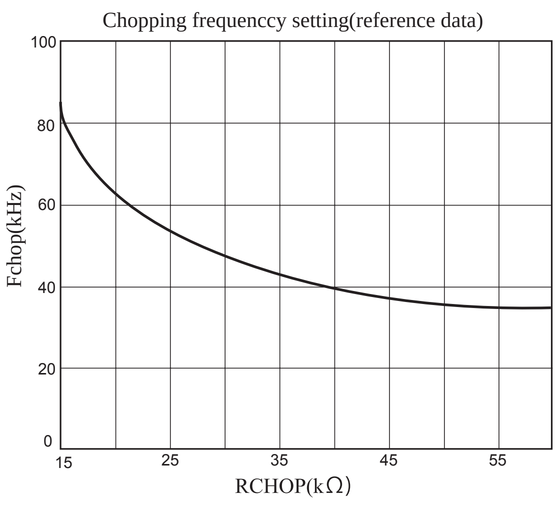
FR	Operating mode
Low	CW
High	CCW



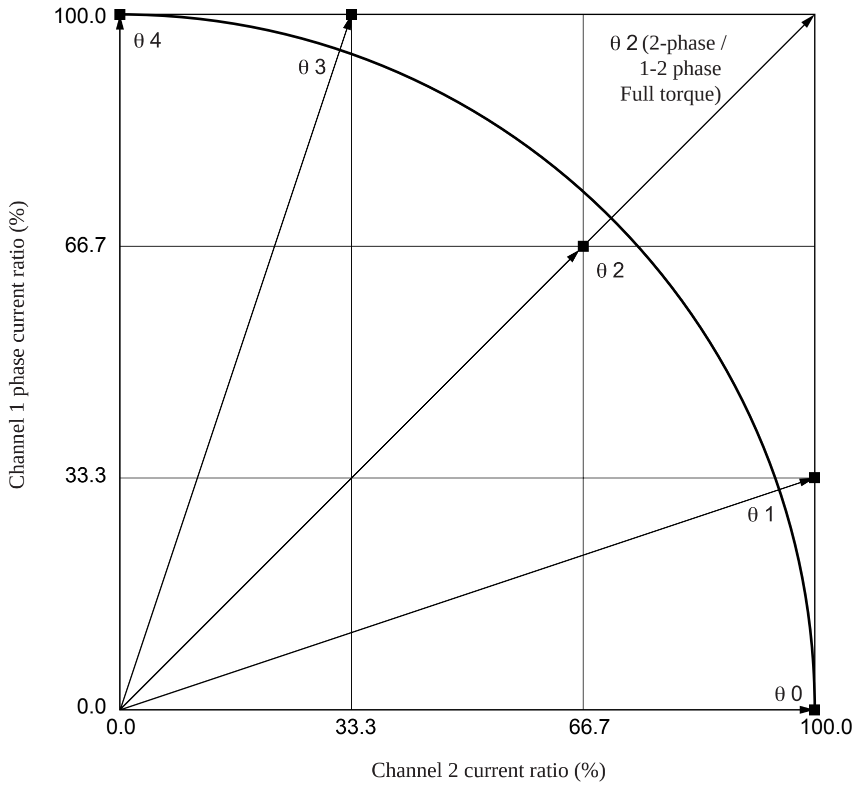
The internal D/A converter proceeds by one bit at the rising edge of the input STEP pulse.
In addition, CW and CCW mode are switched by setting the FR pin.
In CW mode, the channel 2 current phase is delayed by 90° relative to the channel 1 current.
In CCW mode, the channel 2 current phase is advanced by 90° relative to the channel 1 current.

(7) Chopping frequency setting

For constant-current control, chopping operation is made with the frequency determined by the external resistor
The chopping frequency to be set with the resistance connected to the RCHOP pin (pin 11) is as shown below.



(8) Output current vector locus (one step is normalized to 90 degrees)

