Ordering number : ENA0814B

SANYO

SANYO Semiconductors
DATA SHEET

An ON Semiconductor Company

Bi-CMOS LSI

LV8741V — PWM Current Control Stepping Motor Driver

Overview

The LV8741V is a PWM current-control stepping motor driver IC.

Features

- Single-channel PWM current control stepping motor driver (selectable with DC motor driver channel 2) incorporated.
- BiCDMOS process IC
- On resistance (upper side : 0.5Ω ; lower side : 0.5Ω ; total of upper and lower : 1.0Ω ; Ta = 25°C, I_O = 1.5A)
- Excitation mode can be set to 2-phase, 1-2 phase full torque, 1-2 phase or W1-2 phase
- Excitation step proceeds only by step signal input
- Motor holding current selectable in four steps
- I_O max = 1.5A
- Output-stage push-pull structure enabling high-speed operation
- Output short-circuit protection circuit (selectable from latch-type or auto reset-type) incorporated
- Thermal shutdown circuit and power supply monitor circuit incorporated
- Supports control power supply V_{CC} = 3.3V

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage 1	V_M max		38	V
Supply voltage 2	V_{CC} max		6	V
Output peak current	I_O peak	tw ≤ 10ms, duty 20%	1.75	A
Output current	I_O max		1.5	A
Logic input voltage	V_{IN}		-0.3 to V_{CC}+0.3	V
EMO input voltage	VEMO		-0.3 to V_{CC}+0.3	V

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Parameter	Symbol	Conditions	Ratings	Unit
Allowable power dissipation 1	Pd max1	Independent IC	0.55	W
Allowable power dissipation 2	Pd max2	* Our recommended two-layer substrate *1, *2	2.9	W
Operating temperature	Topr		-20 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

*1 Specified circuit board : 90×90×1.7mm^3 : glass epoxy printed circuit board

*2 For mounting to the backside by soldering, refer the precautions.

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range 1	V_M		9.5 to 35	V
Supply voltage range 2	V_{CC}		2.7 to 5.5	V
VREF input voltage range	VREF		0 to V_{CC}-1.8	V

Electrical Characteristics at Ta = 25°C, V_M = 24V, V_{CC} = 5V, VREF = 1.5V

Parameter		Symbol	Conditions	Ratings			Unit
				min	typ	max	
Standby mode current drain 1		IMstn	ST = "L"		150	200	μA
Current drain 1		IM	ST = "H", OE = "H", no load		0.75	1	mA
Standby mode current drain 2		I_{CC}stn	ST = "L"		110	160	μA
Current drain 2		I_{CC}	ST = "H", OE = "H", no load		2.5	3	mA
V_{CC} low-voltage cutoff voltage		VthV_{CC}		2.2	2.35	2.5	V
Low-voltage hysteresis voltage		VthHIS		100	150	200	mV
Thermal shutdown temperature		TSD	Design guarantee		180		°C
Thermal hysteresis width		ΔTSD	Design guarantee		40		°C
Output on-resistance		Ronu	I_O = 1.5A, Upper-side on resistance		0.5	0.7	Ω
		Rond	I_O = 1.5A, Lower-side on resistance		0.5	0.6	Ω
Output leakage current		$I_O$leak				50	μA
Diode forward voltage 1		VD1	ID = -1.0A		1	1.3	V
Diode forward voltage 2		VD2	ID = -1.5A		1.1	1.5	V
Logic pin input current		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 selection reference voltage level	W1-2-phase drive		Step 0(When initialized : channel 1 comparator level)	0.485	0.5	0.515	V
			Step 1 (Initial state+1)	0.485	0.5	0.515	V
			Step 2 (Initial state+2)	0.323	0.333	0.343	V
			Step 3 (Initial state+3)	0.155	0.167	0.179	V
	1-2 phase drive		Step 0 (When initialized: channel 1 comparator level)	0.485	0.5	0.515	V
			Step 2 (Initial state+1)	0.323	0.333	0.343	V
	1-2 phase (full torque) drive		Step 0 (Initial state, channel 1 comparator level)	0.485	0.5	0.515	V
			Step 2 (Initial state+1)	0.485	0.5	0.515	V
	2 phase drive		Step 2	0.485	0.5	0.515	V
Chopping frequency		Fchop	RCHOP = 20kΩ	45	62.5	75	kHz
Current setting reference voltage		VRF00	ATT1 = L, ATT2 = L	0.485	0.5	0.515	V
		VRF01	ATT1 = H, ATT2 = L	0.323	0.333	0.343	V
		VRF10	ATT1 = L, ATT2 = H	0.237	0.25	0.263	V
		VRF11	ATT1 = H, ATT2 = H	0.155	0.167	0.179	V
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						
VREG5 output voltage	Vreg5	I_O = -1mA	4.5	5	5.5	V
VG output voltage	VG		28	28.7	29.8	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		Iemo = 1mA		50	100	mV

Package Dimensions

unit : mm (typ)

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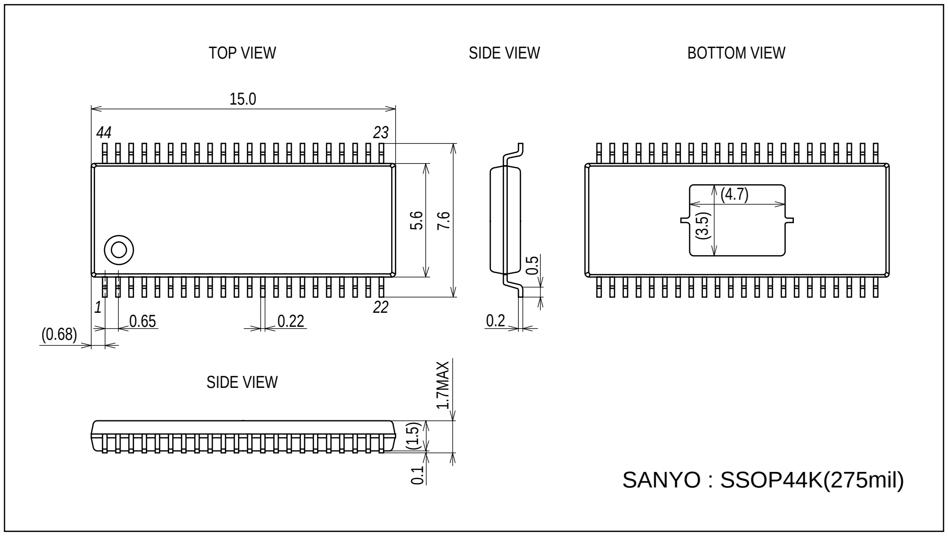
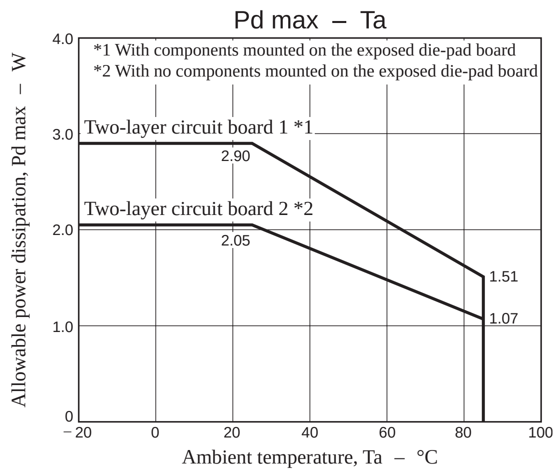
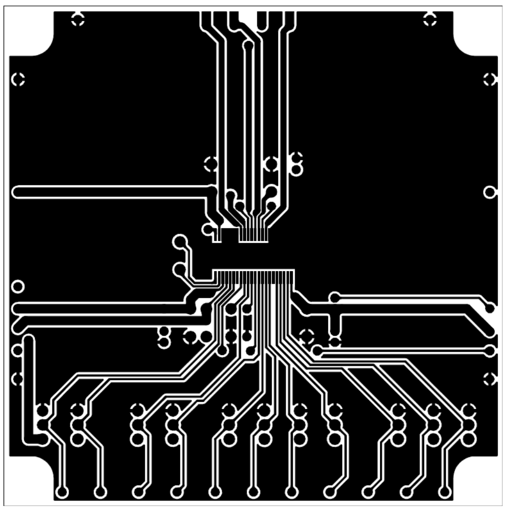
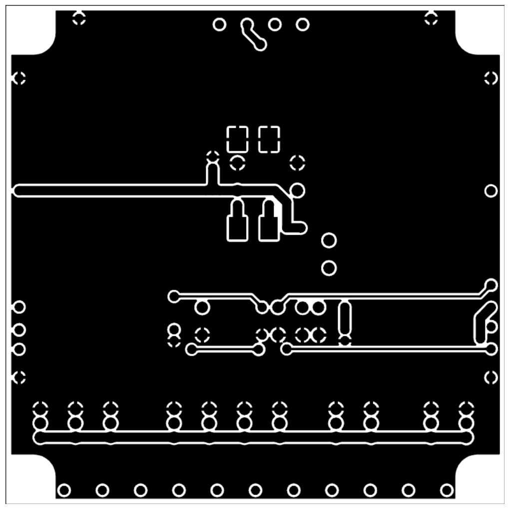




