LV8772

ON Semiconductor®

http://onsemi.com

Bi-CMOS LSI

PWM Constant-Current Control Stepper Motor Driver Application Note

Overview

LV8772 is a micro step drive stepper motor driver corresponding to the 1/16 step resolution. It is most suitable for the drive of a stepping motor for OA, amusements.

Function

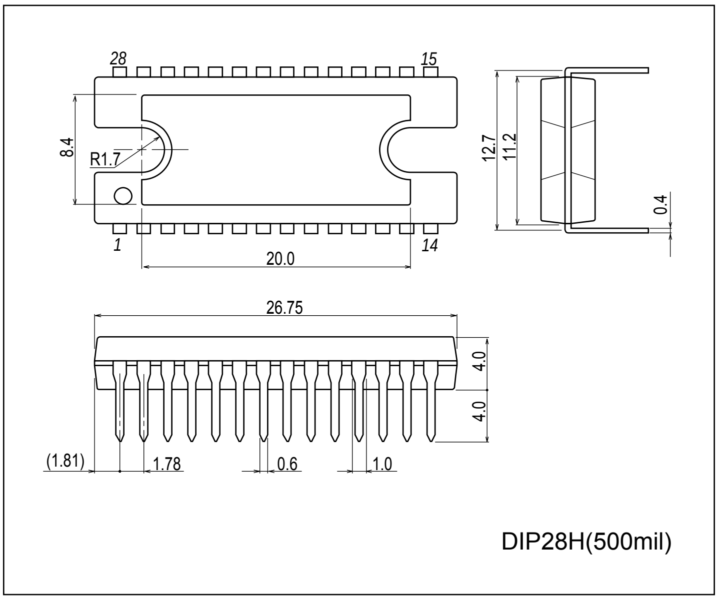
- Single-channel PWM current control stepping motor driver incorporated.
- BiCDMOS process IC
- Low on resistance (total of upper and lower: 0.55Ω, Ta=25°C)
- Micro-step mode can be set to Full-step, Half-step, Quarter-step, or 1/16-step
- Excitation step proceeds only by step signal input
- Motor current selectable in four steps
- Output short-circuit protection circuit incorporated
- Unusual condition warning output pins
- Built-in thermal shutdown circuit
- No control power supply required

Typical Applications

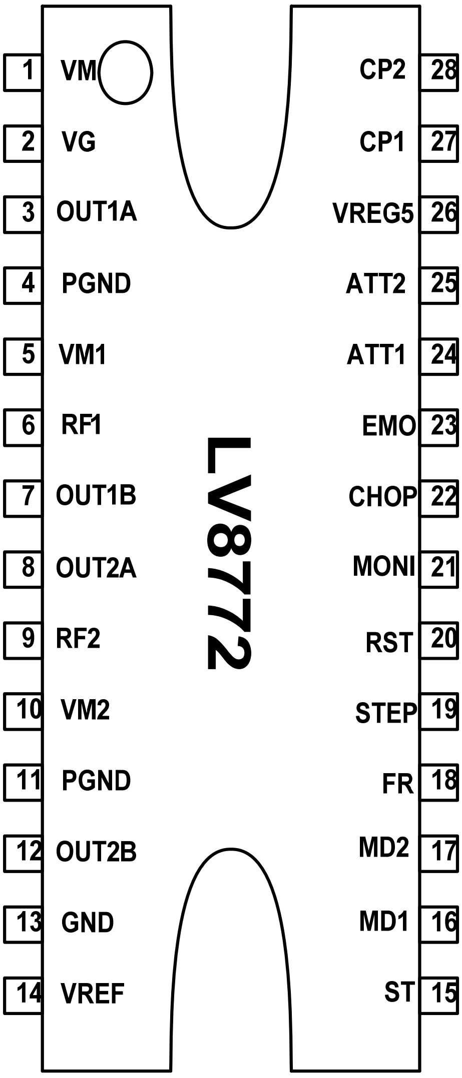
- PPC (Plain Paper Copier)
- LBP (Laser Beam Printer)
- Scanner
- Industrial
- Amusement
- Textile

Package Dimensions

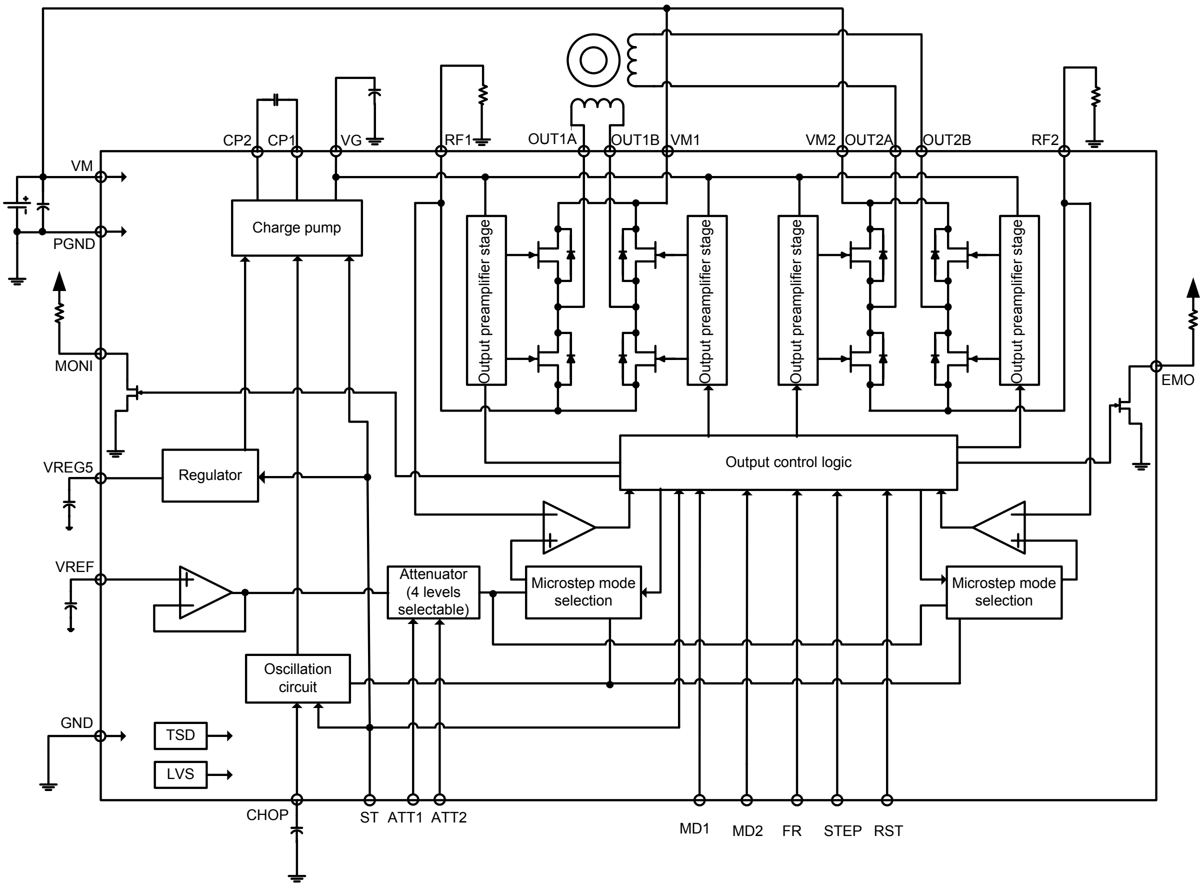
unit: mm (typ)
3147C



Pin Assignment



Block Diagram



Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	VM max	VM, VM1, VM2	36	V
Output peak current	I_O peak	tw ≤ 10ms, duty 20%, each 1ch	3.0	A
Output current	I_O max	each 1ch	2.5	A
Logic input voltage	V_{IN} max	ST, ATT1, ATT2, MD1, MD2, FR, STEP, RST	-0.3 to +6	V
MONI/EMO input voltage	Vmo/Vemo		-0.3 to +6	V
Allowable power dissipation	Pd max1	1 unit	3.0	W
	Pd max2	*	5.4	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

Caution 1) Absolute maximum ratings represent the value which cannot be exceeded for any length of time.
Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply voltage range	VM	VM, VM1, VM2	9		32	V
Logic input voltage	V_{IN}	ST, ATT1, ATT2, MD1, MD2, FR, STEP, RST	0		5.5	V
VREF input voltage range	VREF		0		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”, VM+VM1+VM2		100	400	μA
Current drain	IM	ST = “H”, OE = “L”, with no load, VM+VM1+VM2		3.2	5	mA
VREG5 output voltage	Vreg5	I_O = -1mA	4.5	5	5.5	V
Thermal shutdown temperature	TSD	Design guarantee	150	180	200	°C
Thermal hysteresis width	ΔTSD	Design guarantee		40		°C

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Parameter		Symbol	Conditions	Ratings			Unit
				min	typ	max	
Motor driver							
Output on resistance		Ronu1	I_O = 2.5A, Upper-side on resistance		0.3	0.4	Ω
		Rond1	I_O = 2.5A, Lower-side on resistance		0.25	0.33	Ω
Output leakage current		$I_O$leak				50	μA
Diode forward voltage		VD	ID = -2.5A		1.2	1.4	V
Logic pin input current		I_{IN}L	V_{IN} = 0.8V, ST, ATT1, ATT2, MD1, MD2, FR, STEP, RST	4	8	12	μA
		I_{IN}H	V_{IN} = 5V	30	50	70	μA
Logic input voltage	high-level	V_{IN}H	ST, ATT1, ATT2, MD1, MD2, FR, STEP, RST	2.0		5.5	V
	low-level	V_{IN}L		0		0.8	V
Current setting comparator threshold voltage (current step switching)	1/16 step resolution	Vtdac0_4W	Step 0 (When initialized : channel 1 comparator level)	0.291	0.3	0.309	V
		Vtdac1_4W	Step 1 (Initial state+1)	0.291	0.3	0.309	V
		Vtdac2_4W	Step 2 (Initial state+2)	0.285	0.294	0.303	V
		Vtdac3_4W	Step 3 (Initial state+3)	0.279	0.288	0.297	V
		Vtdac4_4W	Step 4 (Initial state+4)	0.267	0.276	0.285	V
		Vtdac5_4W	Step 5 (Initial state+5)	0.255	0.264	0.273	V
		Vtdac6_4W	Step 6 (Initial state+6)	0.240	0.249	0.258	V
		Vtdac7_4W	Step 7 (Initial state+7)	0.222	0.231	0.240	V
		Vtdac8_4W	Step 8 (Initial state+8)	0.201	0.21	0.219	V
		Vtdac9_4W	Step 9 (Initial state+9)	0.180	0.189	0.198	V
		Vtdac10_4W	Step 10 (Initial state+10)	0.157	0.165	0.173	V
		Vtdac11_4W	Step 11 (Initial state+11)	0.134	0.141	0.148	V
		Vtdac12_4W	Step 12 (Initial state+12)	0.107	0.114	0.121	V
		Vtdac13_4W	Step 13 (Initial state+13)	0.080	0.087	0.094	V
		Vtdac14_4W	Step 14 (Initial state+14)	0.053	0.06	0.067	V
		Vtdac15_4W	Step 15 (Initial state+15)	0.023	0.03	0.037	V
	Quarter step resolution	Vtdac0_W	Step 0 (When initialized : channel 1 comparator level)	0.291	0.3	0.309	V
		Vtdac4_W	Step 4 (Initial state+1)	0.267	0.276	0.285	V
		Vtdac8_W	Step 8 (Initial state+2)	0.201	0.21	0.219	V
		Vtdac12_W	Step 12 (Initial state+3)	0.107	0.114	0.121	V
	Half step resolution	Vtdac0_H	Step 0 (When initialized : channel 1 comparator level)	0.291	0.3	0.309	V
		Vtdac8_H	Step 8 (Initial state+1)	0.201	0.21	0.219	V
	Full step resolution	Vtdac8_F	Step 8' (When initialized : channel 1 comparator level)	0.291	0.3	0.309	V
Current setting comparator threshold voltage (current attenuation rate switching)		Vtatt00	ATT1 = L, ATT2 = L	0.291	0.3	0.309	V
		Vtatt01	ATT1 = H, ATT2 = L	0.232	0.24	0.248	V
		Vtatt10	ATT1 = L, ATT2 = H	0.143	0.15	0.157	V
		Vtatt11	ATT1 = H, ATT2 = H	0.053	0.06	0.067	V
Chopping frequency		Fchop	Cchop = 180pF	45	55	65	kHz
CHOP pin charge/discharge current		Ichop		7	10	13	μA
Chopping oscillation circuit threshold voltage		Vtup		0.8	1	1.2	V
		Vtdown		0.4	0.5	0.6	V
VREF pin input current		Iref	VREF = 1.5V	-0.5			μA
MONI pin saturation voltage		Vsatmon	Imoni = 1mA			400	mV
Charge pump							
VG output voltage		VG		28	28.7	29.8	V
Rise time		tONG	VG = 0.1μF		200	500	μS
Oscillator frequency		Fosc		90	125	150	kHz
Output short-circuit protection							
EMO pin saturation voltage		Vsatemo	Iemo = 1mA			400	mV