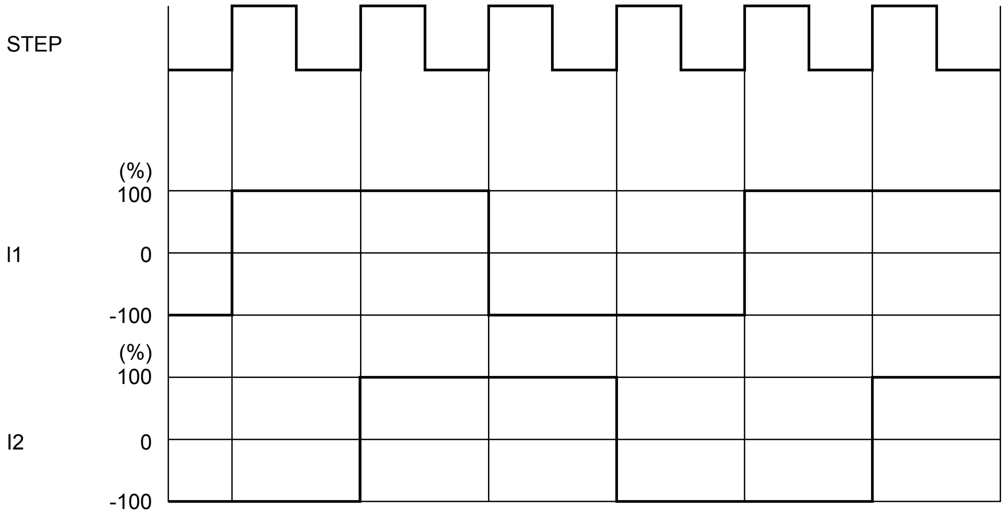


Setting current ration in each excitation mode

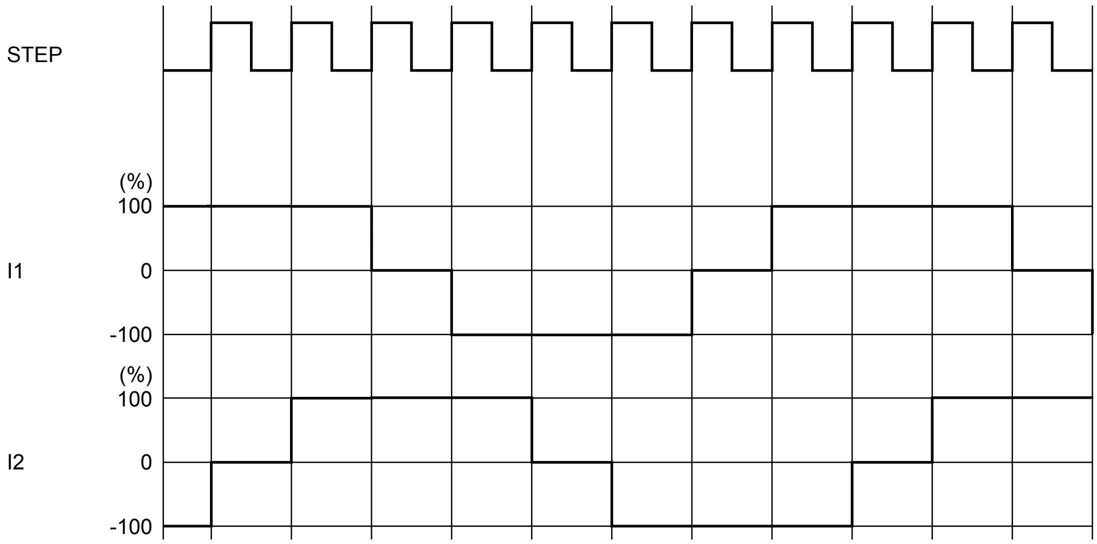
STEP	W1-2 phase (%)		1-2 phase (%)		1-2 phase full torque (%)		2-phase (%)	
	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2
θ0	0	100	0	100	0	100		
θ1	33.3	100						
θ2	66.7	66.7	66.7	66.7	100	100	100	100
θ3	100	33.3						
θ4	100	0	100	0	100	0		

(9) Typical current waveform in each excitation mode

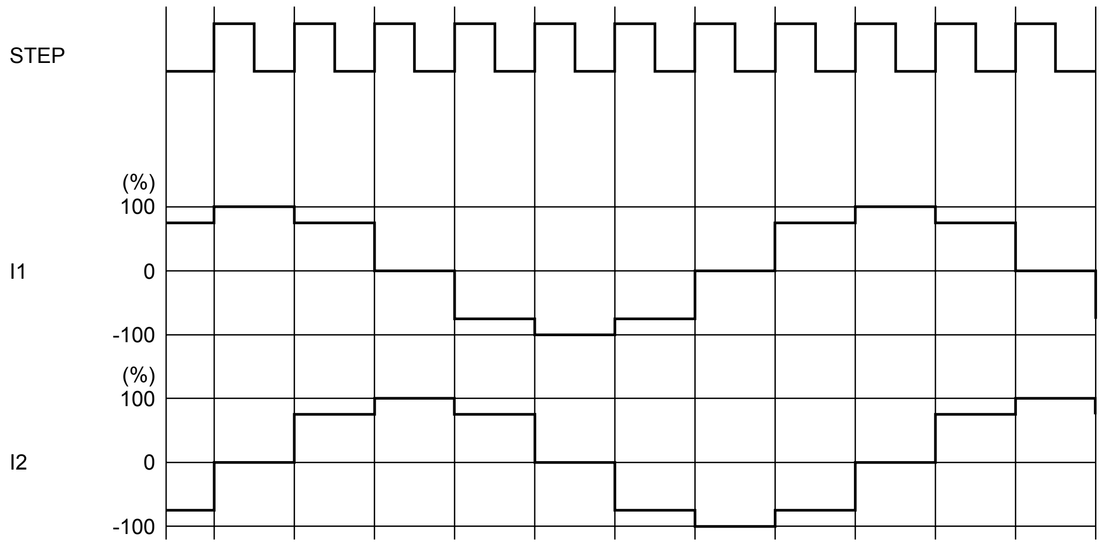
2-phase excitation (CW mode)



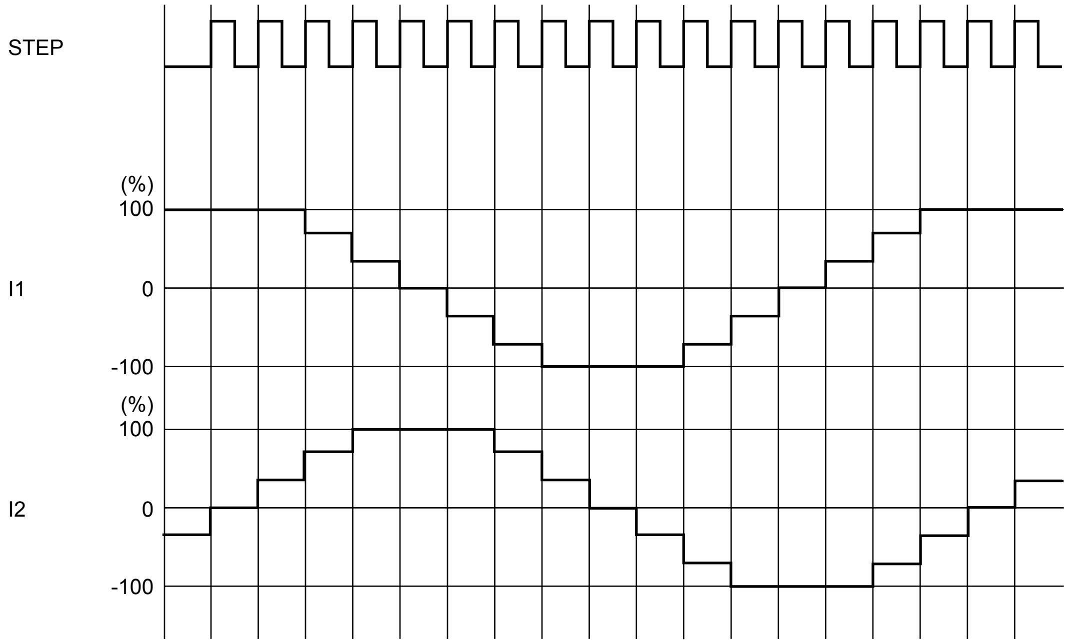
1-2 phase excitation Full torque (CW mode)