Substrate Specifications (Substrate recommended for operation of LV8741V)

Size	: 90mm × 90mm × 1.7mm (two-layer substrate [2S0P])
Material	: Glass epoxy
Copper wiring density	: L1 = 90% / L2 = 95%


L1 : Copper wiring pattern diagram


L2 : Copper wiring pattern diagram

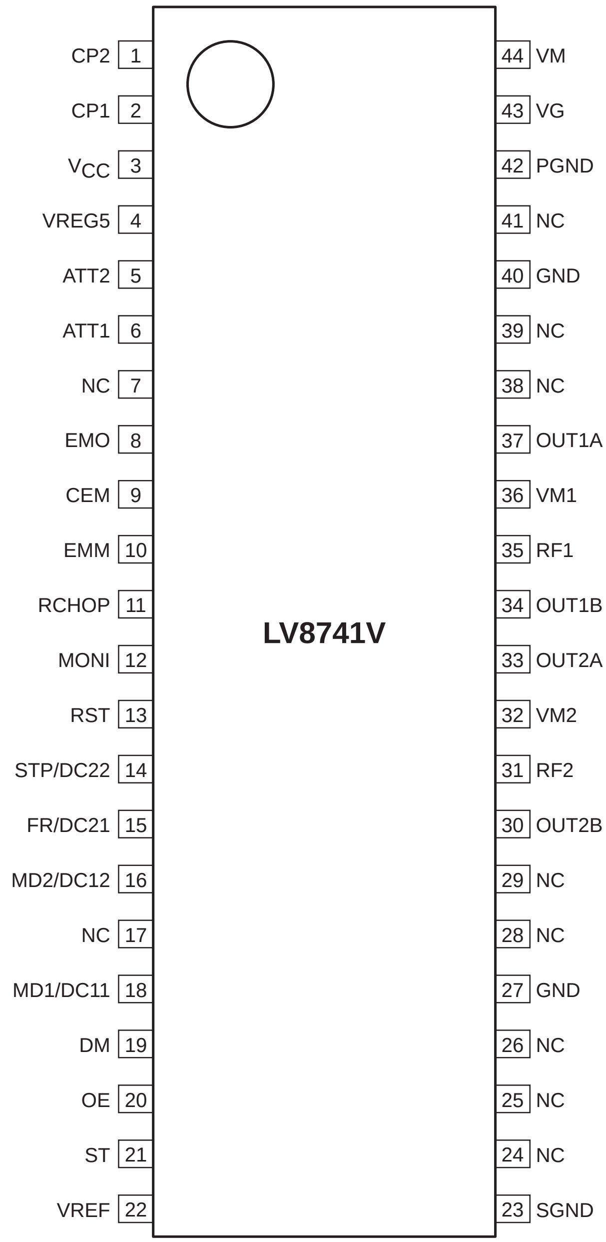
Cautions

1) The data for the case with the Exposed Die-Pad substrate mounted shows the values when 95% 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

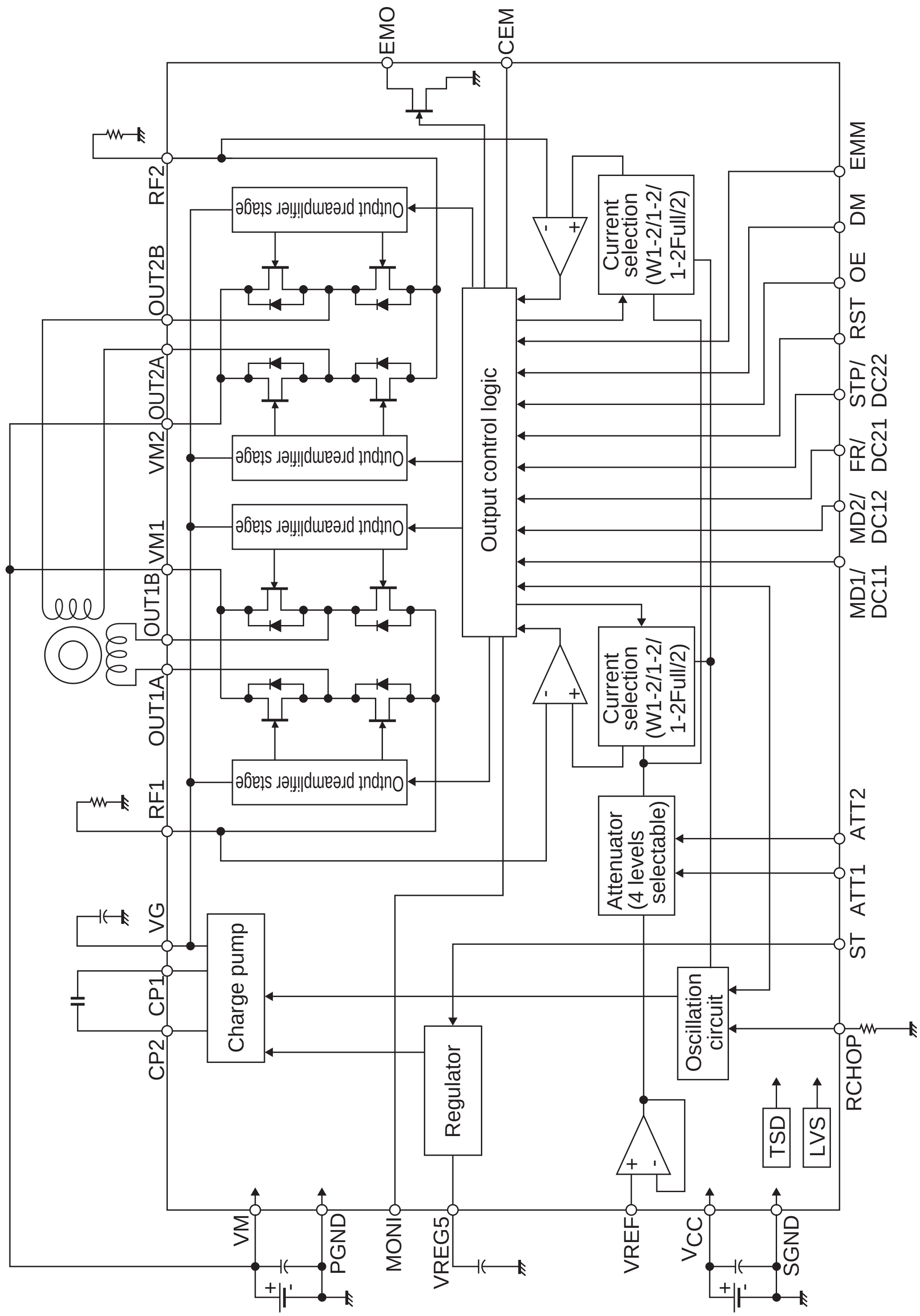
3) After the set design, be sure to verify the design with the actual product.
Confirm the solder joint state and verify also the reliability of solder joint for the Exposed Die-Pad, etc.
Any void or deterioration, if observed in the solder joint of these parts, causes deteriorated thermal conduction,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