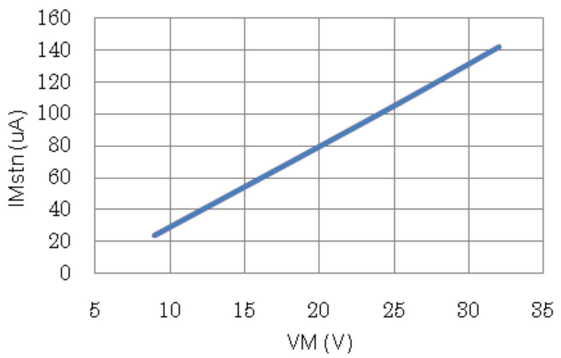


Figure 1. Standby Mode Current Drain vs VM Voltage

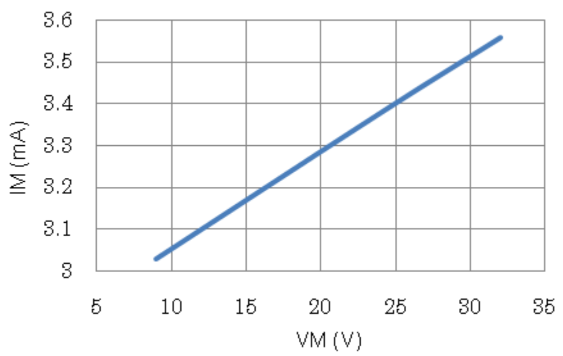


Figure 2. Current Drain vs VM Voltage

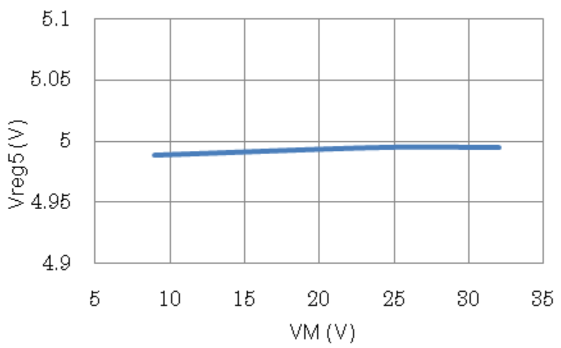


Figure 3. VREG5 Output Voltage vs VM Voltage

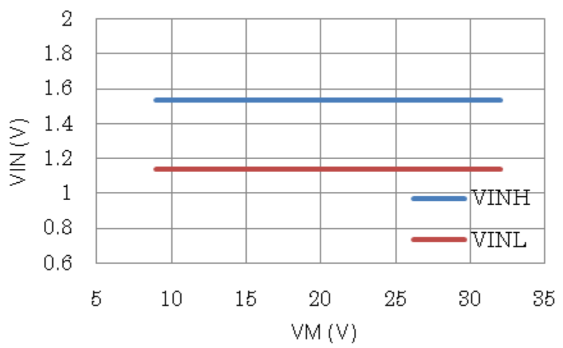


Figure 4. Logic High/Low-Level Input Voltage vs Output Current

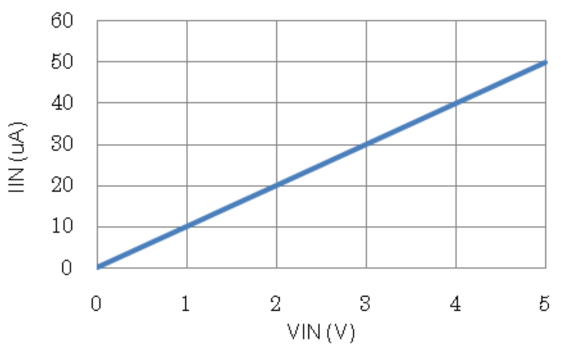


Figure 5. Logic Pin Input Current vs Input Voltage

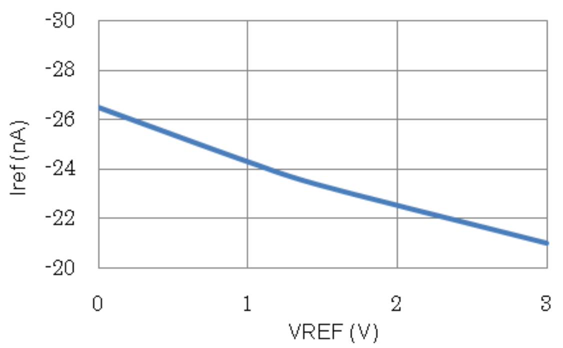


Figure 6. VREF Pin Input Current vs VREF Voltage

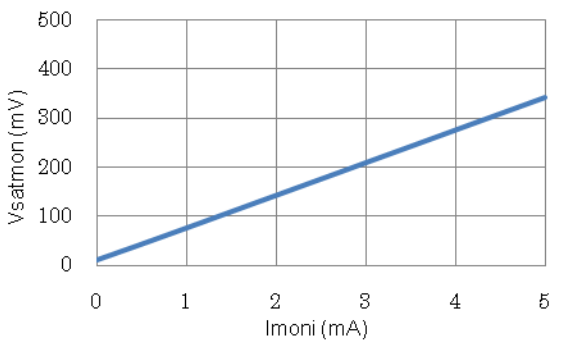


Figure 7. MONI Pin Saturation Voltage vs MONI Current

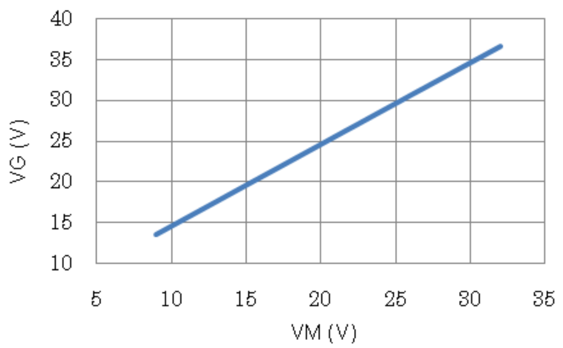


Figure 8. VG Output Voltage vs VM Voltage

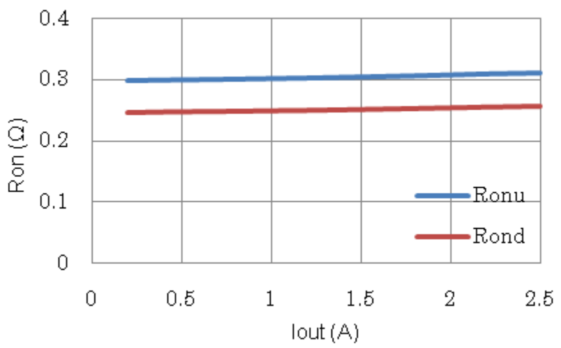


Figure 9. Output on Resistance vs Output Current

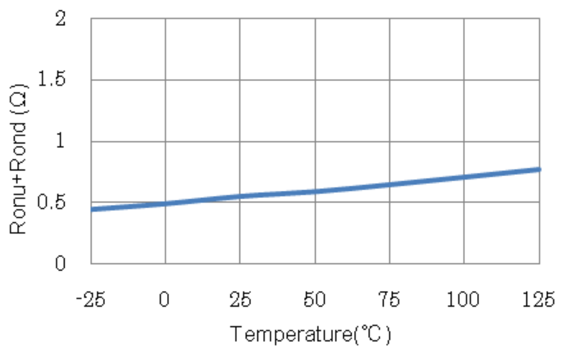


Figure 10. Output on Resistance vs Temperature

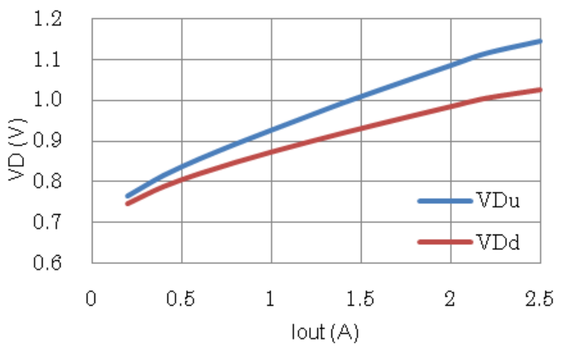
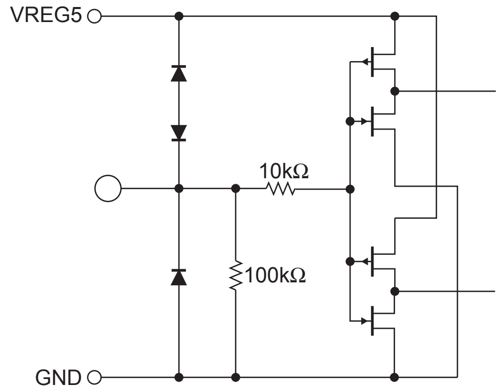
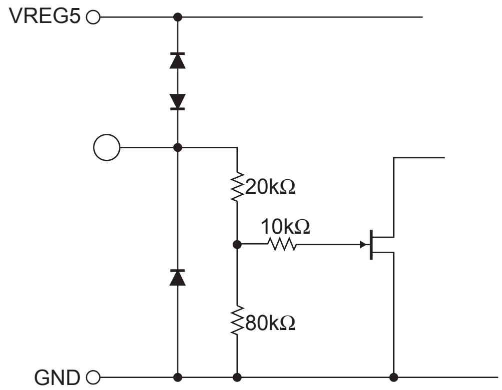
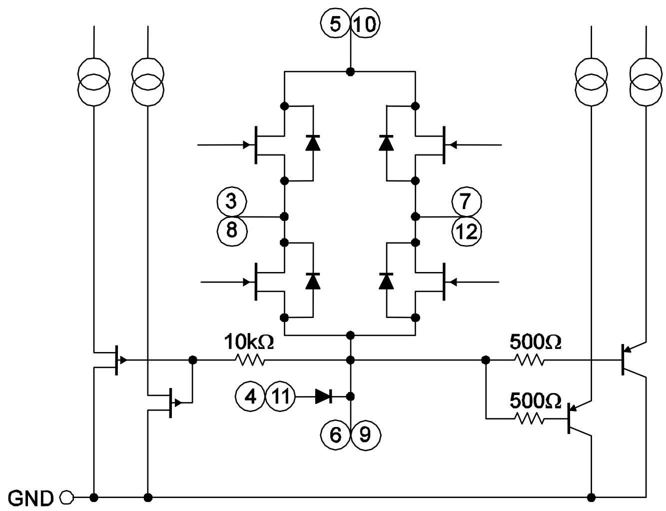


Figure 11. Diode Forward Voltage vs Output Current

Pin Functions

Pin No.	Pin Name	Pin Function	Equivalent Circuit
25	ATT2	Motor holding current switching pin.	
24	ATT1	Motor holding current switching pin.	
20	RST	RESET input pin.	
19	STEP	STEP signal input pin.	
18	FR	CW / CCW signal input pin.	
17	MD2	Excitation mode switching pin 2.	
16	MD1	Excitation mode switching pin 1.	
15	ST	Chip enable pin.	
12	OUT2B	Channel 2 OUTB output pin.	
4,11	PGND	Power system ground.	
10	VM2	Channel 2 motor power supply connection pin.	
9	RF2	Channel 2 current-sense resistor connection pin.	
8	OUT2A	Channel 2 OUTA output pin.	
7	OUT1B	Channel 1 OUTB output pin.	
6	RF1	Channel 1 current-sense resistor connection pin.	
5	VM1	Channel 1 motor power supply pin.	
3	OUT1A	Channel 1 OUTA output pin.	