1-2 phase excitation Full torque (CW mode)

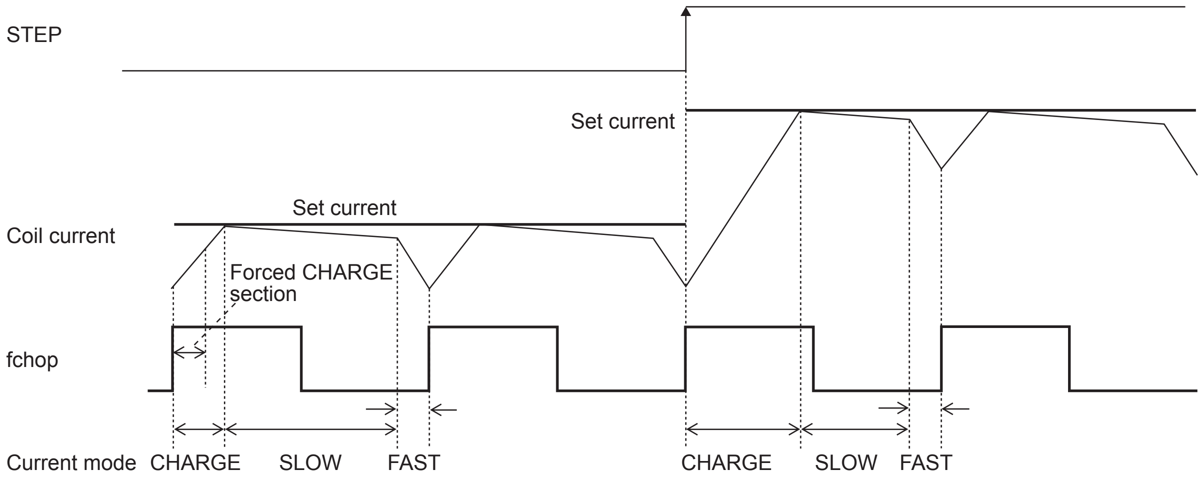


W1-2 phase excitation (CW mode)

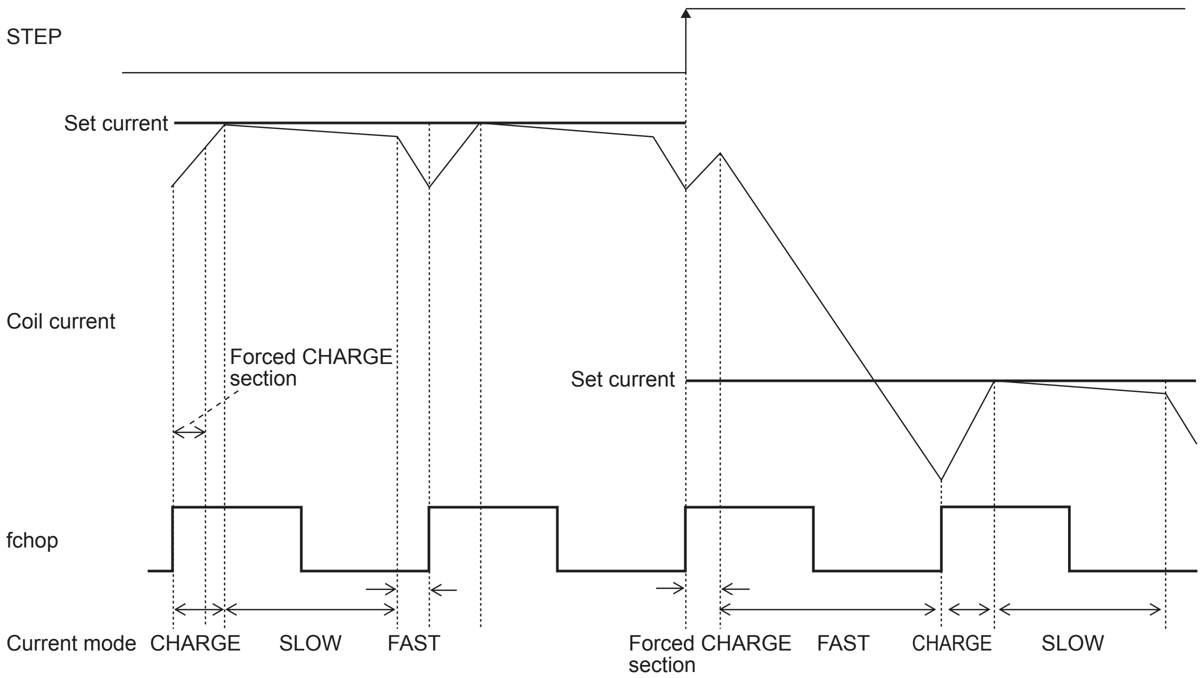


(10) Current control operation specification

(Sine wave increasing direction)



(Sine wave decreasing direction)



In each current mode, the operation sequence is as described below :

- At rise of chopping frequency, the CHARGE mode begins.(The section in which the CHARGE mode is forced regardless of the magnitude of the coil current (ICOIL) and set current (IREF) exists for 1/16 of one chopping cycle.)
- The coil current (ICOIL) and set current (IREF) are compared in this forced CHARGE section.