Pin Assignment



Top view

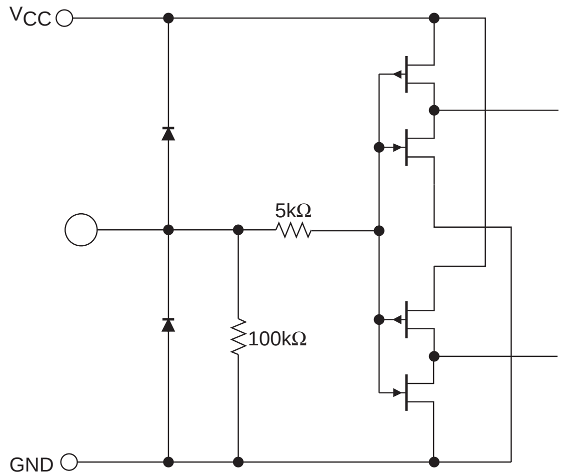
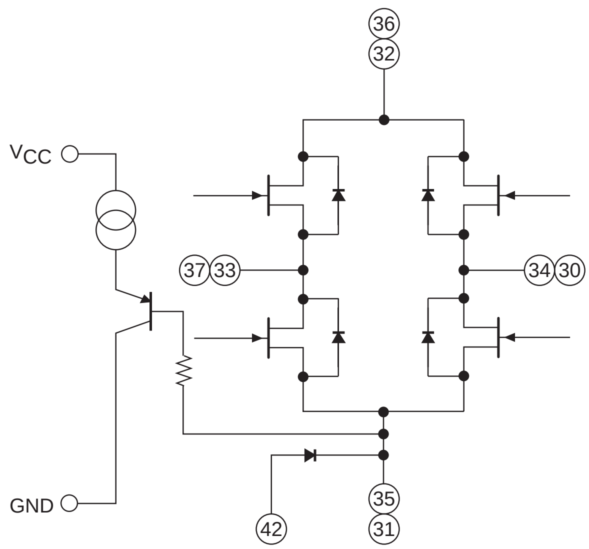
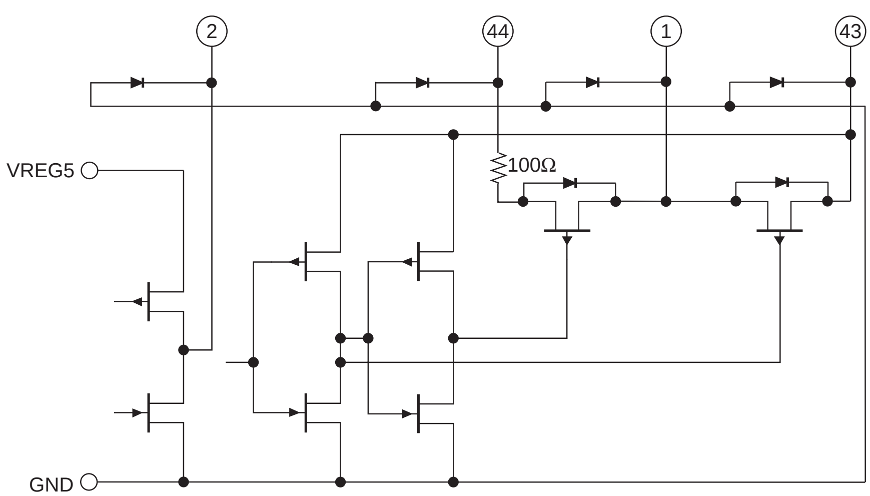
Block Diagram



Pin Functions

Pin No.	Pin name	Description
36	VM1	Channel 1 motor power supply pin
37	OUT1A	Channel 1 OUTA output pin
34	OUT1B	Channel 1 OUTB output pin
35	RF1	Channel 1 current-sense resistor connection pin
32	VM2	Channel 2 motor power supply connection pin
33	OUT2A	Channel 2 OUTA output pin
30	OUT2B	Channel 2 OUTB output pin
31	RF2	Channel 2 current-sense resistor connection pin
42	PGND	Power system ground
12	MONI	Position detection monitor pin
14	STP/DC22	STM STEP signal input pin/DCM2 output control input pin
22	VREF	Constant current control reference voltage input pin
18	MD1/DC11	STM excitation mode switching pin/DCM1 output control input pin
16	MD2/DC12	STM excitation mode switching pin/DCM1 output control input pin
13	RST	Reset signal input pin
20	OE	Output enable signal input pin
15	FR/DC21	STM forward/reverse rotation signal input pin/DCM2 output control input pin
6	ATT1	Motor holding current switching pin
5	ATT2	Motor holding current switching pin
21	ST	Chip enable pin
44	VM	Motor power supply connection pin
3	V_{CC}	Logic power supply connection pin
23	SGND	Signal system ground
11	RCHOP	Chopping frequency setting resistor connection pin
19	DM	Drive mode (STM/DCM) switching pin
4	VREG5	Internal power supply capacitor connection pin
2	CP1	Charge pump capacitor connection pin
1	CP2	Charge pump capacitor connection pin
43	VG	Charge pump capacitor connection pin
8	EMO	Output short-circuit state warning output pin
10	EMM	Overcurrent mode switching pin
9	CEM	Pin to connect the output short-circuit state detection time setting capacitor
27,40	GND	Ground
7, 17, 24, 25, 26, 28, 29, 38, 39, 41	NC	No Connection (No internal connection to the IC)

Equivalent Circuits

Pin No.	Pin	Equivalent Circuit
5 6 10 13 14 15 16 18 19 20 21	ATT2 ATT1 EMM RST STP/DC22 FR/DC21 MD2/DC12 MD1/DC11 DM OE ST	
30 31 32 33 34 35 36 37 42	OUT2B RF2 VM2 OUT2A OUT1B RF1 VM1 OUT1A PGND	
1 2 43 44	CP2 CP1 VG VM	

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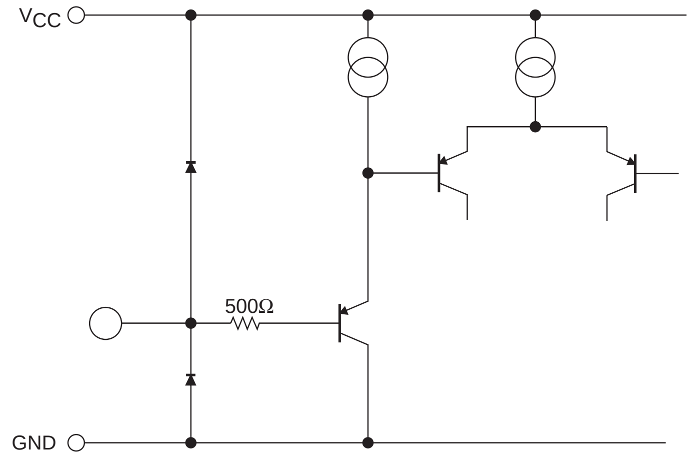
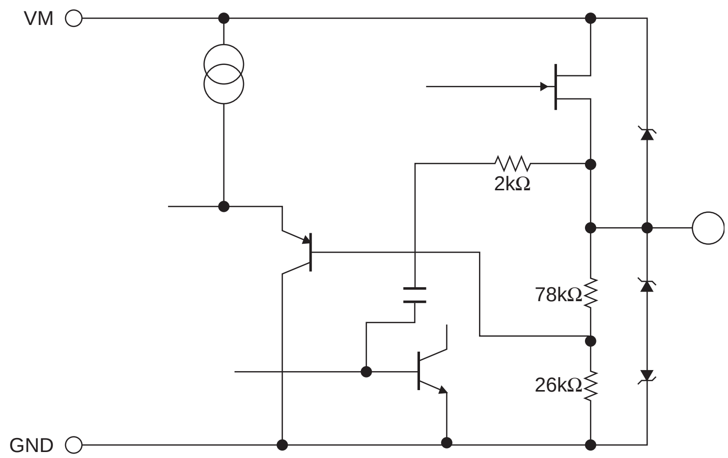
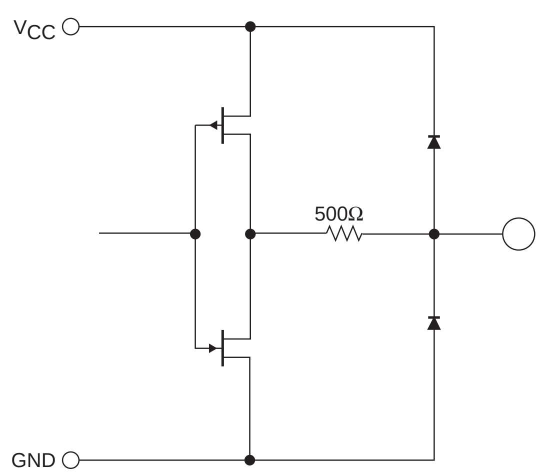
Pin No.	Pin	Equivalent Circuit
22	VREF	
4	VREG5	
12	MONI	

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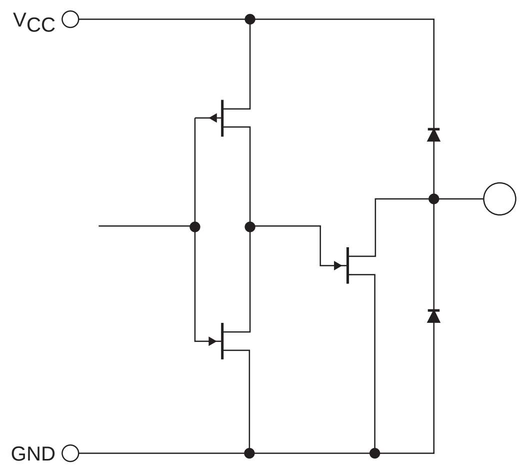
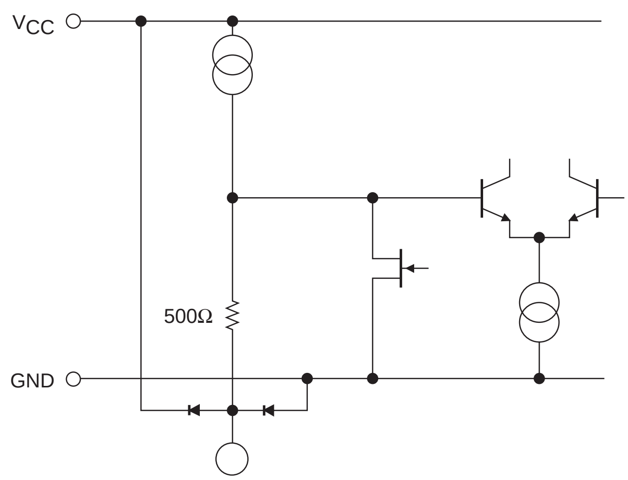
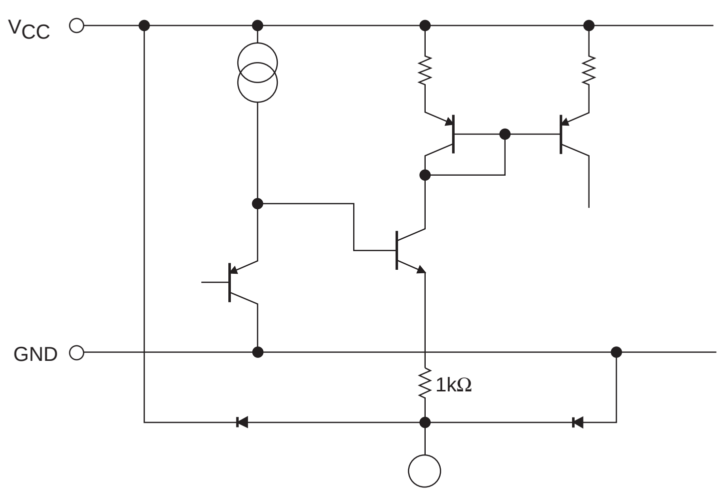
Pin No.	Pin	Equivalent Circuit
8	EMO	
9	CEM	
11	RCHOP	