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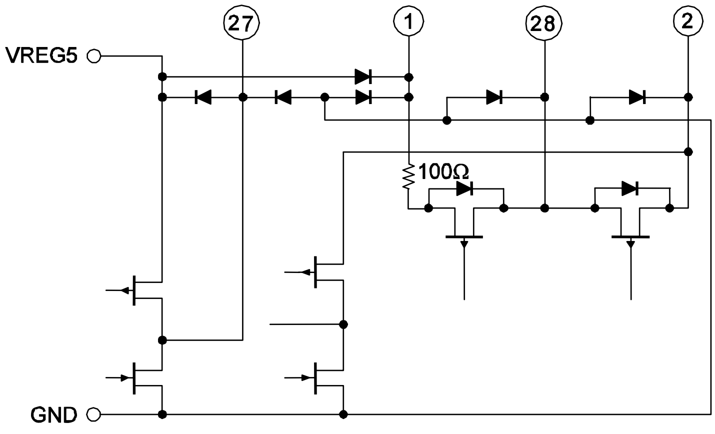
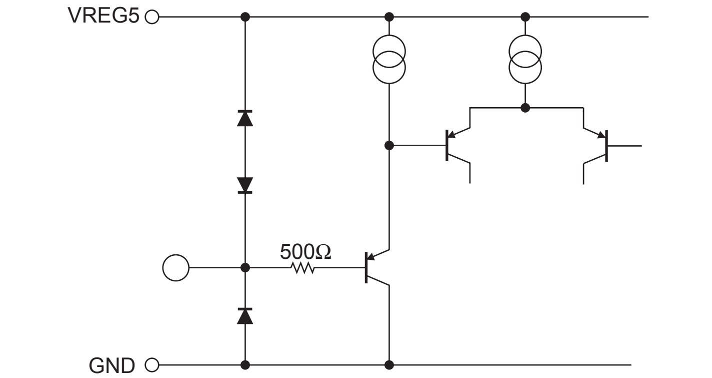
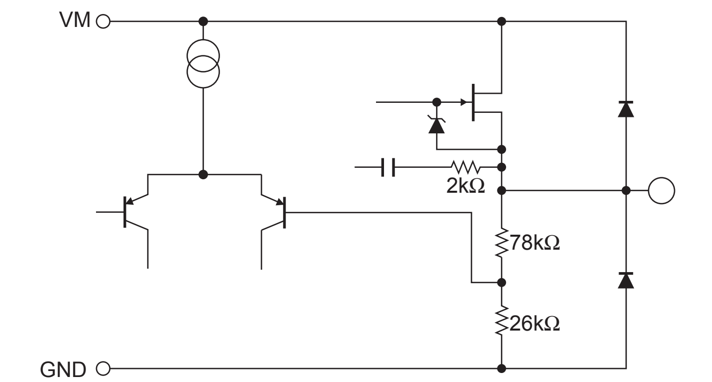
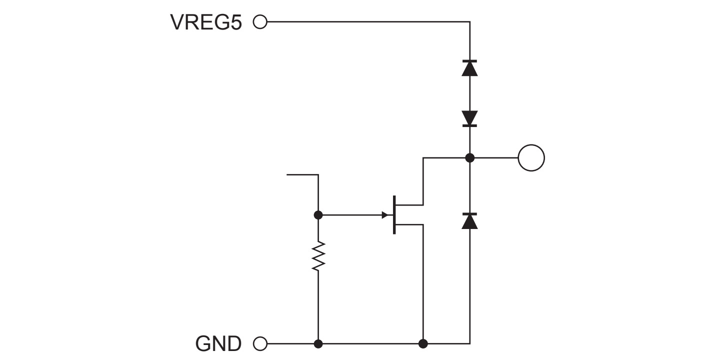
<table>
<tr><th>Pin No.</th><th>Pin Name</th><th>Pin Function</th><th>Equivalent Circuit</th></tr>
<tr><td>2
1
28
27</td><td>VG
VM
CP2
CP1</td><td>Charge pump capacitor connection pin.
Motor power supply connection pin.
Charge pump capacitor connection pin.
Charge pump capacitor connection pin.</td><td>
</td></tr>
<tr><td>14</td><td>VREF</td><td>Constant current control reference voltage input pin.</td><td>
</td></tr>
<tr><td>26</td><td>VREG5</td><td>Internal power supply capacitor connection pin.</td><td>
</td></tr>
<tr><td>23

21</td><td>EMO

MONI</td><td>Output short-circuit state warning output pin.
Position detection monitor pin.</td><td>
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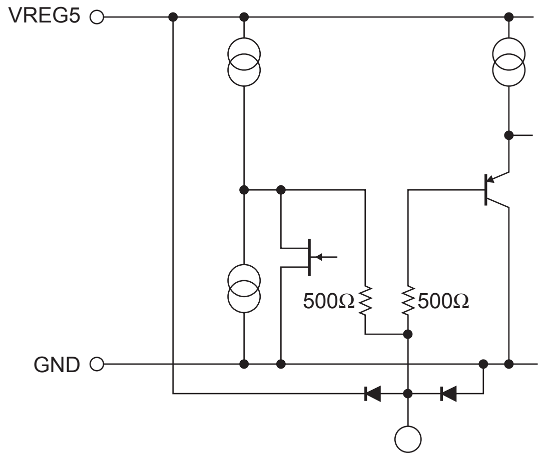
Pin No.	Pin Name	Pin Function	Equivalent Circuit
22	CHOP	Chopping frequency setting capacitor connection pin.	
13	GND	Ground.	

Description of operation

Input Pin Function

The function to prevent including the turn from the input to the power supply is built into each input pin. Therefore, the current turns to the power supply even if power supply (VM) is turned off with the voltage impressed to the input pin and there is not crowding.

(1) Chip enables function

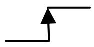
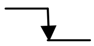
This IC is switched between standby and operating mode by setting the ST pin. In standby mode, the IC is set to power-save mode and all logic is reset. In addition, the internal regulator circuit and charge pump circuit do not operate in standby mode.

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

STM mode

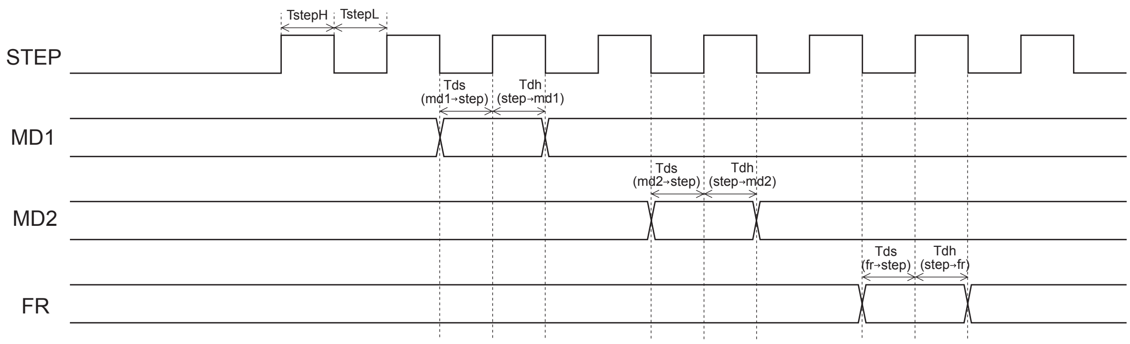
(1) STEP pin function

STEP input advances electrical angle at every rising edge (advances step by step).

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

STEP input MIN pulse width (common in H/L): 500ns (MAX input frequency: 1MHz)
However, constant current control is performed by PWM during chopping period, which is set by the capacitor connected between CHOP and GND. You need to perform chopping more than once per step. For this reason, for the actual STEP frequency, you need to take chopping frequency and chopping count into consideration.
For example, if chopping frequency is 50kHz (20μs) and chopping is performed twice per step, the maximum STEP frequency is obtained as follows: f = 1/(20μs×2) = 25kHz.

(2) Input timing



TstepH/TstepL : Clock H/L pulse width (min 500ns)
Tds : Data set-up time (min 500ns)
Tdh : Data hold time (min 500ns)

Figure 12. Input timing chart

(3) Position detection monitoring function

The MONI position detection monitoring pin is of an open drain type.
When the excitation position is in the initial position, the MONI output is placed in the ON state.
(Refer to "Examples of current waveforms in each of the excitation modes.")

(4) Setting constant-current control reference current

This IC is designed to automatically exercise PWM constant-current chopping control for the motor current by setting the output current. Based on the voltage input to the VREF pin and the resistance connected between RF and GND, the output current that is subject to the constant-current control is set using the calculation formula below:

I_{OUT} = (VREF/5) /RF resistance

* The above setting is the output current at 100% of each excitation mode.

If VREF is open or the setting is out of the recommendation operating range, output current will increase and you cannot set constant current under normal condition. Hence, make sure that VREF is set in accordance with the specification.
However, if current control is not performed (if the IC is used by saturation drive) make sure that the setting is as follows: VREF=5V or VREF=VREG5.

Power dissipation of RF resistor is obtained as follows: $Pd=Iout^2 \times RF$. Make sure to take allowable power dissipation into consideration when you select RF resistor.

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.

Attenuation function for VREF input voltage

ATT1	ATT2	Current setting reference voltage attenuation ratio
Low	Low	100%
High	Low	80%
Low	High	50%
High	High	20%

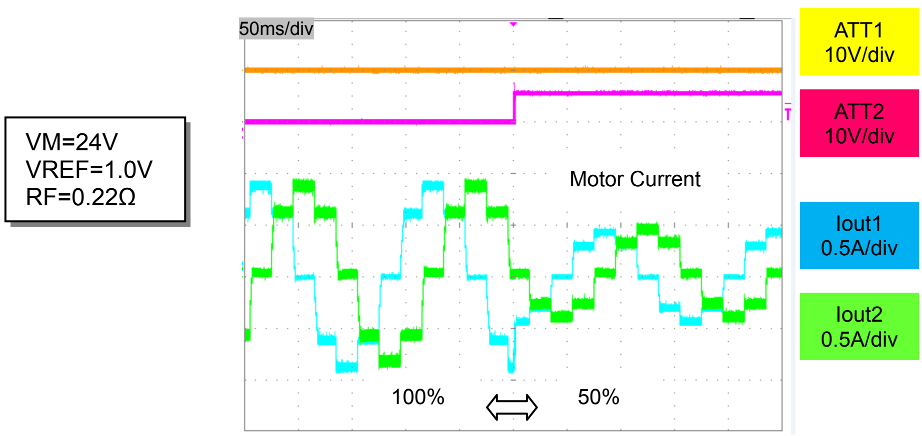


Figure 13. Attenuation operation

The formula used to calculate the output current when using the function for attenuating the VREF input voltage is given below.

I_{OUT} = (VREF/5) × (attenuation ratio) /RF resistance

Example: At VREF of 1.0V, 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} = 1.0V/5 × 100%/0.22Ω = 0.91A

If, in this state, (ATT1, ATT2) is set to (H, H), IOUT will be as follows:

I_{OUT} =0.91A × 50% = 455mA

In this way, the output current is attenuated when the motor holding current is supplied so that power can be conserved.

(5) Reset function

RST	Operating mode
Low	Normal operation
High	Reset state

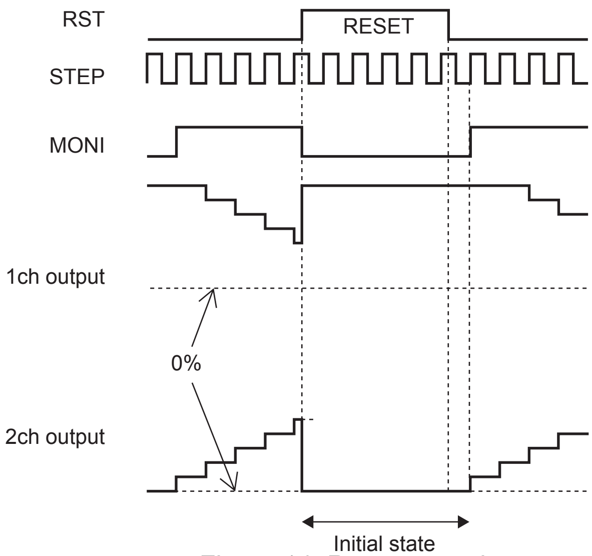


Figure 14. Reset operation

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

(6) Forward/reverse switching function

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

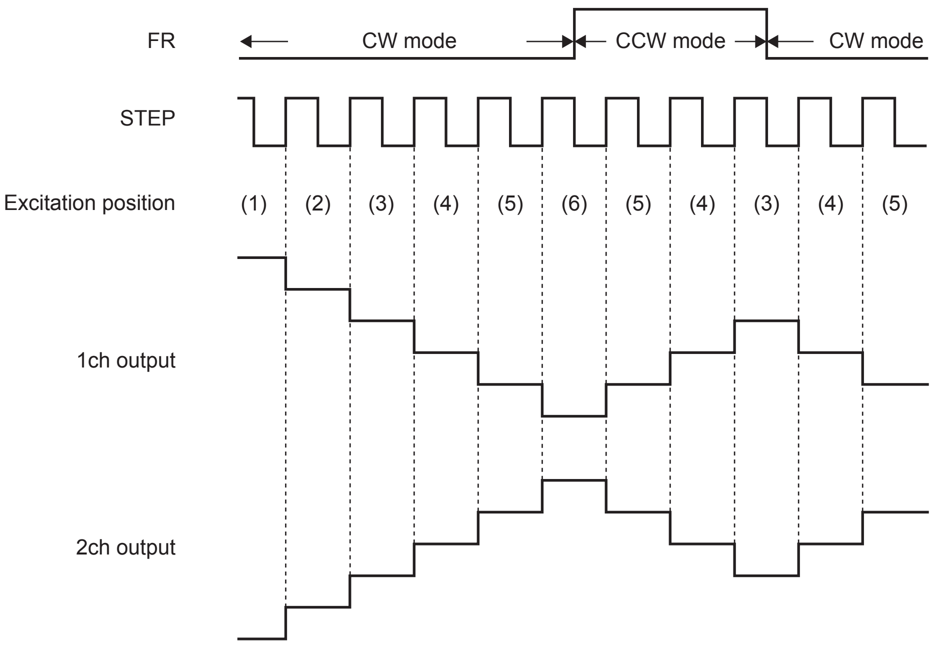


Figure 15. FR operation

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, this IC performs chopping operations at the frequency determined by the capacitor (Cchop) connected between the CHOP pin and GND.
The chopping frequency is set as shown below by the capacitor (Cchop) connected between the CHOP pin and GND.

$$Fchop = Ichop / (Cchop \times Vtchop \times 2) \quad (Hz)$$

Ichop: Capacitor charge/discharge current, typ 10μA
Vtchop: Charge/discharge hysteresis voltage (Vtup-Vtdown), typ 0.5V

For instance, when Cchop is 200pF, the chopping frequency will be as follows:

$$Fchop = 10\mu A / (180pF \times 0.5V \times 2) = 55\ kHz$$

The higher the chopping frequency is, the greater the output switching loss becomes. As a result, heat generation issue arises. The lower the chopping frequency is, the lesser the heat generation becomes. However, current ripple occurs. Since noise increases when switching of chopping takes place, you need to adjust frequency with the influence to the other devices into consideration. The frequency range should be between 40kHz and 125kHz.