  When (ICOIL<IREF) state exists in the forced CHARGE section ;

  CHARGE mode up to ICOIL ≥ IREF, then followed by changeover to the SLOW DECAY mode, and finally by the FAST DECAY mode for the 1/16 portion of one chopping cycle.

  When (ICOIL<IREF) state does not exist in the forced CHARGE section;

  The FAST DECAY mode begins. The coil current is attenuated in the FAST DECAY mode till one cycle of chopping is over.

Above operations are repeated. Normally, the SLOW (+FAST) DECAY mode continues in the sine wave increasing direction, then entering the FAST DECAY mode till the current is attenuated to the set level and followed by the SLOW DECAY mode.

Parallel input control (DM-High)

(1) Parallel input control logic

I01(02)	I11(12)	Output current (I_O)
Low	Low	0
High	Low	I_O = ((VREF/5)/RF)×1/3
Low	High	I_O = ((VREF/5)/RF)×2/3
High	High	I_O = (VREF/5)/RF

PH1(2)	current direction
Low	OUTB → OUTA
High	OUTA → OUTB

(2) Setting constant-current control reference voltage

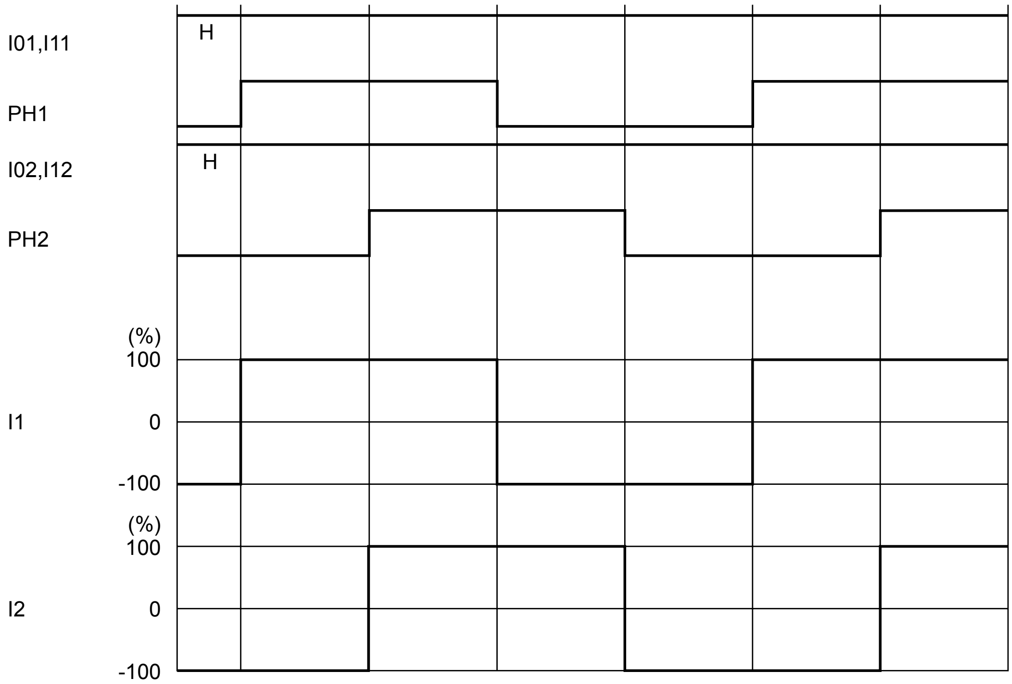
The constant current control standard voltage setting function is the same specification as the CLK-IN input control.

(3) Current control function

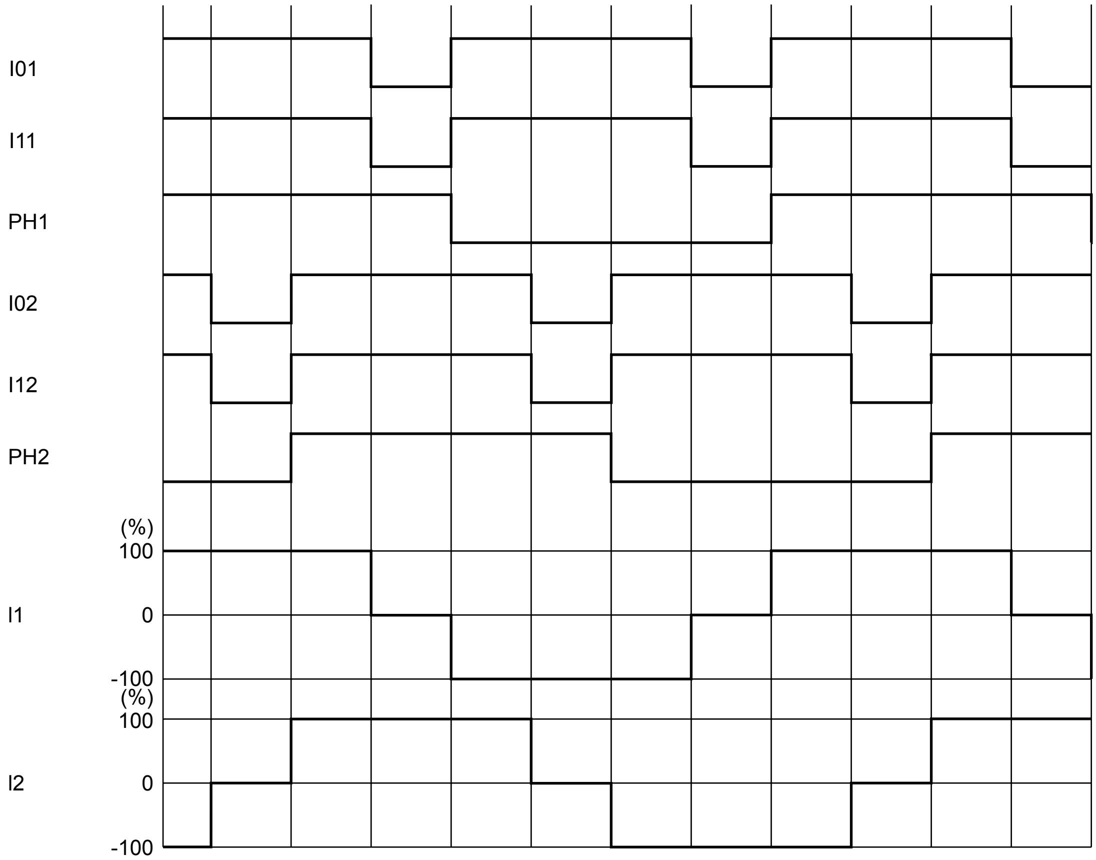
The current control function is the same use as the CLK-IN input control.