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

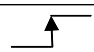
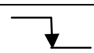
(2) Drive mode switching pin function

The IC drive mode is switched by setting the DM pin. In STM mode, stepping motor channel 1 can be controlled by the CLK-IN input. In DCM mode, DC motor channel 2 or stepping motor channel 1 can be controlled by parallel input. Stepping motor control using parallel input is 2-phase or 1-2 phase full torque.

DM	Drive mode	Application
Low or Open	STM mode	Stepping motor channel 1 (CLK-IN)
High	DCM mode	DC motor channel 2 or stepping motor channel 1 (parallel)

STM mode (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) Constant-current control reference voltage setting function

ATT1	ATT2	Current setting reference voltage
Low	Low	VREF/3×100%
High	Low	VREF/3×67%
Low	High	VREF/3×50%
High	High	VREF/3×33%

The voltage input to the VREF pin can be switched to four-step settings as the reference voltage for setting the output current. 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.

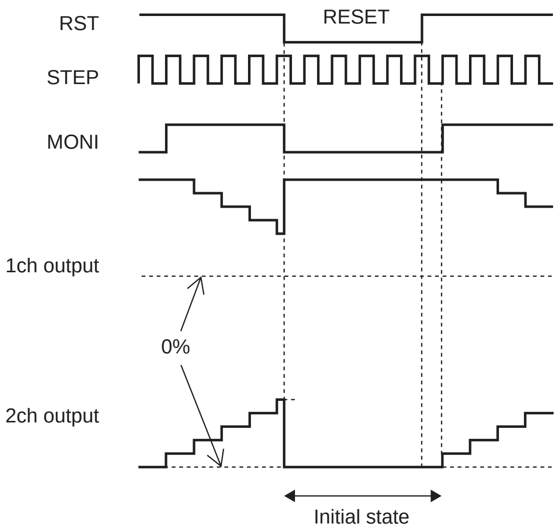
$$I_{OUT} = (VREF/3 \times \text{Voltage setting ratio})/\text{RF resistor}$$

(Example) When VREF = 1.5V, setting current ratio = 100% [(ATT1, ATT2) = (Low, Low)] and RF resistor = 0.5Ω, the following output current flows :

$$I_{OUT} = 1.5V/3 \times 100\%/0.5\Omega = 1A$$

(4) Reset function

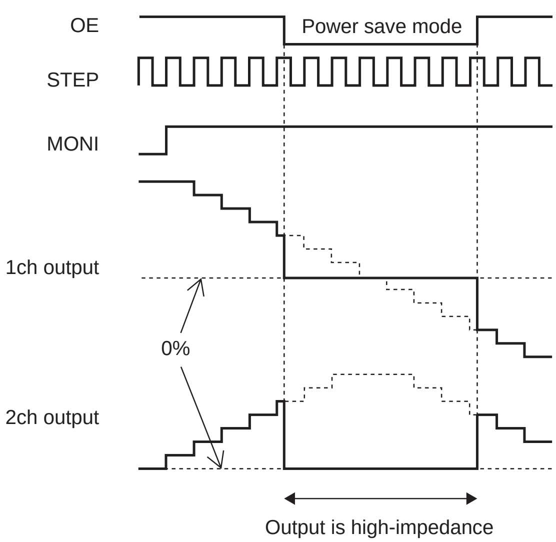
RST	Operating mode
High	Normal operation
Low	Reset state



When the RST pin is set Low, the output excitation position is forced to the initial state, and the MONI output also goes Low.
When RST is set High after that, the excitation position proceeds to the next STEP input.

(5) Output enable function

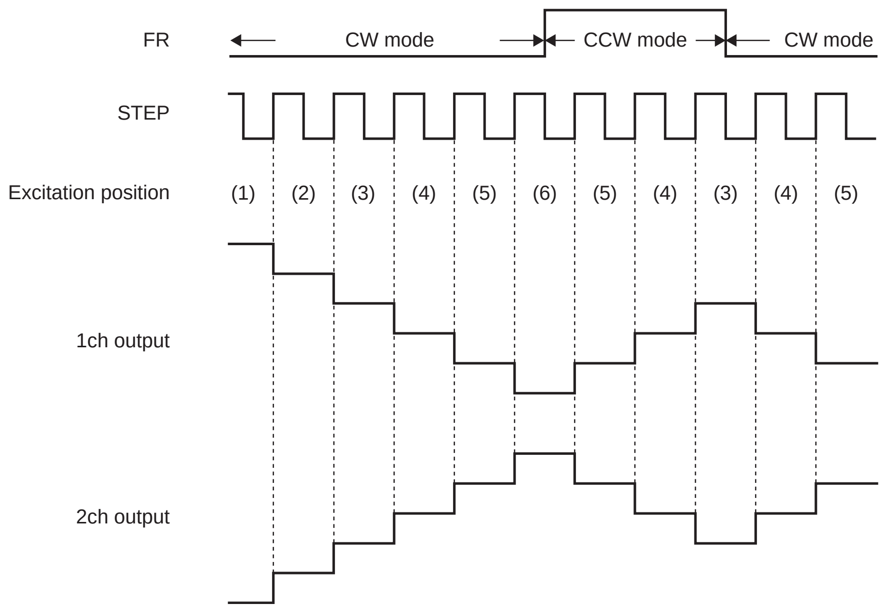
OE	Operating mode
Low	Output OFF
High	Output ON



When the OE pin is set Low, 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 High, the output level conforms to the excitation position proceeded by the STEP input.

(6) Forward/reverse switching function

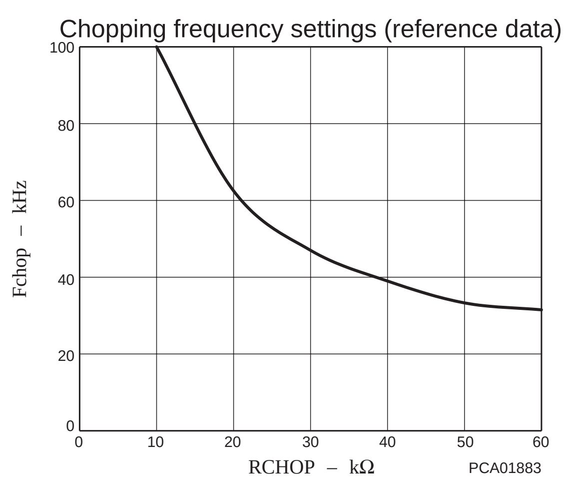
FR	Operating mode
Low	Clockwise (CW)
High	Counter-clockwise (CCW)