(8) Blanking period

If, when exercising PWM constant-current chopping control over the motor current, the mode is switched from decay to charge, the recovery current of the parasitic diode may flow to the current sensing resistance, causing noise to be carried on the current sensing resistance pin, and this may result in erroneous detection. To prevent this erroneous detection, a blanking period is provided to prevent the noise occurring during mode switching from being received. During this period, the mode is not switched from charge to decay even if noise is carried on the current sensing resistance pin.
The blanking time is fixed at approximately 1μs.

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

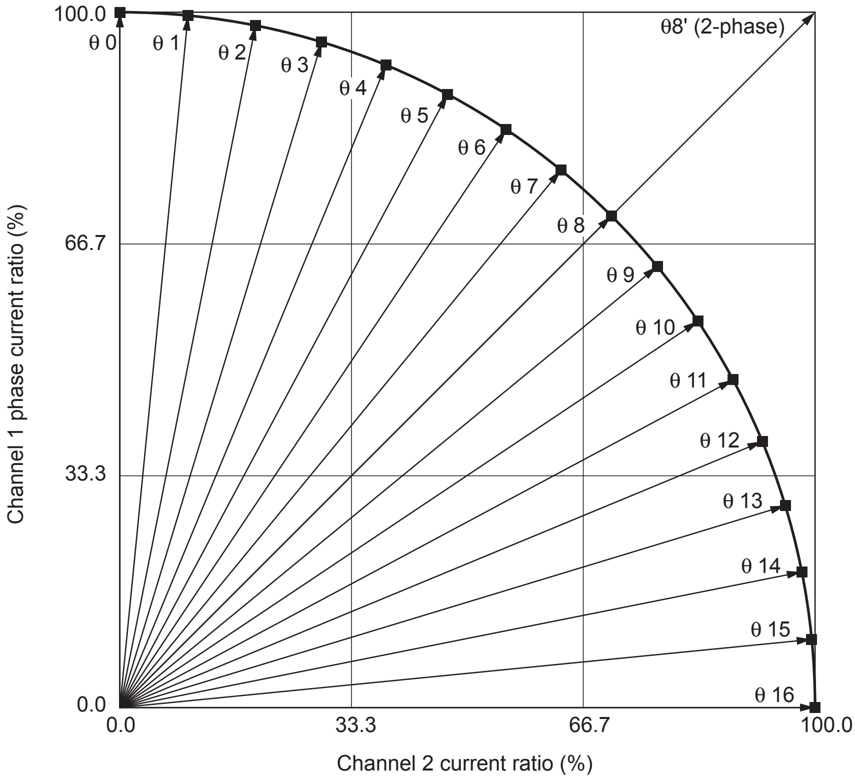


Figure 16. Current vector position

Setting current ration in each Micro-step mode

STEP	1/16 step (%)		Quarter step (%)		Half step (%)		Full step (%)	
	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2
θ0	100	0	100	0	100	0		
θ1	100	10						
θ2	98	20						
θ3	96	29						
θ4	92	38	92	38				
θ5	88	47						
θ6	83	55						
θ7	77	63						
θ8	70	70	70	70	70	70	100	100
θ9	63	77						
θ10	55	83						
θ11	47	88						
θ12	38	92	38	92				
θ13	29	96						
θ14	20	98						
θ15	10	100						
θ16	0	100	0	100	0	100		

(10) Excitation mode setting function

MD1	MD2	Micro-step resolution (Excitation mode)	Initial position	
			Channel 1	Channel 2
Low	Low	Full step (2 phase excitation)	100%	-100%
High	Low	Half step (1-2 phase excitation)	100%	0%
Low	High	Quarter step (W1-2 phase excitation)	100%	0%
High	High	1/16 step (4W1-2 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.

(11) Micro-step mode switching operation

When micro-step mode is switched while the motor is rotating, each drive mode operates with the following sequence.

Clockwise mode

Before the micro-step mode changes		Position after the micro-step mode is changed			
Micro-step mode	Position	1/16 step	Quarter step	Half step	Full step
1/16 step	θ0-θ1		θ4	θ8	θ8’
	θ2-θ3		θ4	θ8	θ8’
	θ4-θ5		θ8	θ8	θ8’
	θ6-θ7		θ8	θ8	θ8’
	θ8-θ9		θ12	θ16	θ8’
	θ10-θ11		θ12	θ16	θ8’
	θ12-θ13		θ16	θ16	θ8’
	θ14-θ15		θ16	θ16	θ8’
	θ16		-θ12	-θ8	-θ8’
Quarter step	θ0	θ1		θ8	θ8’
	θ4	θ5		θ8	θ8’
	θ8	θ9		θ16	θ8’
	θ12	θ13		θ16	θ8’
	θ16	-θ15		-θ8	-θ8’
Half step	θ0	θ1	θ4		θ8’
	θ8	θ9	θ12		θ8’
	θ16	-θ15	-θ12		-θ8’
Full step	θ8’	θ9	θ12	θ16	

*As for θ0 to θ16, please refer to the step position of current ratio setting.

If you switch micro-step mode while the motor is driving, the mode setting will be reflected from the next STEP and the motor advances to the closest excitation position at switching operation.

(12) Typical current waveform in each micro-step mode

Full step (CW mode)

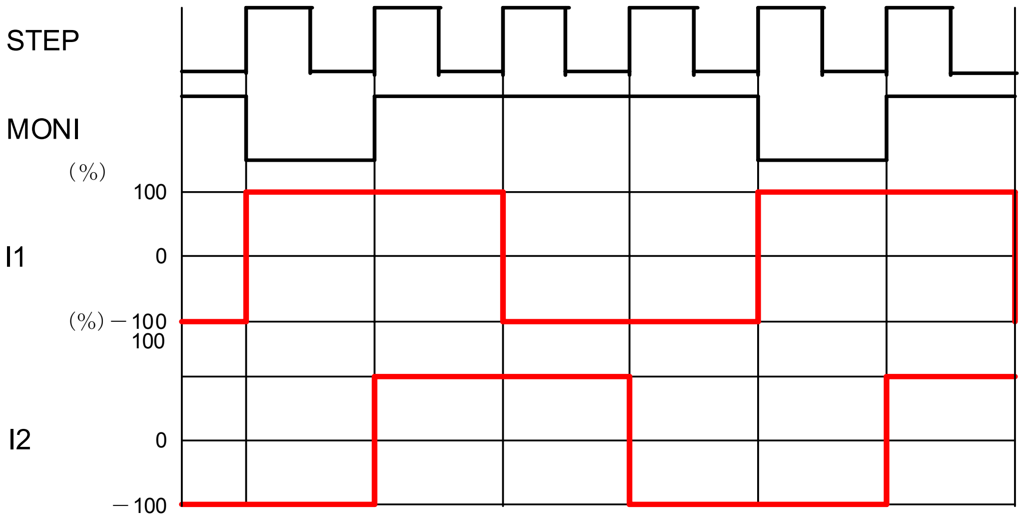


Figure 17. Current waveform of Full step in CLK-IN

Half step (CW mode)

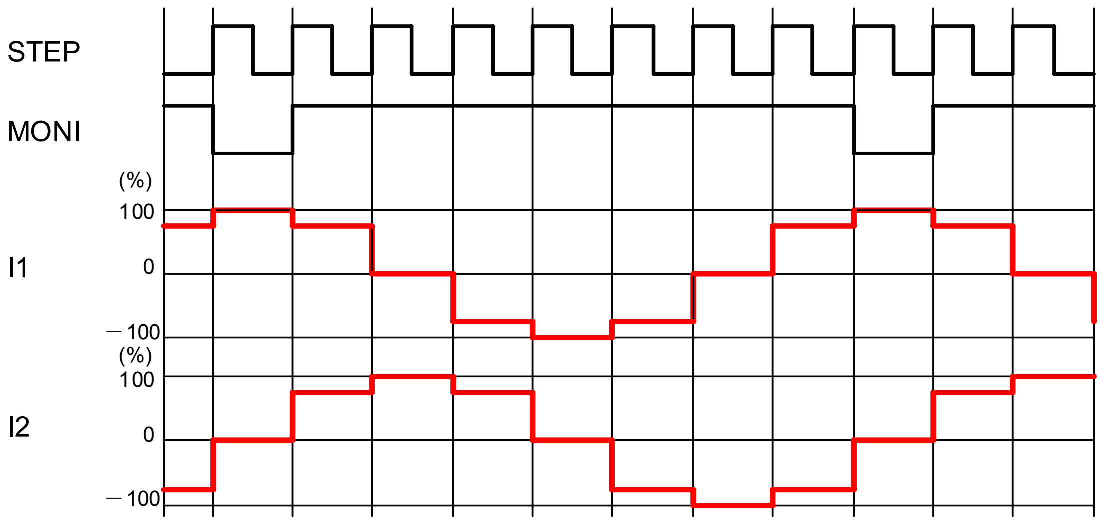


Figure 18. Current waveform of Half step in CLK-IN

Quarter step (CW mode)

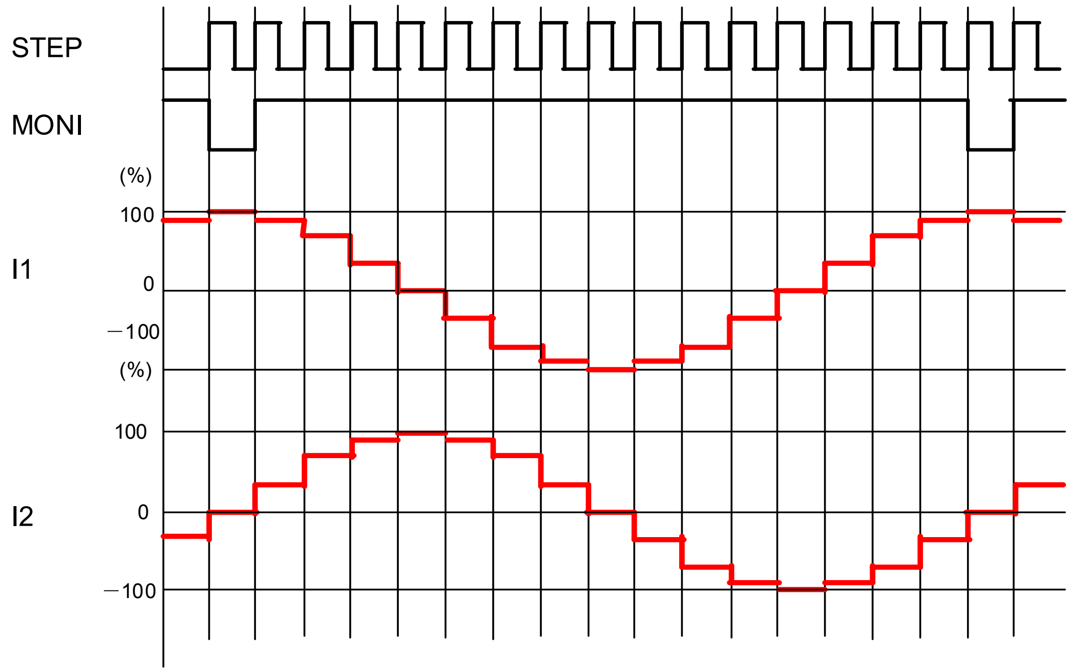


Figure 19. Current waveform of Quarter step in CLK-IN

1/16 step (CW mode)