(4) Typical current waveform in each excitation mode when stepping motor parallel input control

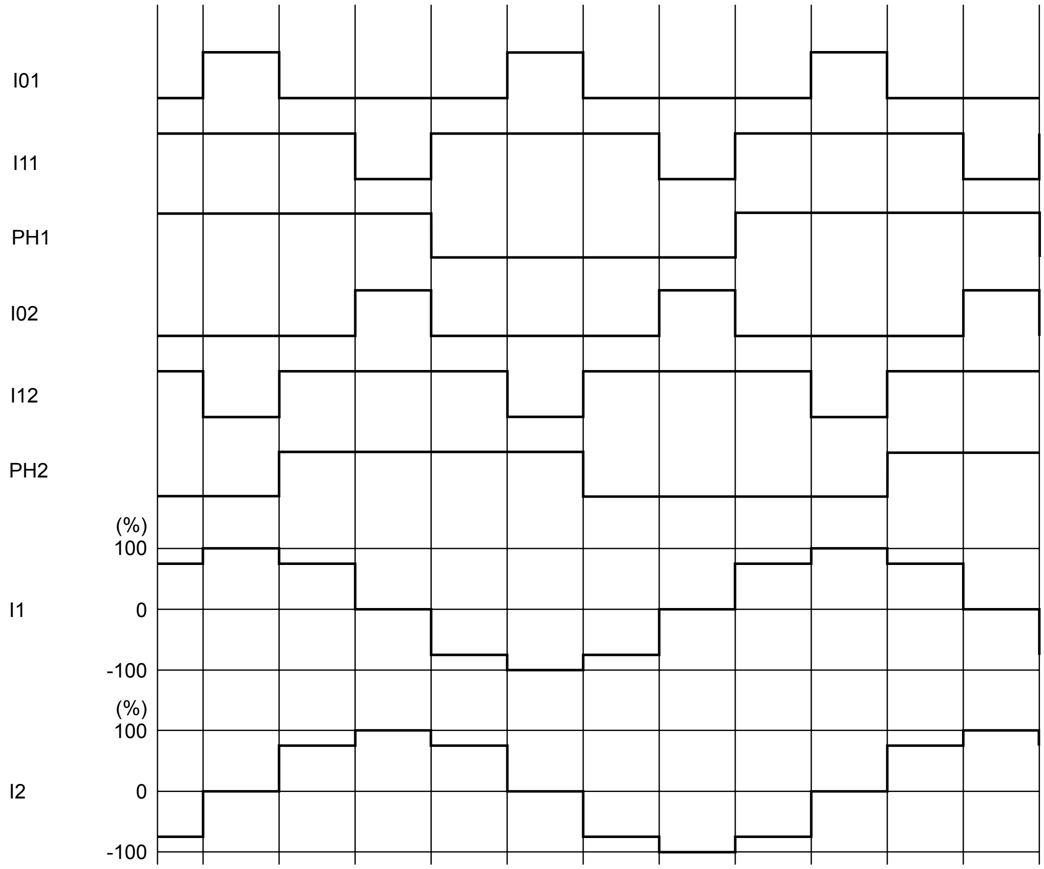
2-phase excitation (CW mode)