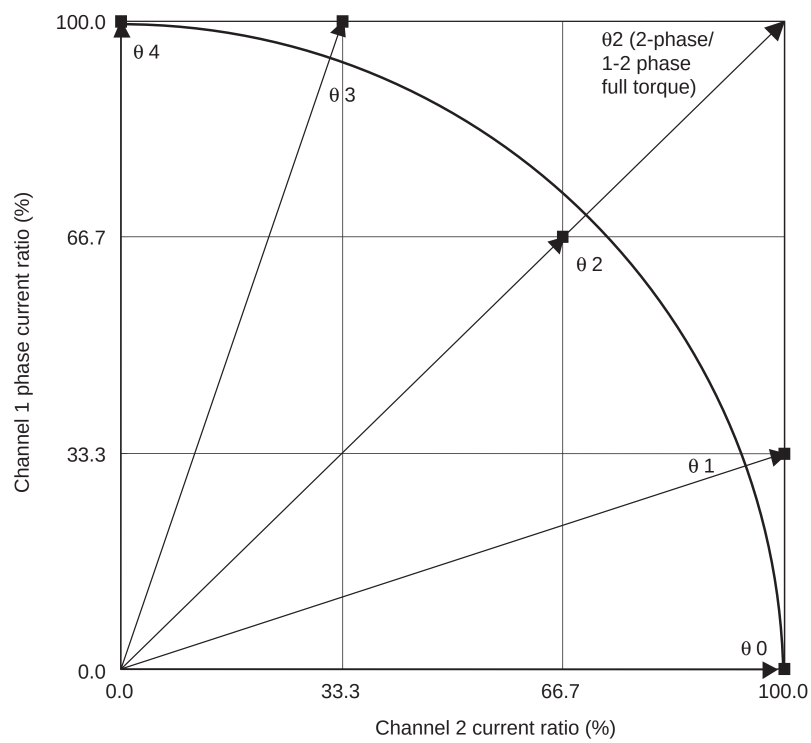
The internal D/A converter proceeds by one bit at the rising edge of the input STEP pulse.
In addition, CW and CCW mode are switched by setting the FR pin.
In CW mode, the channel 2 current phase is delayed by 90° relative to the channel 1 current.
In CCW mode, the channel 2 current phase is advanced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

(7) Setting the chopping frequency

For constant-current control, chopping operation is made with the frequency determined by the external resistor (connected to the RCHOP pin).
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)

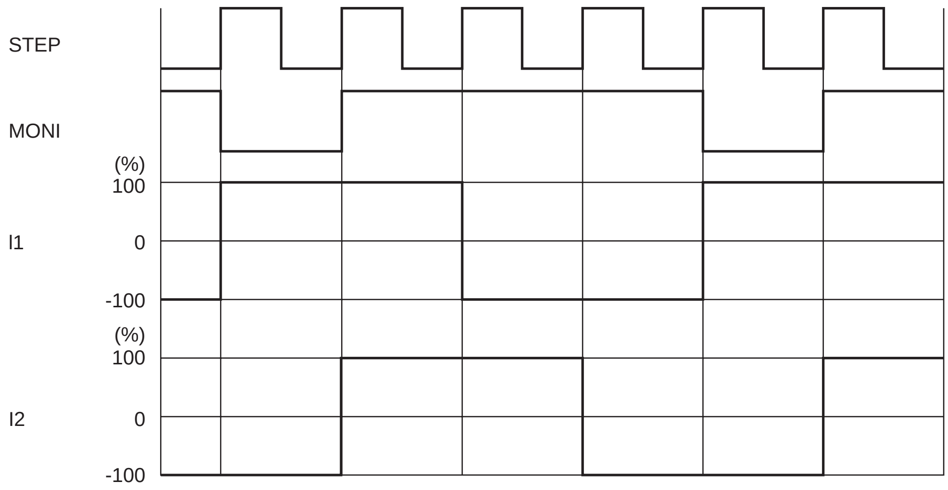


Setting current ration in each excitation mode

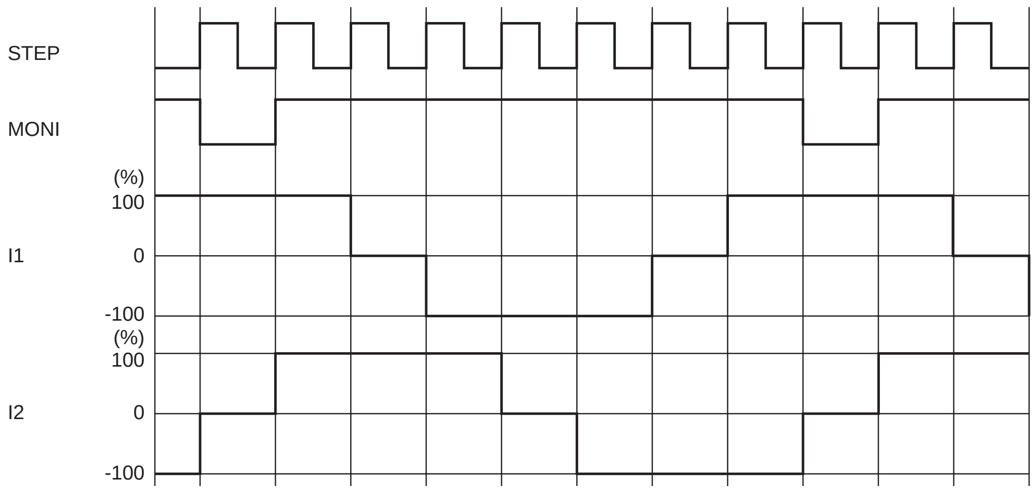
STEP	W1-2 phase (%)		1-2 phase (%)		1-2 phase full torque (%)		2-phase (%)	
	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2
θ0	0	100	0	100	0	100		
θ1	33.3	100						
θ2	66.7	66.7	66.7	66.7	100	100	100	100
θ3	100	33.3						
θ4	100	0	100	0	100	0		

(9) Typical current waveform in each excitation mode

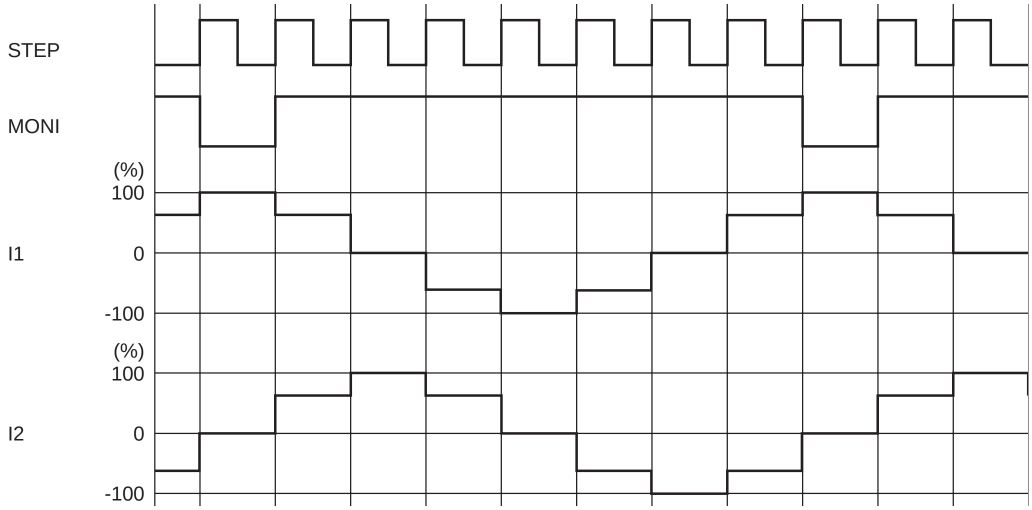
2-phase excitation (CW mode)



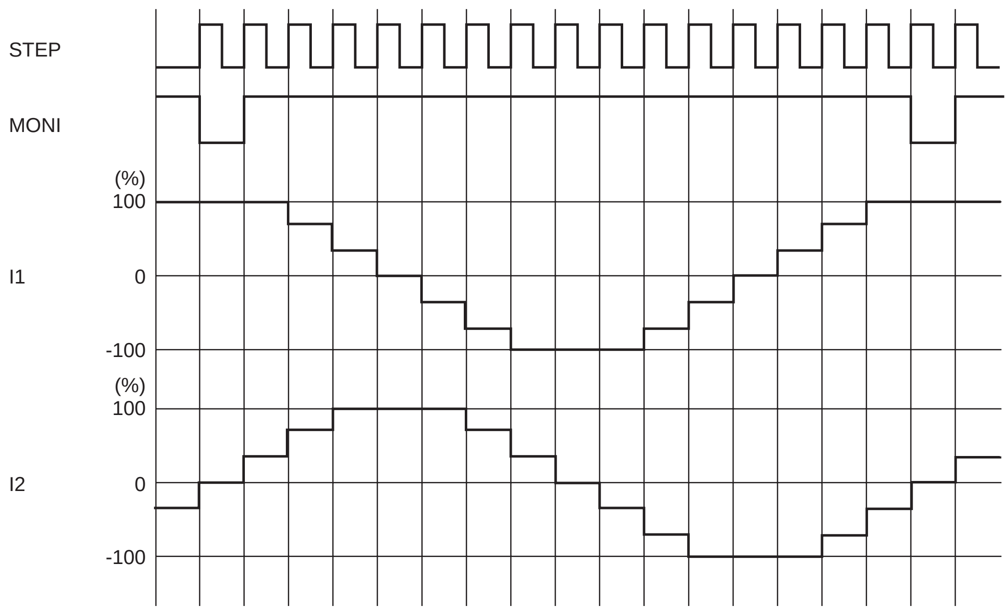
1-2 phase excitation full torque (CW mode)



1-2 phase excitation (CW mode)