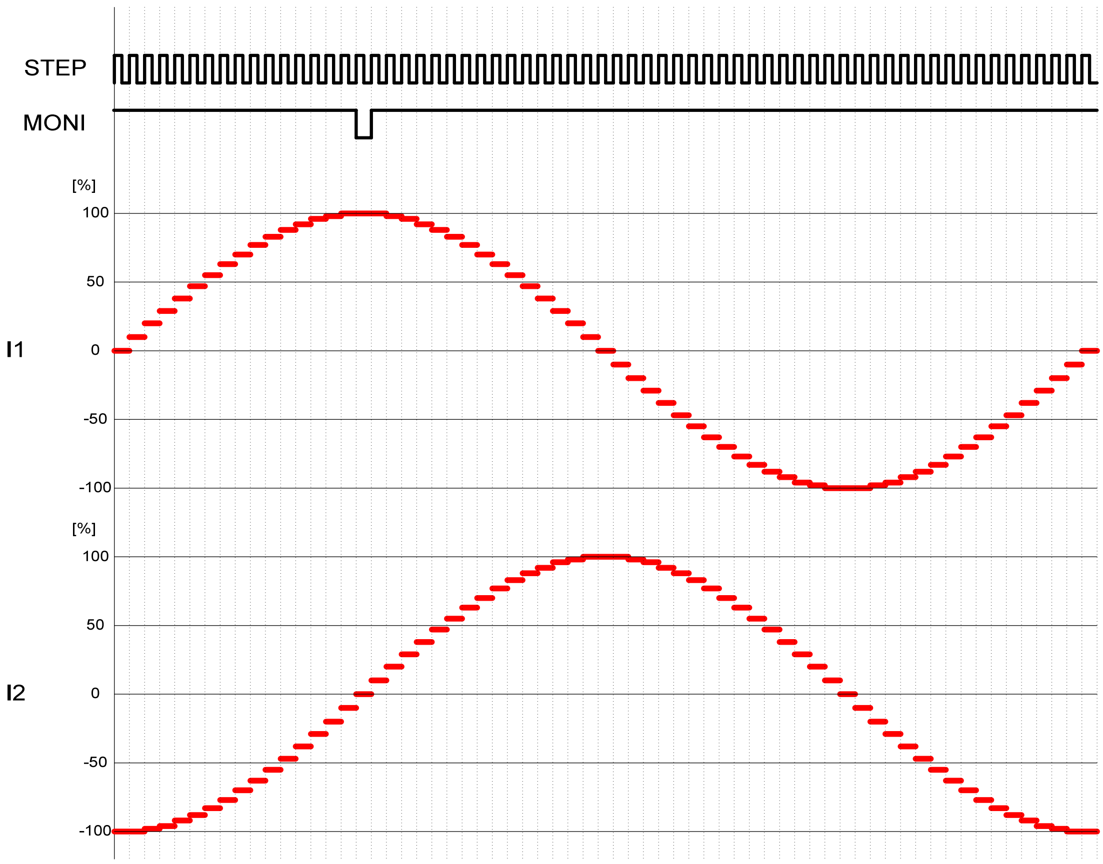
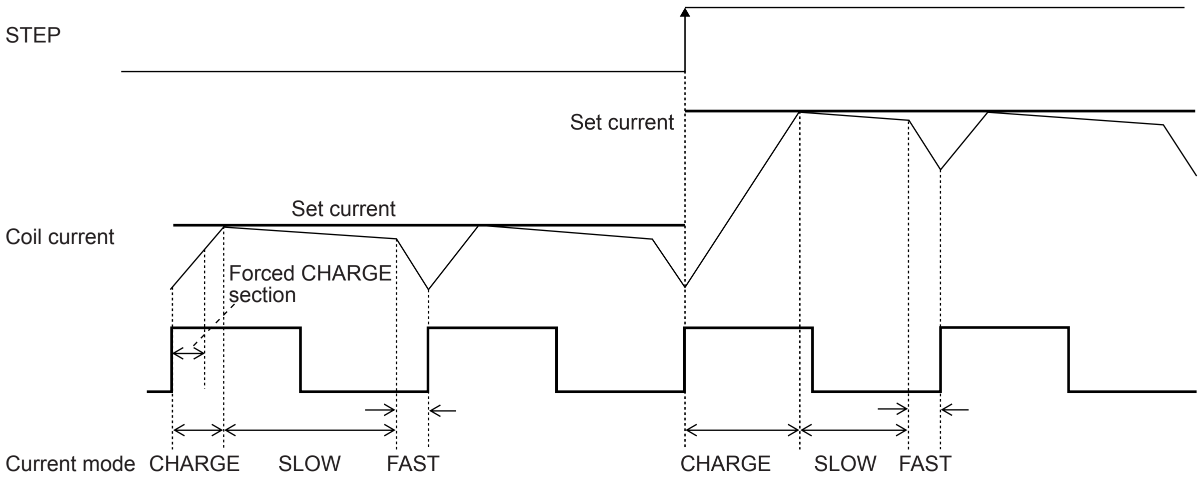


Figure 20. Current waveform of 1/16 step in CLK-IN

(13) Current control operation specification

(Sine wave increasing direction)



(Sine wave decreasing direction)

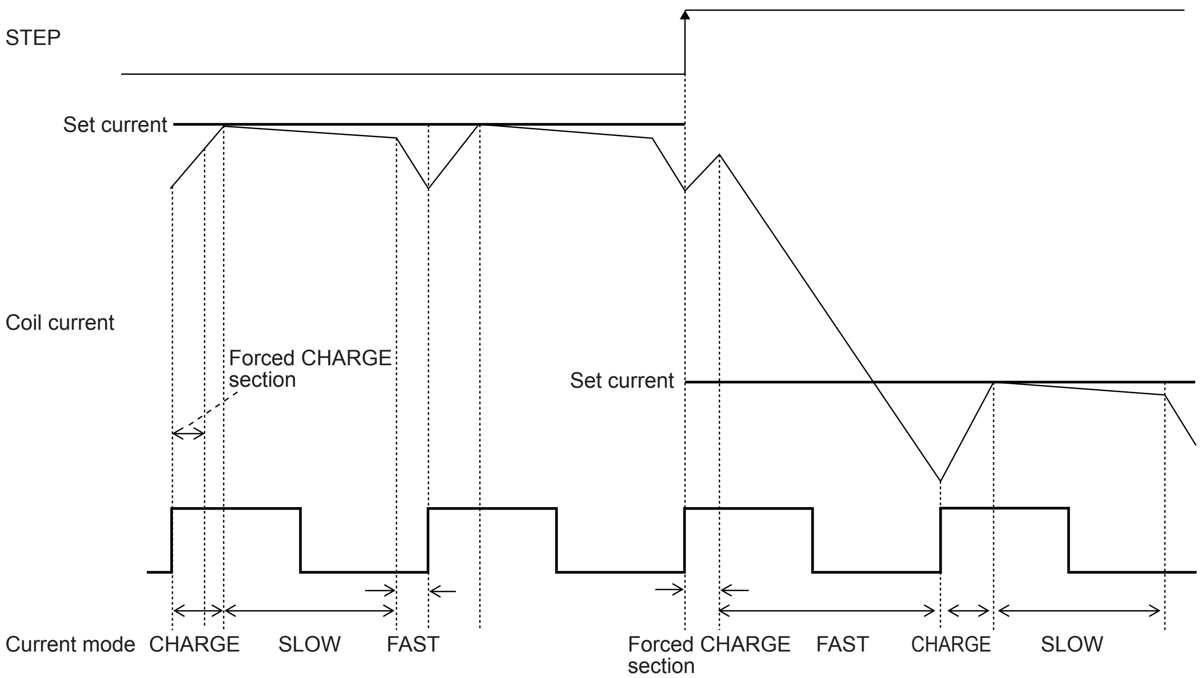


Figure 21. Current control operation

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

- At rise of chopping frequency, the CHARGE mode begins. (In the time defined as the "blanking time," the CHARGE mode is forced regardless of the magnitude of the coil current (ICOIL) and set current (IREF).)
- The coil current (ICOIL) and set current (IREF) are compared in this blanking time.
  - When (ICOIL < IREF) state exists;
    - The CHARGE mode up to ICOIL ≥ IREF, then followed by changeover to the SLOW DECAY mode, and finally by the FAST DECAY mode for approximately 1μs.
  - When (ICOIL < IREF) state does not exist;
    - 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 Triangle 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.

(14) Output transistor operation mode

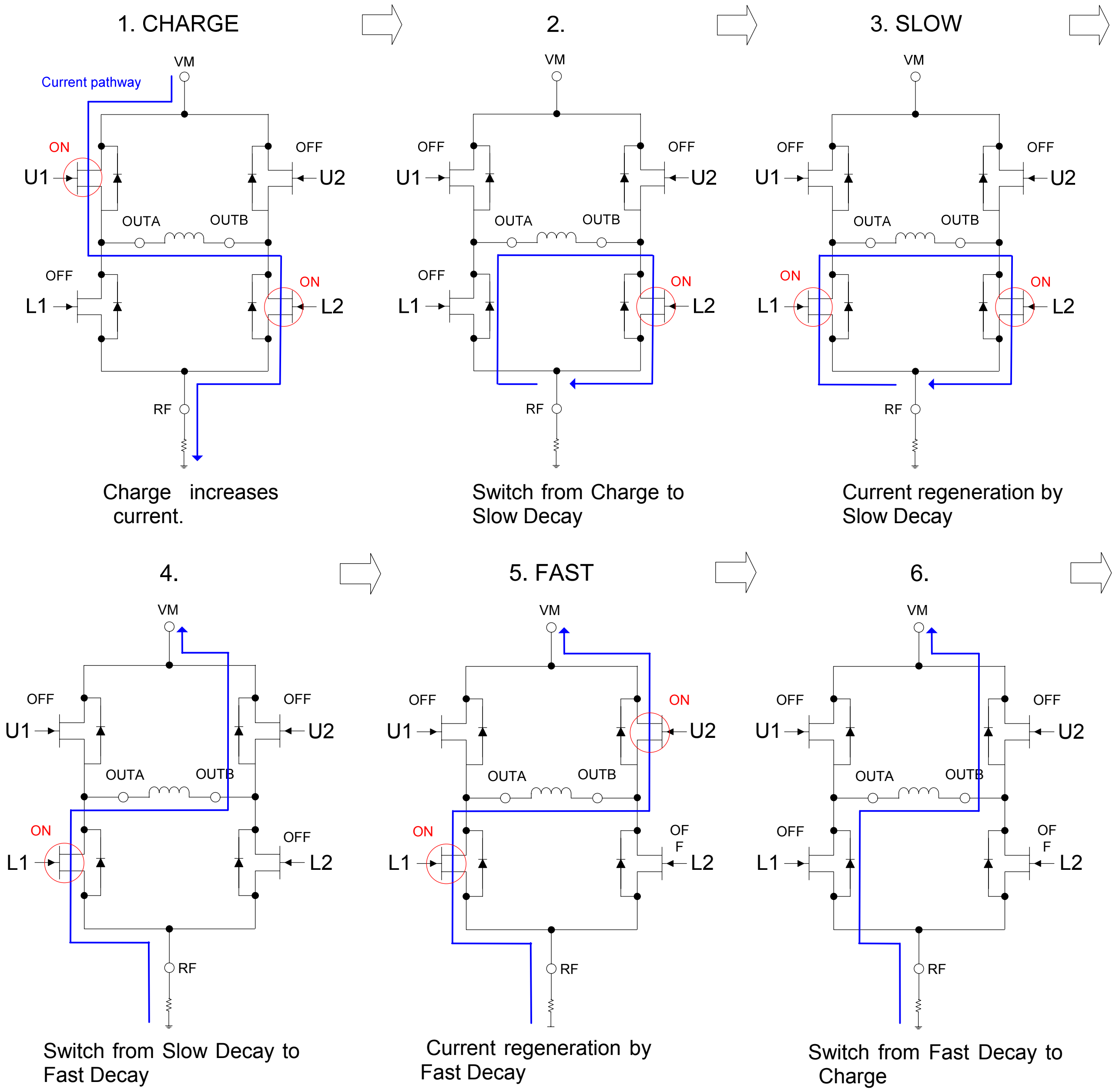


Figure 22. Switching operation

This IC controls constant current by performing chopping to output transistor.
As shown above, by repeating the process from 1 to 6, setting current is maintained.
Chopping consists of 3 modes: Charge/ Slow decay/ Fast decay. In this IC, for switching mode (No.2, 4, 6), there are "off period" in upper and lower transistor to prevent crossover current between the transistors. This off period is set to be constant (≈ 0.375μs) which is controlled by the internal logic. The diagrams show parasitic diode generated due to structure of MOS transistor. When the transistor is off, output current is regenerated through this parasitic diode.