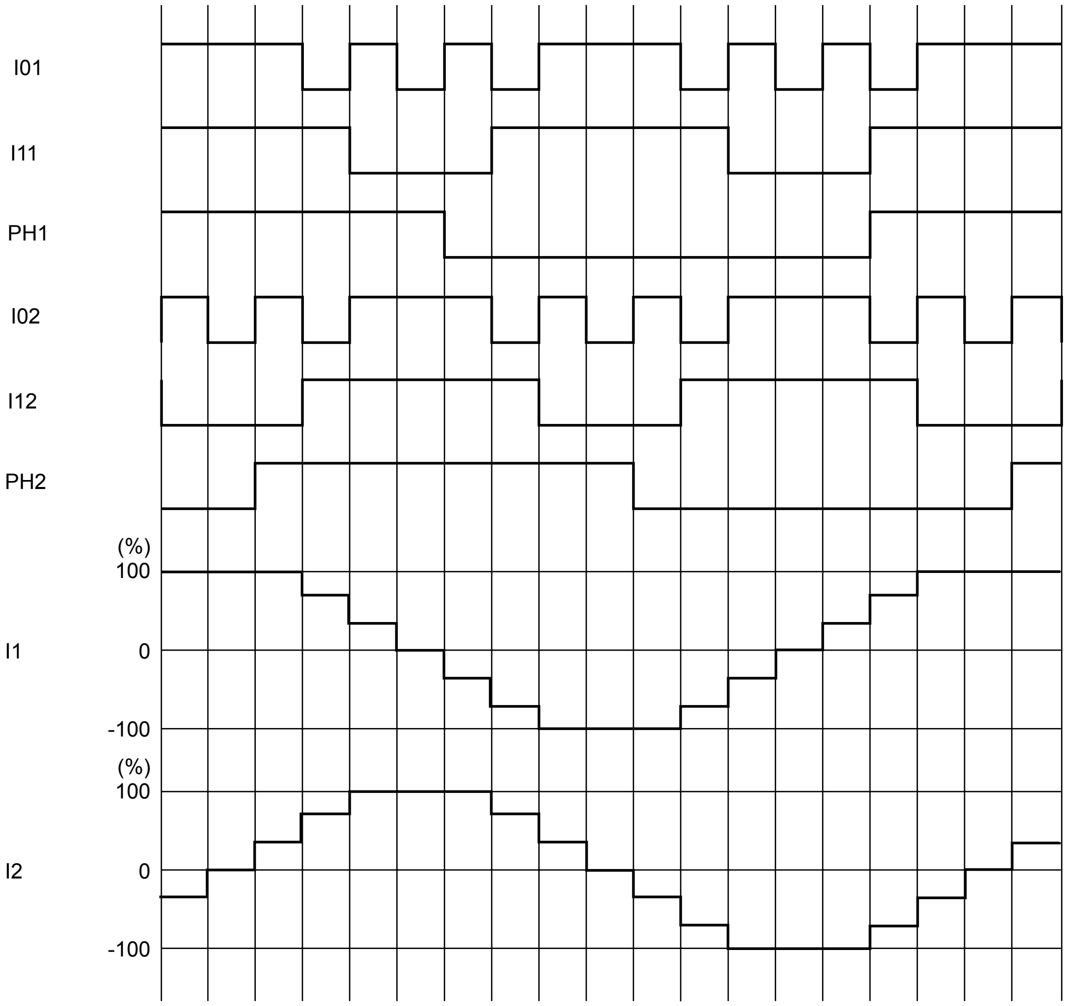
1-2 phase excitation full torque (CW mode)



1-2 phase excitation (CW mode)



W1-2 phase excitation (CW mode)



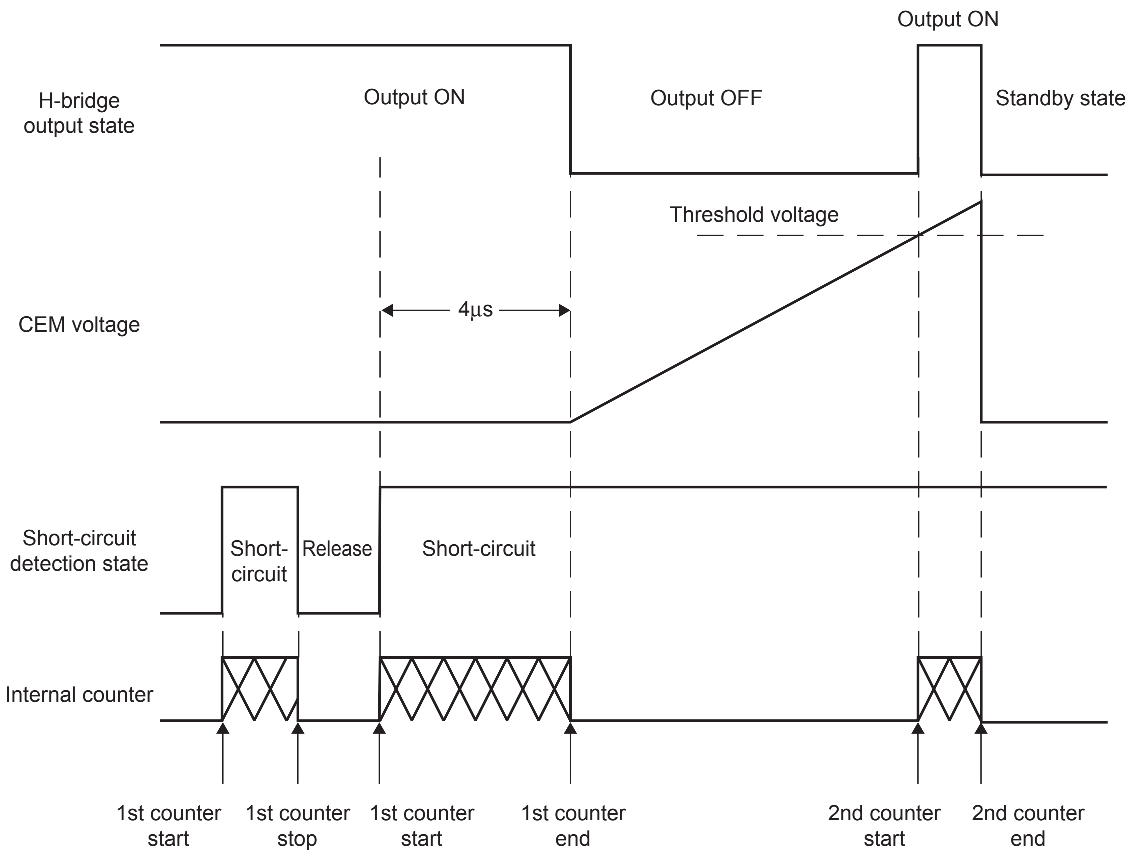
Output short-circuit protection function

This IC incorporates an output short-circuit protection circuit that, when the output has been shorted by an event such as shorting to power or shorting to ground, to prevent the thing that IC destroys, the output short-circuit protection circuit that turns off the output is built into.

(1) Protection function operation(Latch type)

The detection of the output short-circuited state by the IC causes the output short-circuit protection circuit to be activated.