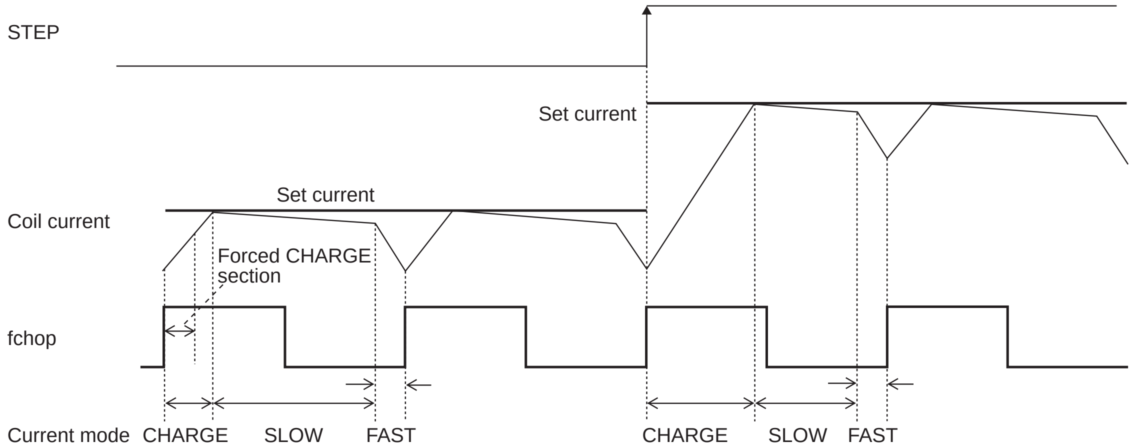


W1-2 phase excitation (CW mode)

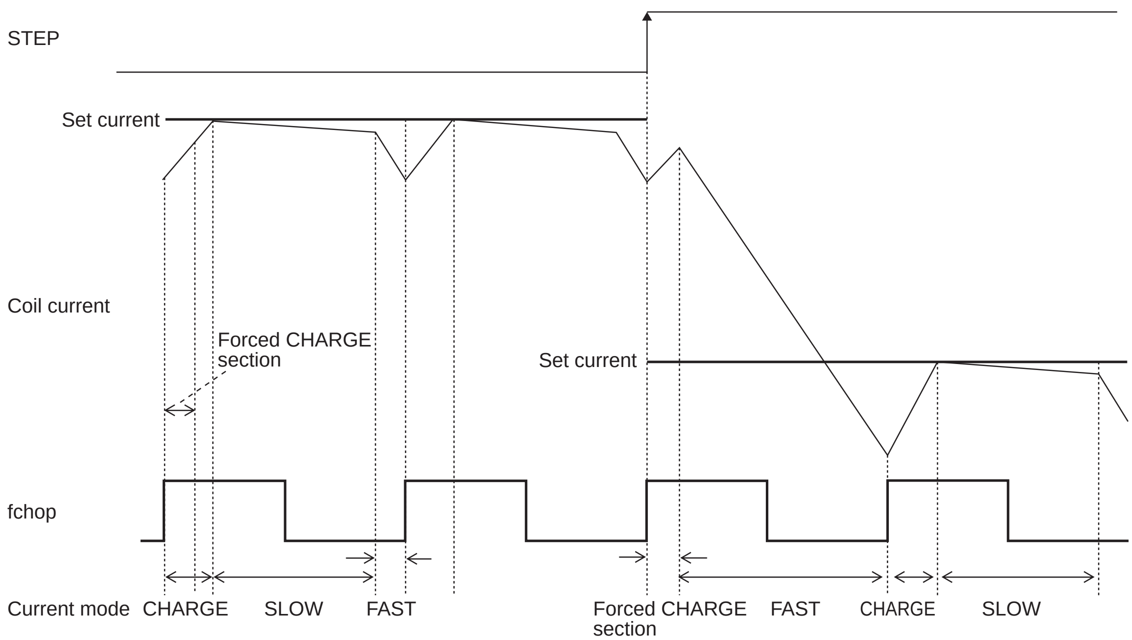


(10) Current control operation specification

(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.

DCM Mode (DM-High)

(1) DCM mode output control logic

Parallel input		Output		Mode
DC11 (21)	DC12 (22)	OUT1 (2) A	OUT1 (2) B	
Low	Low	OFF	OFF	Standby
High	Low	High	Low	CW (Forward)
Low	High	Low	High	CCW (Reverse)
High	High	Low	Low	Brake

(2) Reset function

RST	Operating mode	MONI
High or Low	Reset operation not performed	High output

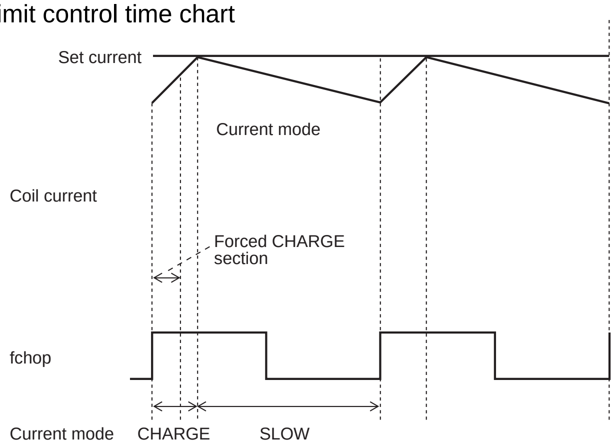
The reset function does not operate in DCM mode. In addition, the MONI output is High, regardless of the RST pin state.

(3) Output enable function

OE	Operating mode
Low	Output OFF
High	Output ON

When the OE pin is set Low, the output is forced OFF and goes to high impedance. When the OE pin is set High, output conforms to the control logic.

(4) Current limit control time chart



(5) Current limit reference voltage setting function

ATT1	ATT2	Current setting reference voltage
Low	Low	VREF/3×100%
High	Low	VREF/3×67%
Low	High	VREF/3×50%
High	High	VREF/3×33%

The voltage input to the VREF pin can be switched to four-step settings as the reference voltage for setting the current limit.

Set current calculation method

The reference voltage is set by the voltage applied to the VREF pin and the two inputs ATT1 and ATT2. The current limit can be set from this reference voltage and the RF resistance value.

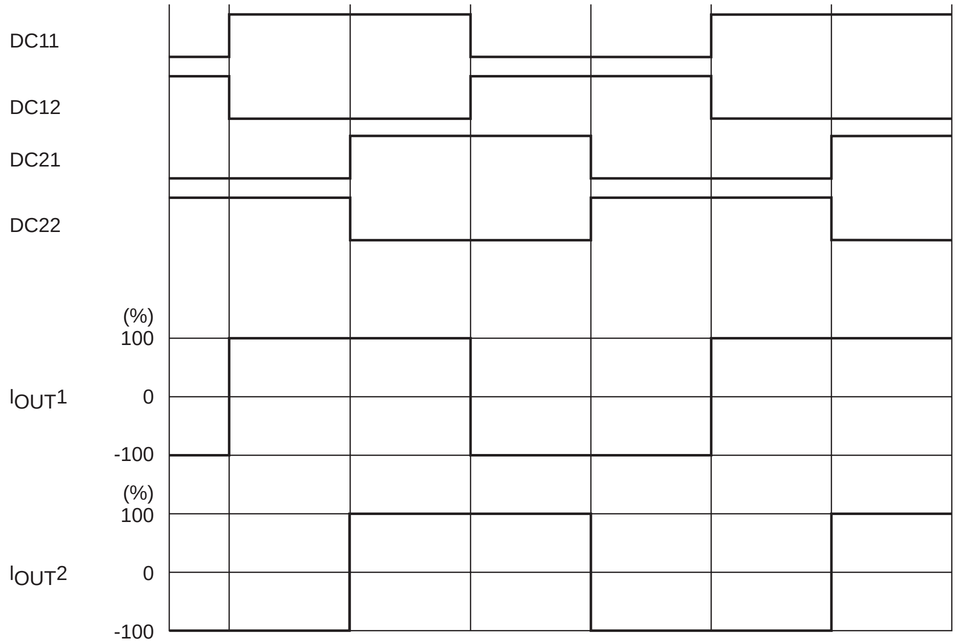
$$I_{limit} = (VREF/3 \times \text{Current setting ratio}) / \text{RF resistance}$$

(Example) When VREF = 1.5V, setting current ratio = 100% [(ATT1, ATT2) = (Low, Low)] and RNF1 (2) = 0.5Ω, the current limit value is as follows :