Output Transistor Operation Function

OUTA→OUTB (CHARGE)

Output Tr	**CHARGE**	**SLOW**	**FAST**
U1	ON	OFF	OFF
U2	OFF	OFF	ON
L1	OFF	ON	ON
L2	ON	ON	OFF

OUTB→OUTA (CHARGE)

Output Tr	**CHARGE**	**SLOW**	**FAST**
U1	OFF	OFF	ON
U2	ON	OFF	OFF
L1	ON	ON	OFF
L2	OFF	ON	ON

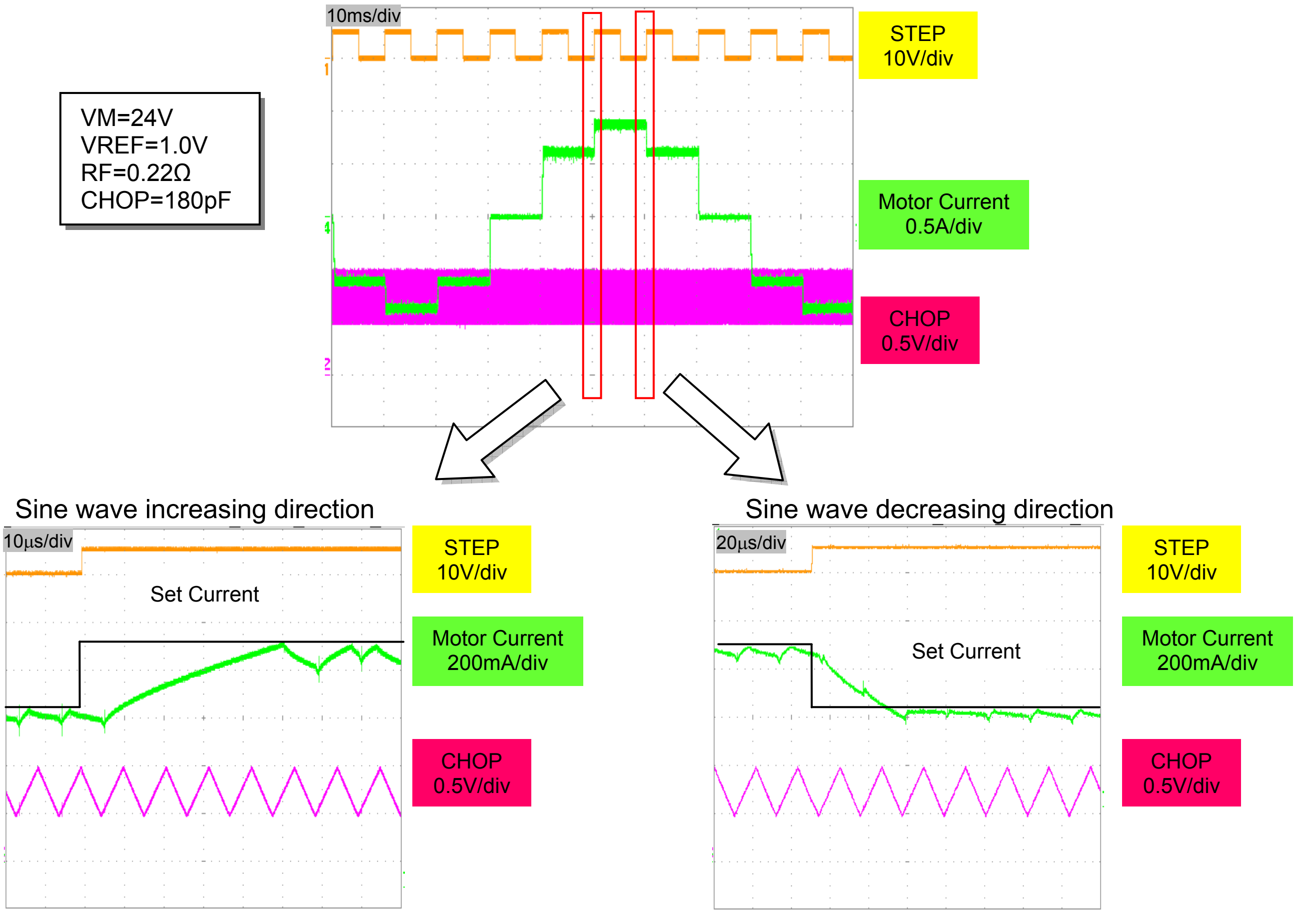


Figure 23. Current control operation waveform

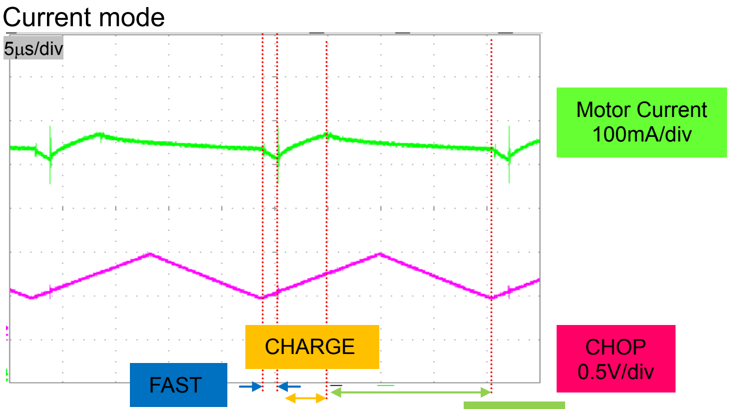


Figure 24. Chopping waveform

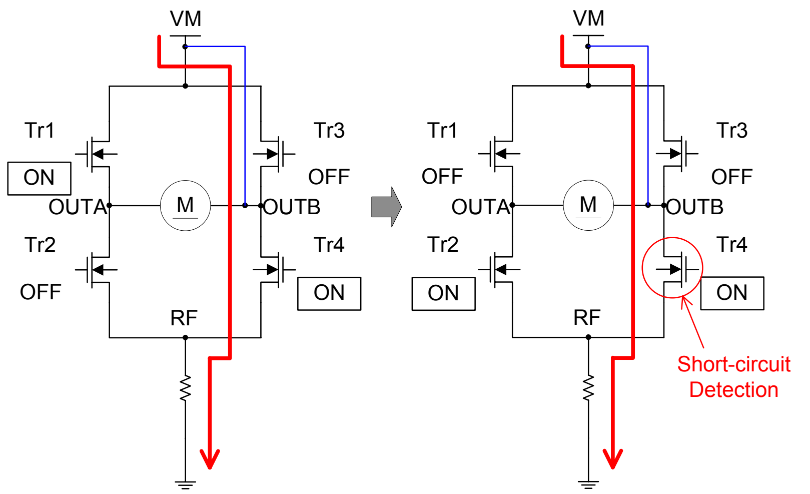
Motor current switches to Fast Decay mode when triangle wave (CHOP) switches from Discharge to Charge. Approximately after 1µs, the motor current switches to Charge mode. When the current reaches to the setting current, it is switched to Slow Decay mode which continues over the Discharge period of triangle wave.

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, sets the output to the standby mode and turns on the warning output in order to prevent the IC from being damaged. This function sets the output to the standby mode for both channels by detecting the short-circuiting in one of the channels.

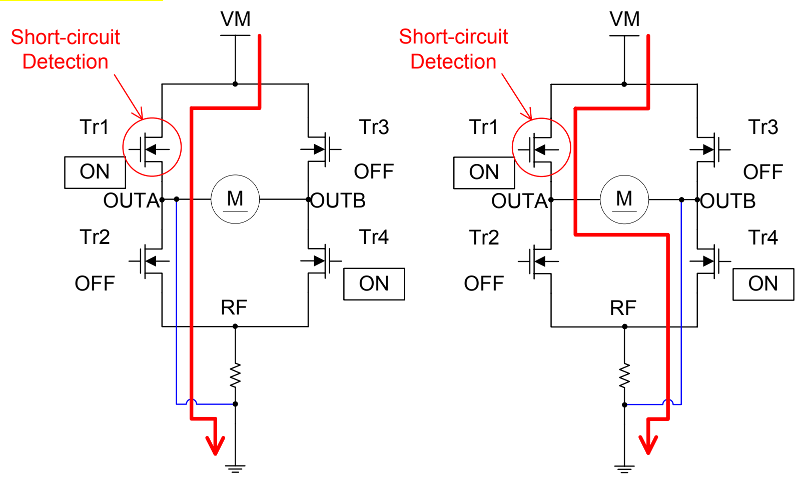
(1) Output short-circuit detection operation

Short to Power



1.High current flows if OUTB short to VM and Tr4 are ON.
2. If RF voltage> setting voltage, then the mode switches to SLOW decay.
3.If the voltage between D and S of Tr4 exceeds the reference voltage for 2μs, short status is detected.

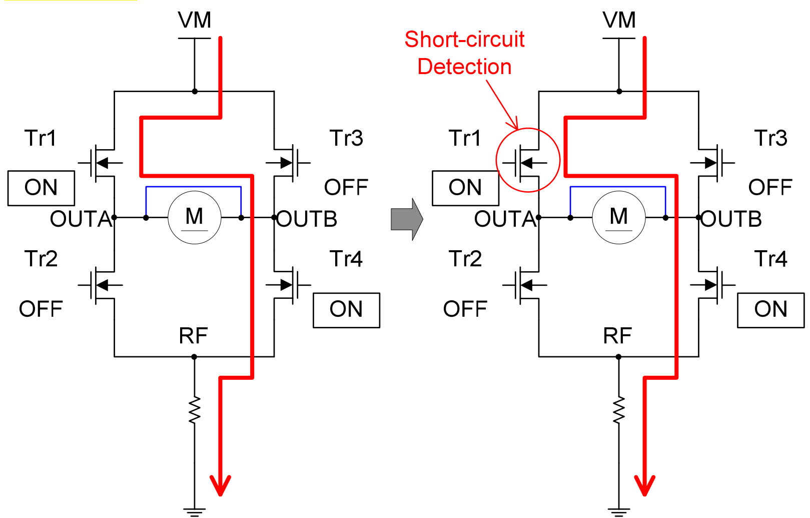
Short to GND



(left schematic)
1.High current flows if OUTA short to GND and Tr1 are ON
2. If the voltage between D and S of Tr1 exceeds the reference voltage for 2μs, short status is detected.

(right schematic)
1. Without going through RF resistor, current control does not operate and current will continue to increase in CHARGE mode.
2. If the voltage between D and S of Tr1 exceeds the reference voltage for 2μs, short status is detected.

Load short



1. Without L load, high current flows.
2. If RF voltage> setting voltage, then the mode switches to SLOW decay.
3. During load short stay in SLOW decay mode, current does not flow and over current state is not detected. Then the mode is switched to FAST decay according to chopping cycle.
4. Since FAST state is short (≈1μs), switches to CHARGE mode before short is detected.
5. If voltage between D and S exceeds the reference voltage continuously during blanking time at the start of CHARGE mode (Tr1), CHARGE state is fixed (even if RF voltage exceeds the setting voltage, the mode is not switched to SLOW decay). After 2us or so, short is detected.

(2) Output short-circuit protection detect current (Reference value)
Short protector operates when abnormal current flows into the output transistor.

Ta = 25°C (typ)

Output Transistor	LV8772
Upper-side Transistor	5.0A
Lower-side Transistor	3.9A

*RF=GND

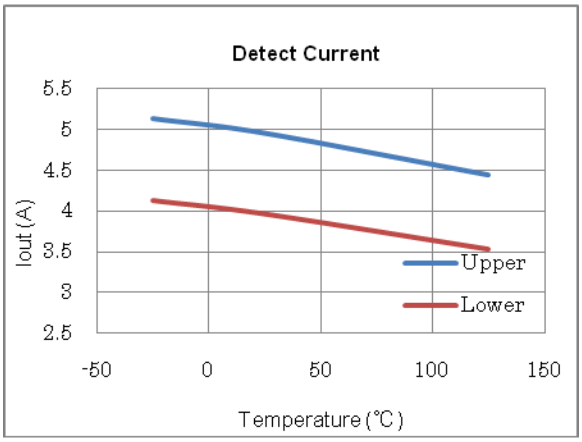


Figure 25. Detect current vs temperature

(3) Output short-circuit protection type

The output short-circuit protection type of LV8772 is the latch type to turn off when the output current exceeds the detection current and the state is maintained.
The output short-circuit protection circuit is activated in an event of short-circuit in the output pin.
When the short-circuit state continues for a period of time set by the internal timer (approximately 4us), the output in which short-circuit was first detected are switched to the standby mode. And if the short-circuit state is still detected, all the outputs of the channel are switched to the standby mode, and the state is held.
This state is released by setting ST to low.