When the short-circuited state continues for the period of time set using the internal timer (approximately 4μs), the output in which the short-circuiting has been detected is first set to OFF. After this, the output is set to ON again as soon as the timer latch time (Tcem) described later has been exceeded, and if the short-circuited state is still detected, all the outputs of the channel concerned are switched to the standby mode, and this state is held.
This state is released by setting ST to low.



(2) Unusual condition warning output pins (EMO)

IC is provided with the EMO pin which notifies the CPU of an unusual condition if the protection circuit operates by detecting an unusual condition of the IC. This pin is of the open-drain output type and when an unusual condition is detected, the EMO output is placed in the ON (EMO = Low) state.

Furthermore, the EMO pin is placed in the ON state when one of the following conditions occurs.

1. Shorting-to-power, shorting-to-ground, or shorting-to-load occurs at the output pin and the output short-circuit protection circuit is activated.
2. The IC junction temperature rises and the thermal protection circuit is activated.

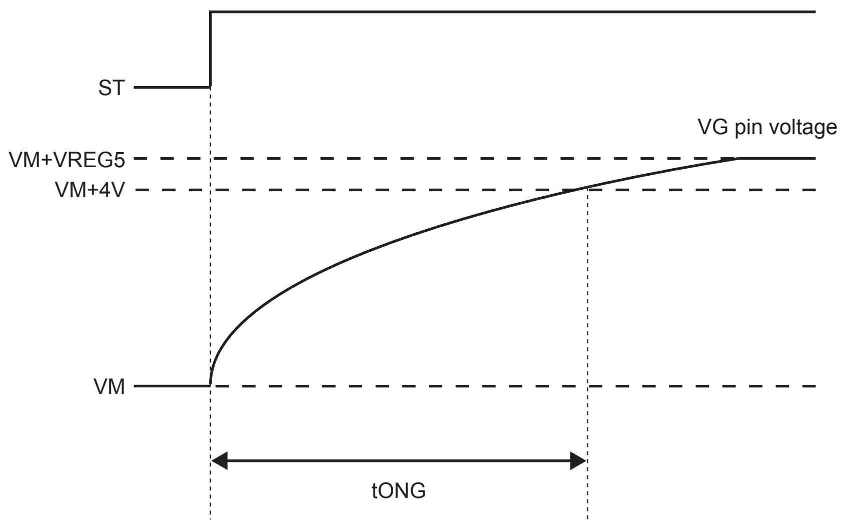
(3) Timer latch time (Tcem)

The time taken for the output to be set to OFF when the output has been short-circuited can be set using capacitor Ccem, connected between the CEM pin and GND. The value of capacitor Ccem is determined by the formula given below.

Timer latch : Tcem Tcem ≈ Ccem × Vtcem/Icem [sec]
Vtcem : Comparator threshold voltage, typ 1V
Icem : CEM pin charge current, typ 10μA

Charge Pump Circuit

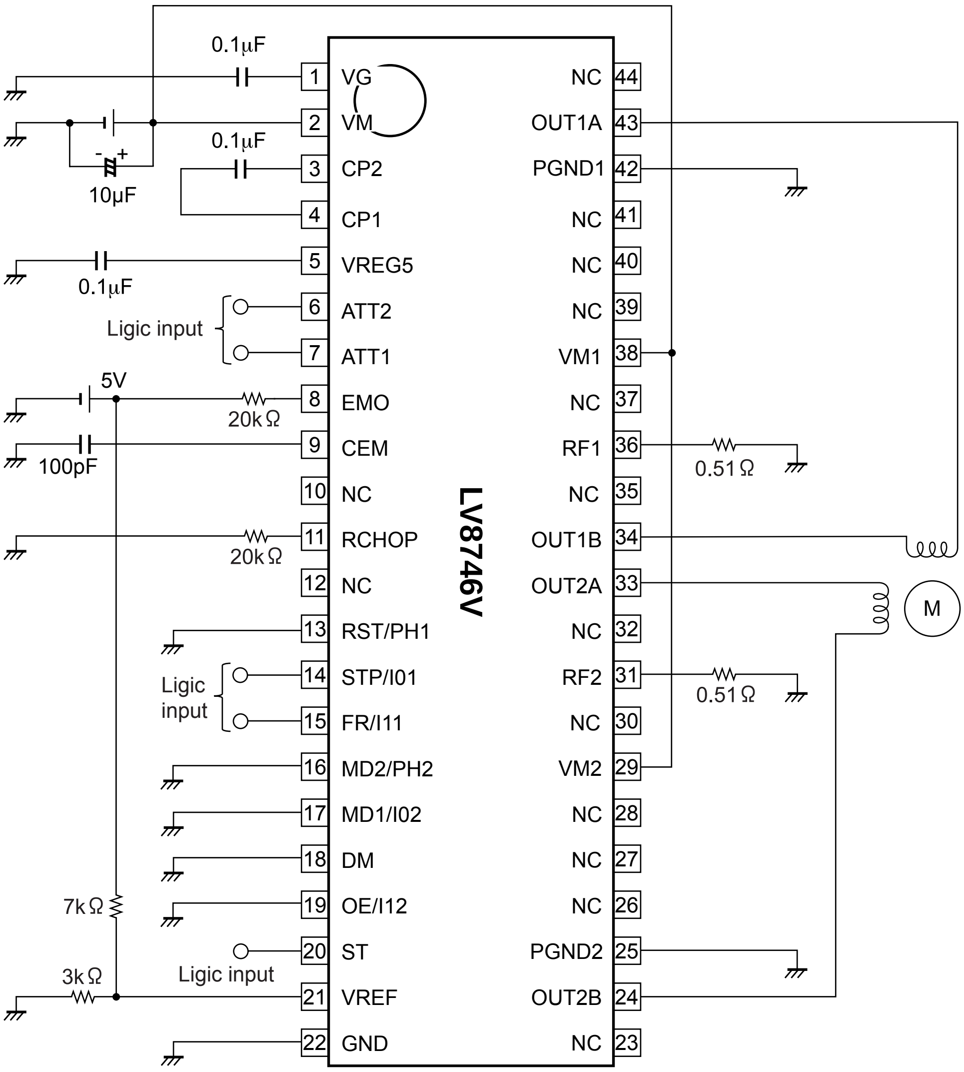
When the ST pin is set High, the charge pump circuit operates and the VG pin voltage is boosted from the VM voltage to the VM + VREG5 voltage. If the VG pin voltage is not boosted sufficiently, the output cannot be controlled, so be sure to provide a wait time of tONG or more after setting the ST pin High before starting to drive the motor.