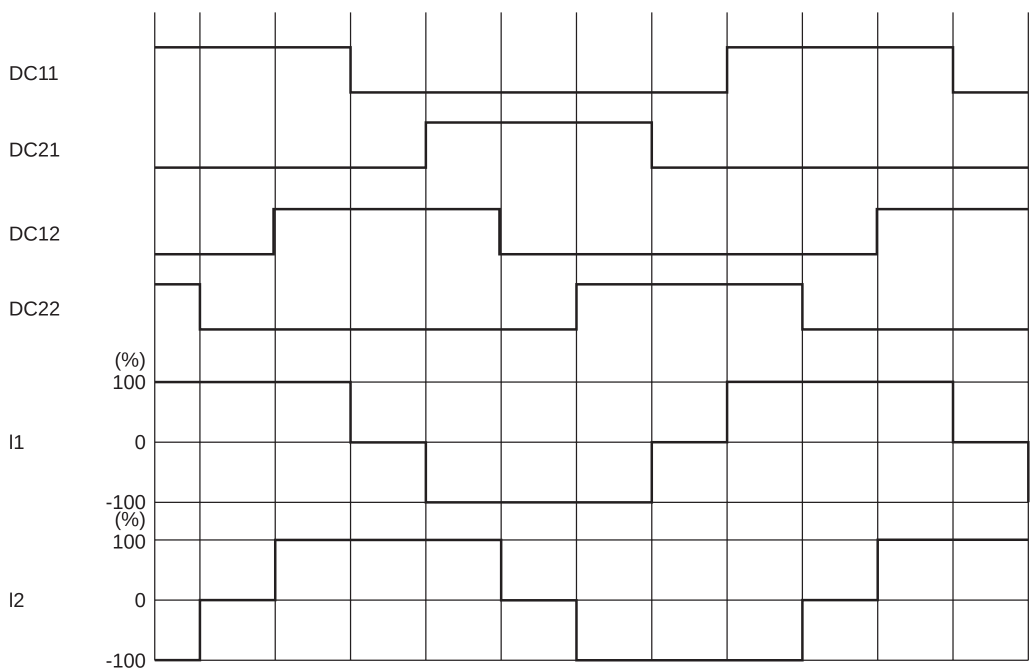
$$I_{limit} = 1.5V/3 \times 100\%/0.5\Omega = 1A$$

(6) 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)



Output short-circuit protection circuit

To protect the IC from damage due to short-circuit of the output caused by lightening or ground fault, the output short-circuit protection circuit to put the output in standby mode and turn on the alarm output is incorporated. Note that when the RF pin is short-circuited to GND, this output short-circuit protection is not effective against shorting to power.

(1) Output short-circuit protection operation changeover function

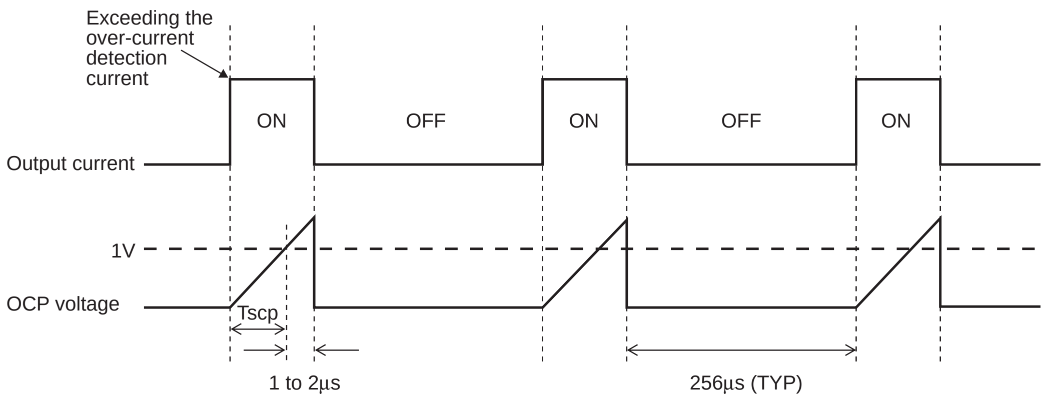
Changeover to the output short-circuit protection of IC is made by the setting of OCPM pin.

EMM	State
Low or Open	Auto reset method
High	Latch method

(2) Auto reset method

When the output current is below the output short-circuit protection current, the output is controlled by the input signal. When the output current exceeds the detection current, the switching waveform as shown below appears instead.

(When a 20kΩ resistor is inserted between RCHOP and GND)



When detecting the output short-circuit state, the short-circuit detection circuit is activated.

When the short-circuit detection circuit operation exceeds the timer latch time described later, the output is changed over to the standby mode and reset to the ON mode again in 256μs (TYP). In this event, if the overcurrent mode still continues, the above switching mode is repeated till the overcurrent mode is canceled.

(3) Latch method

Similarly to the case of automatic reset method, the short-circuit detection circuit is activated when it detects the output short-circuit state.

When the short-circuit detection circuit operation exceeds the timer latch time described later, the output is changed over to the standby mode.

In this method, latch is released by setting PS = “L”

(4) Output short-circuit condition warning output pin

EMO, warning output pin of the output short-circuit protection circuit, is an open-drain output.

EMO outputs ON when output short-circuit is detected.

(5) Timer latch time (Tscp)

The time to output OFF when an output short-circuit occurs can be set by the capacitor connected between the CEM pin and GND. The capacitor (C) value can be determined as follows :

Timer latch : Tscp $\quad$ Tscp ≈ Td+C × V/I [sec]

Td : Internal delay time TYP 4µs

V : Threshold voltage of comparator TYP 1V

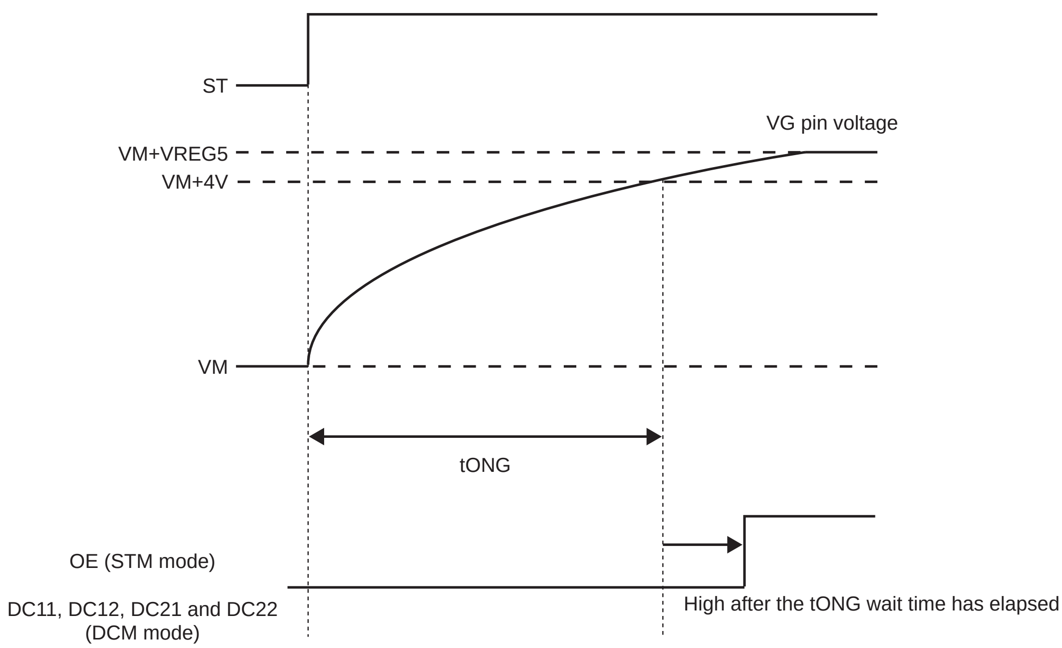
I : CEM charge current TYP 2.5µA

The Tscp time must be set so as not to exceed 80% of the chopping period.

The CEN pin must be connected to (S) GND when the output short protection funtion is not to be used.

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.

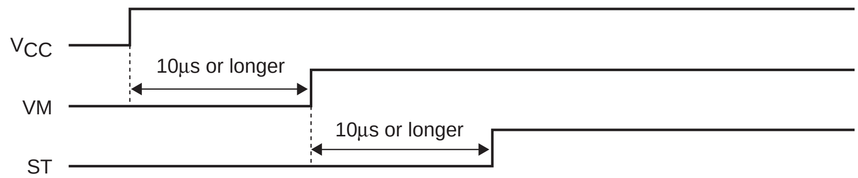


VG Pin Voltage Schematic View

When controlling the stepping motor driver with the CLK-IN input, set the ST pin High, wait for the tONG time duration or longer, and then set the OE pin High. In addition, when controlling the stepping motor and DC motor driver with parallel input, set the ST pin High, wait for the tONG time duration or longer, and then start the control for each channel.

Recommended Power-on Sequence

Provide a wait time of 10μs or more after the V_{CC} power supply rises before supplying the motor power supply.
Provide a wait time of 10μs or more after the motor power supply rises before setting the ST pin High.