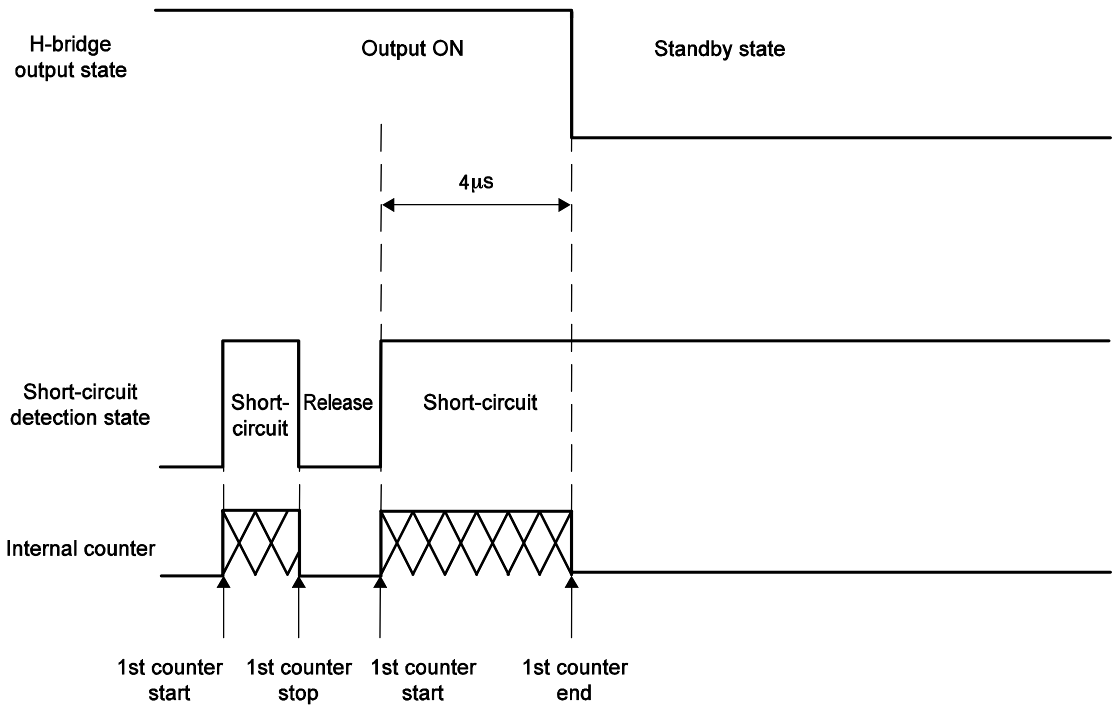


Figure 26. Timing chart in latch type

(4) Unusual condition warning output pins (EMO)
This 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.

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. Because the output is not turned on if VM+4V or more is not pressured, the voltage of the VG pin recommends the drive of the motor to put the time of t_{ONG} or more, and to begin.

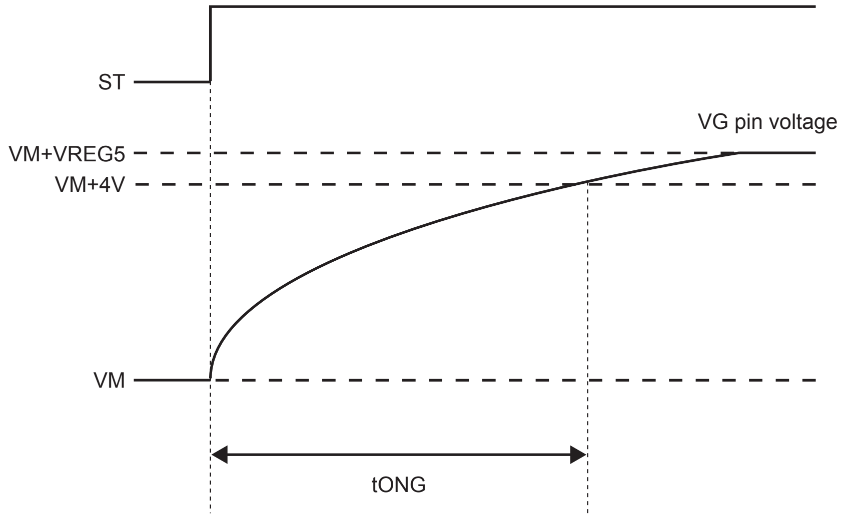


Figure 27. VG pin voltage schematic view

VG voltage is used to drive upper output FET and VREG5 voltage is used to drive lower output FET. Since VG voltage is equivalent to the addition of VM and VREG5 voltage, VG capacitor should allow higher voltage.
The capacitor between CP1 and CP2 is used to boost charge pump. Since CP1 oscillates with 0V↔VREG5 and CP2 with VM↔VM+VREG5, make sure to allow enough capacitance between CP1 and CP2.
Since the capacitance is variable depends on motor types and driving methods, please check with your application before you define constant to avoid ripple on VG voltage.

(Recommended value) VG: 0.1μF
CP1-CP2: 0.1μF

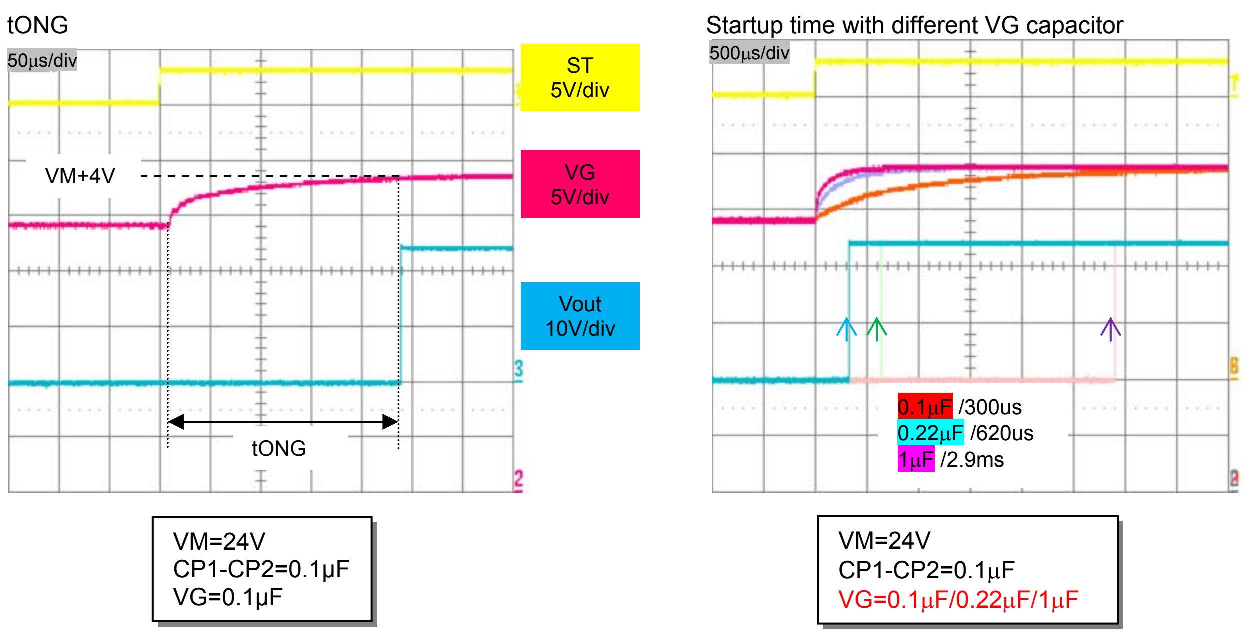


Figure 28.VG voltage pressure waveform

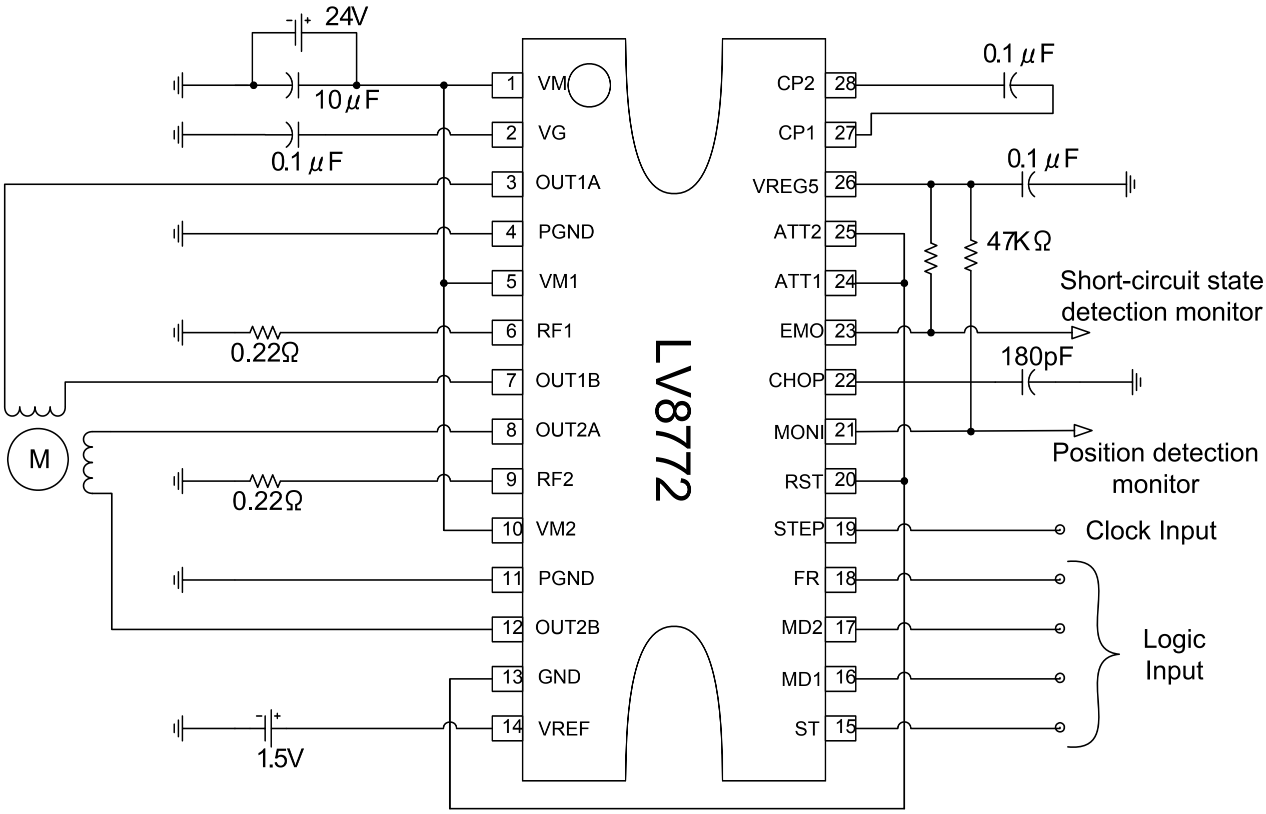
Thermal shutdown function

The thermal shutdown circuit is incorporated and the output is turned off when junction temperature Tj exceeds 180°C and the abnormal state warning output is turned on. As the temperature falls by hysteresis, the output turned on again (automatic restoration).
The thermal shutdown circuit does not guarantee the protection of the final product because it operates when the temperature exceed the junction temperature of Tjmax=150°C.

TSD = 180°C (typ)
ΔTSD = 40°C (typ)

Application Circuit Example

- Stepping motor driver circuit



The formula for setting the constants in the examples of the application circuits above are as follows:

Constant current (100%) setting

When VREF = 1.5V

I_{OUT} = VREF/5/RF resistance

= 1.5V/5/0.22Ω = 1.36A

Chopping frequency setting

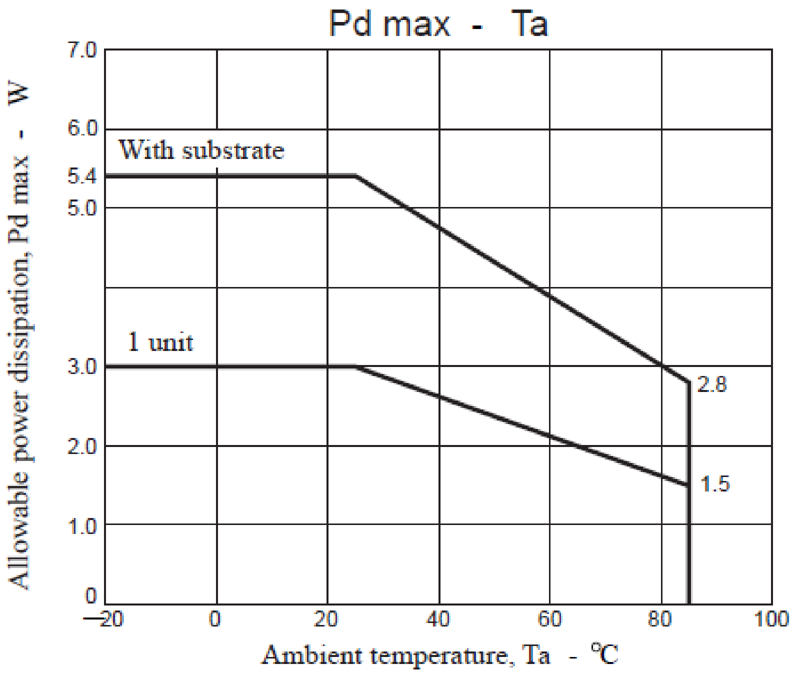
Fchop = Ichop/ (Cchop × Vtchop × 2)

= 10μA/ (180pF × 0.5V × 2) = 55kHz

Allowable power dissipation

The pad on the backside of the IC functions as heatsink by soldering with the board. Since the heat-sink characteristics vary depends on board type, wiring and soldering, please perform evaluation with your board for confirmation.