VG Pin Voltage Schematic View

Application Circuit Example

• Clock Inn mode application circuit



The setting conditions for the above circuit diagram example are as follows :

- 2-phase excitation (MD1/I02 = Low, MD2/PH2 = Low)
- Reset function fixed to normal operation (RST = Low)
- Chopping frequency : 62.5kHz (RCHOP = 20kΩ)

ATT1	ATT2	Current setting reference voltage
Low	Low	VREF/5×100%
High	Low	VREF/5×67%
Low	High	VREF/5×50%
High	High	VREF/5×33%

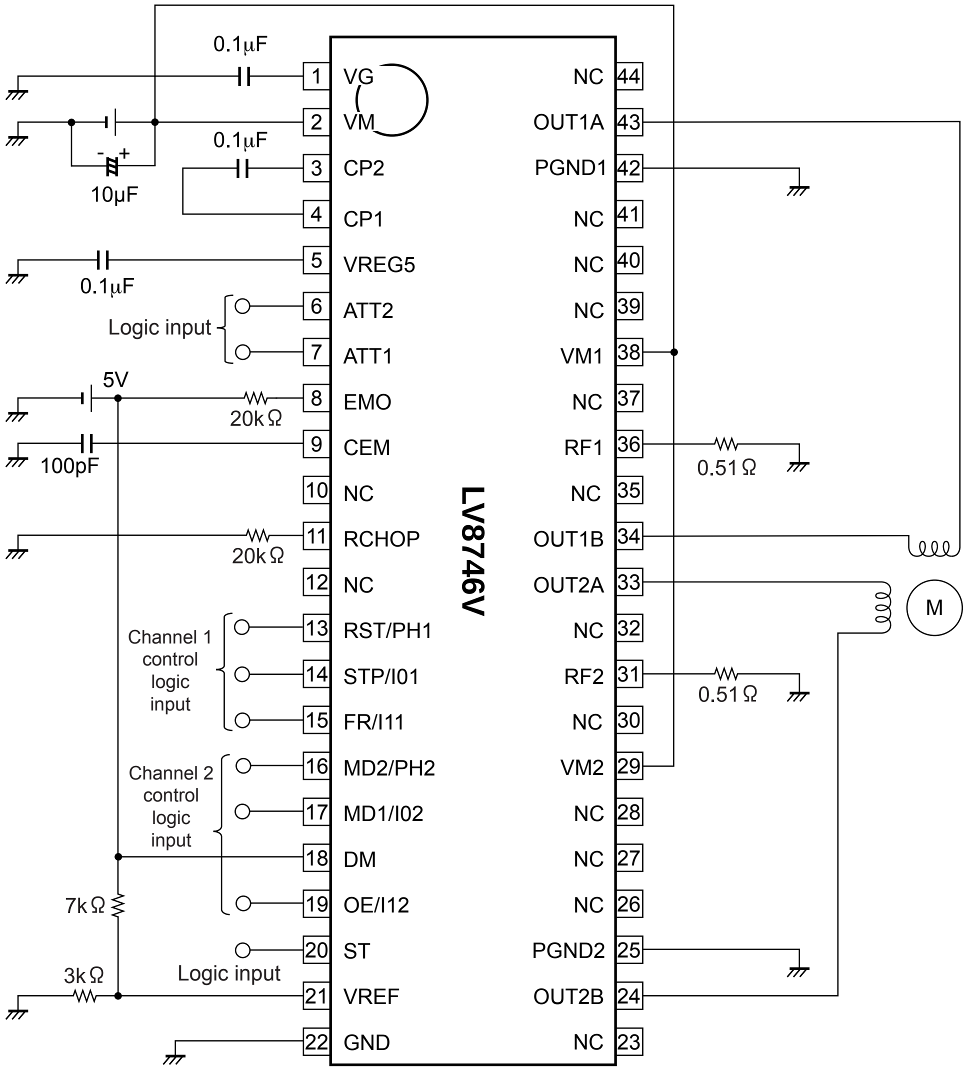
The set current value is as follows :

I_{OUT} = (VREF/5× Voltage setting ratio) / RF

Example) When ATT=Low,ATT2=Low (VREF = 1.5V,RF=0.51Ω)

I_{OUT} = (1.5V / 5 × 1) / 0.51Ω = 0.6A

• DC motor driver circuit (DM = High, and the current limit function is in use.)



The setting conditions for the above circuit diagram example are as follows :

- Chopping frequency : 62.5kHz (RCHOP = 20kΩ)

I01(02)	I11(12)	Output current (I_O)
Low	Low	0
High	Low	I_O = ((VREF/5) / RF) × 1/3
Low	High	I_O = ((VREF/5) / RF) × 2/3
High	High	I_O = (VREF/5) / RF

Example) When ATT=Low,ATT2=Low,I01(02)=High,I11(12)=High (VREF = 1.5V,RF=0.51Ω)
I_{OUT} = (1.5V / 5 × 1) / 0.51Ω = 0.6A

PH1(2)	Electrical current direction
Low	OUTB → OUTA
High	OUTA → OUTB

This catalog provides information as of Octorber, 2009. Specifications and information herein are subject to change without notice.