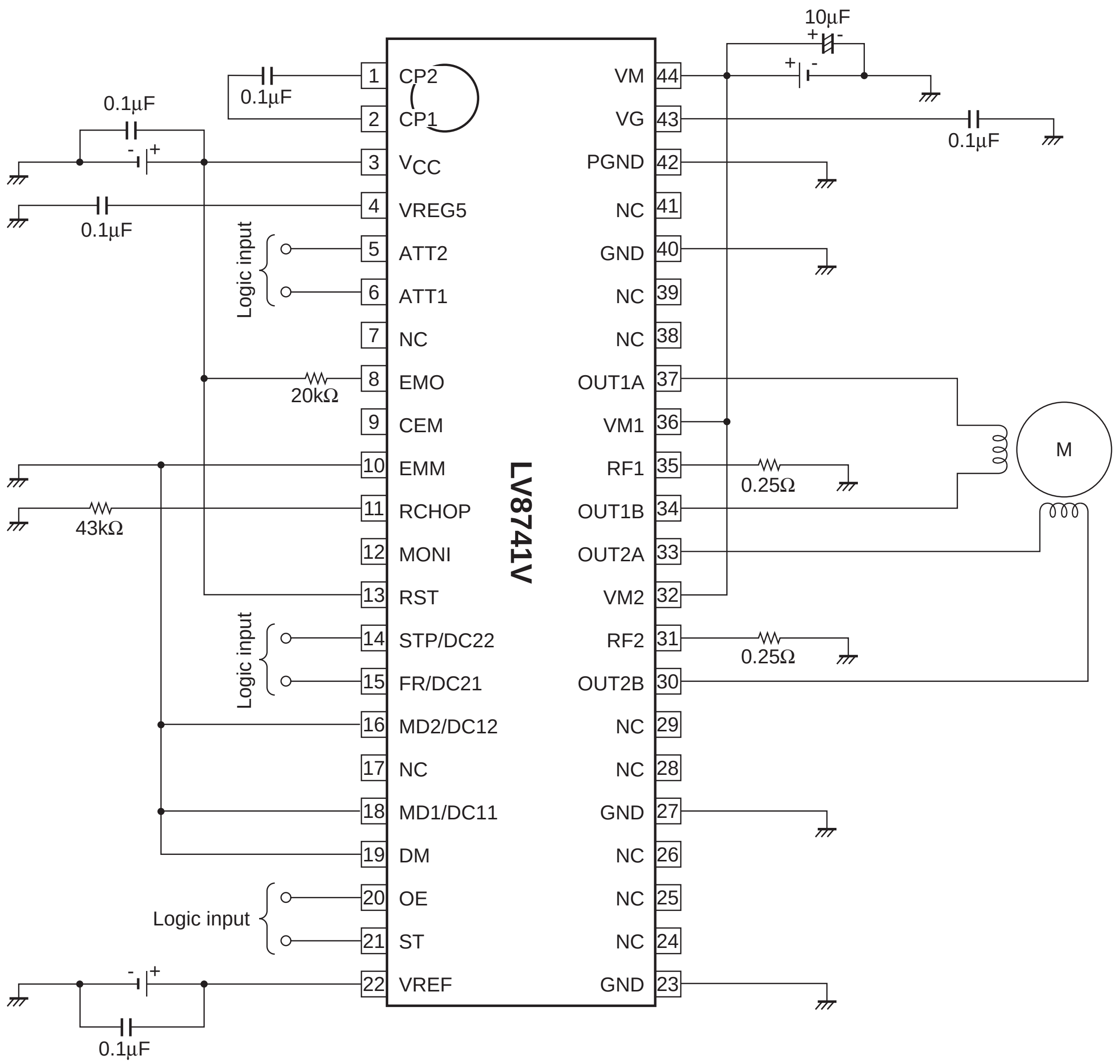
The above power-on sequence is only a recommendation, and there is no risk of damage to the IC even if this sequence is not followed.

Notes on Board Design Layout

- Use thick GND lines and connect to GND stabilization points by the shortest distance possible to lower the impedance.
- Use thick VM, VM1 and VM2 lines, and short-circuit these lines to each other by a short distance.
- Place the capacitors connected to V_{CC} and VM as close to the IC as possible, and connect each capacitor to a separate GND stabilization point using a thick independent line.
- Place the RF resistor as near to the IC as possible, and connect it to the GND stabilization point using a thick independent line.
- When thermal radiation is necessary for the exposed die-pad on the bottom of the IC, solder it to GND. Also, do not connect the exposed die-pad to other than GND.

Application Circuits

- Stepping motor driver application circuit example



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

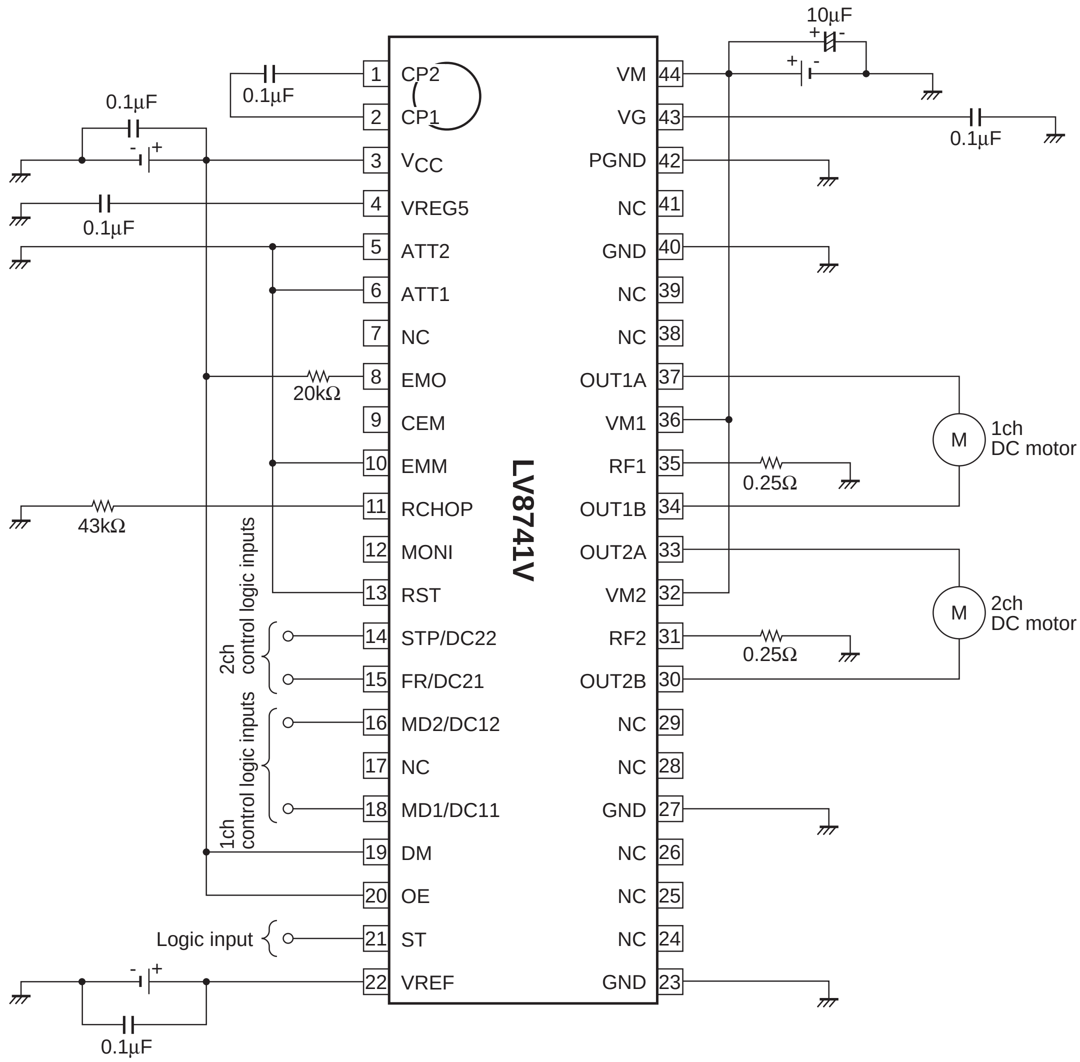
- 2-phase excitation (MD1/DC11 = Low, MD2/DC12 = Low)
- Auto recovery-type output short-circuit protection function (EMM = Low)
- Reset function fixed to normal operation (RST = High)
- Chopping frequency : 37kHz (RCHOP = 43kΩ)

ATT1	ATT2	Current setting reference voltage
L	L	VREF/3×100%
H	L	VREF/3×67%
L	H	VREF/3×50%
H	H	VREF/3×33%

The set current value is as follows :

I_{OUT} = (VREF/3 × Voltage setting ratio) /0.25Ω

• DC motor driver application circuit example



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

- Auto recovery-type output short-circuit protection function (EMM = Low)
- Output enable function fixed to output ON state (OE = High)
- Current limit reference voltage setting = 100% (ATT1 = Low, ATT2 = Low)
- Chopping frequency : 37kHz (RCHOP = 43kΩ)

The current limit value is as follows :

Ilimit = (VREF/3) /0.25Ω

This catalog provides information as of January, 2008. Specifications and information herein are subject to change without notice.