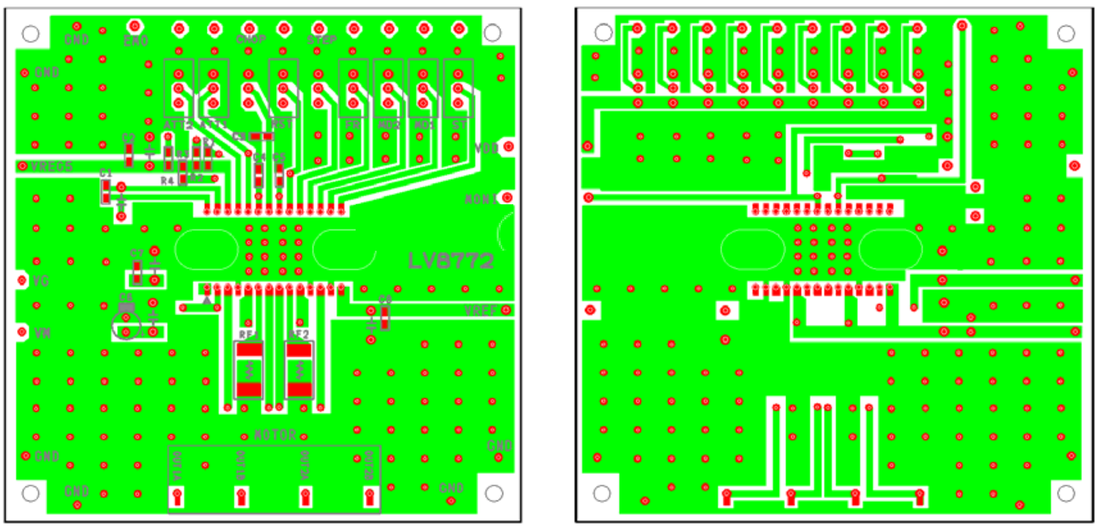
Specified circuit board: 90mm x 90mm x 1.6mm, glass epoxy **2-layer board**



Substrate Specifications (Substrate recommended for operation of LV8772)

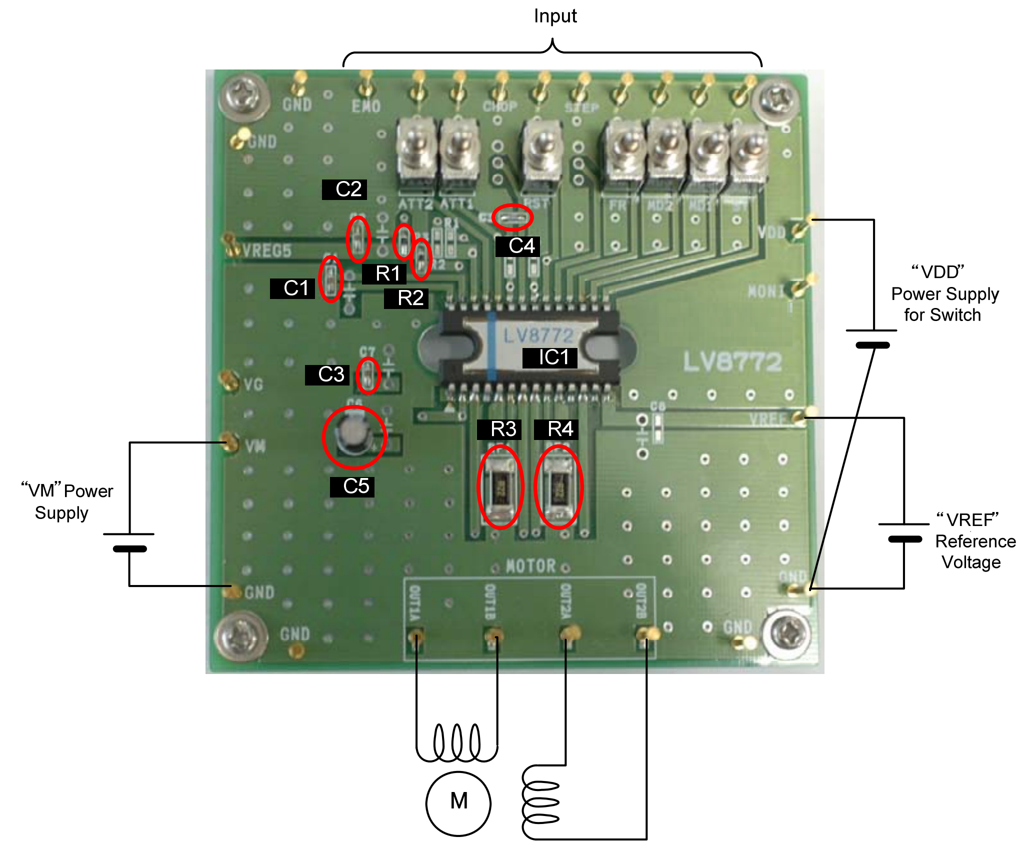
Size : 90mm × 90mm × 1.6mm (two-layer substrate [2S0P])

Material : Glass epoxy



Evaluation board

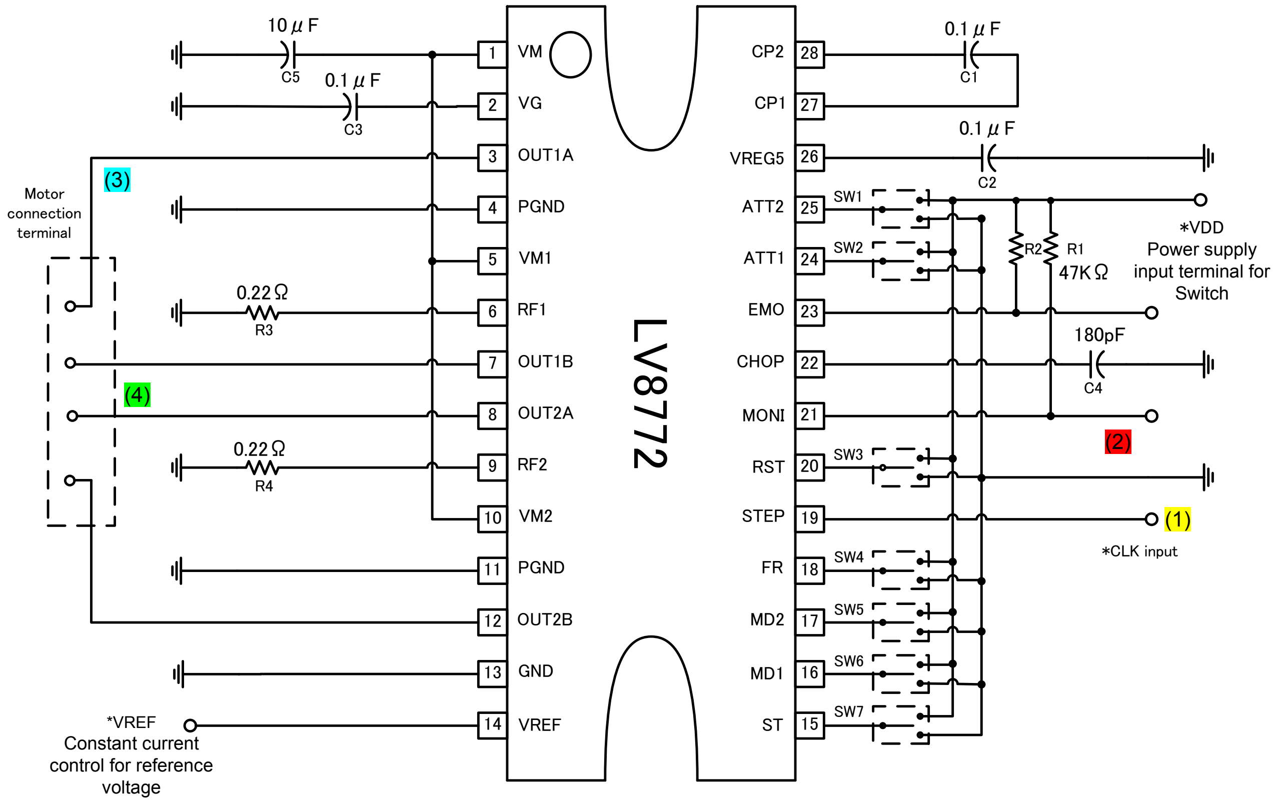
LV8772 (90.0mm×90.0mm×1.6mm, glass epoxy 2-layer board)



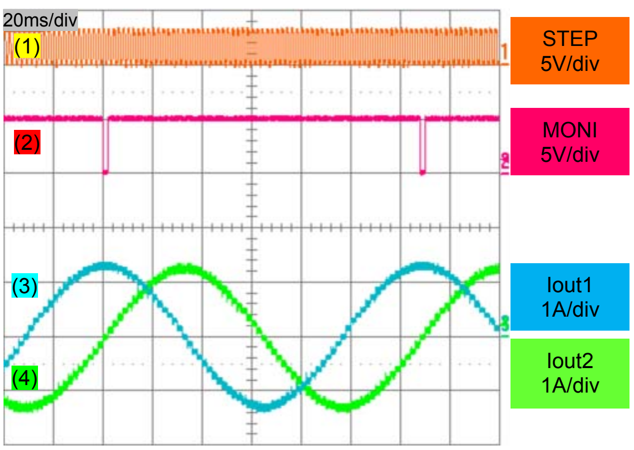
Bill of Materials for LV8772 Evaluation Board

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
C1	1	Capacitor for Charge pump	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C2	1	Capacitor for Charge pump	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C3	1	VREG5 stabilization Capacitor	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C4	1	Capacitor to set chopping frequency	180pF, 50V	±5%		Murata	GRM1882C1H181JA01*	Yes	Yes
C5	1	VM Bypass Capacitor	10μF, 50V	±20%		SUN Electronic Industries	50ME10HC	Yes	Yes
R1	1	Pull-up Resistor for for terminal MONI	47kΩ, 1/10W	±5%		KOA	RK73B1JT**473J	Yes	Yes
R2	1	Pull-up Resistor for for terminal EMO	47kΩ, 1/10W	±5%		KOA	RK73B1JT**473J	Yes	Yes
R3	1	Channel 1 output current detective Resistor	0.22Ω, 1W	±5%		ROHM	MCR100JZHJLR22	Yes	Yes
R4	1	Channel 2 output current detective Resistor	0.22Ω, 1W	±5%		ROHM	MCR100JZHJLR22	Yes	Yes
IC1	1	Motor Driver			DIP28H (500mil)	ON Semiconductor	LV8772	No	Yes
SW1-SW7	7	Switch				MIYAMA	MS-621C-A01	Yes	Yes
TP1-TP26	26	Test Point				MAC8	ST-1-3	Yes	Yes

Evaluation board circuit



【Stepping Motor】
VM=24V, VDD=5V, VREF=1.5V
ST=H, RST=L
ATT1=ATT2=L,
FR =L, MD1 =MD2 =H
STEP =500Hz (Duty50%)



Evaluation Board Manual

[Supply Voltage]
VM (9 to 32V): Power Supply for LSI
VREF (0 to 3V): Const. Current Control for Reference Voltage
VDD (2 to 5V): Logic “High” voltage for toggle switch

[Toggle Switch State]
Upper Side: High (VDD)
Middle: Open, enable to external logic input
Lower Side: Low (GND)

[Operation Guide]

For stepping motor control

1. Motor Connection: Connect the Motors between OUT1A and OUT1B, between OUT2A and OUT2B.
2. Initial Condition Setting: Set “Open” the toggle switch STEP, and “Open or Low” the other switches.
3. Power Supply: Supply DC voltage to VM, VREF and VDD.
4. Ready for Operation from Standby State: Turn “High” the ST terminal toggle switch. Channel 1 and 2 are into 2-phase excitement initial position (100%, -100%).
5. Motor Operation: Input the clock signal into the terminal STEP.
6. Other Setting
    i. ATT1, ATT2: Motor current attenuation.
    ii. RST: Initial Mode.
    iii. FR: Motor rotation direction (CW / CCW) setting.
    iv. MD1, MD2: Excitation mode.

[Setting for External Component Value]

1. Constant Current (100%)

At VREF=1.5V

Iout =VREF [V] / 5 / RF [Ω]
=1.5 [V] / 5 / 0.22 [Ω]
=1.36 [A]

2. Chopping Frequency

Fchop =Ichop [μA] / (Cchop x Vt x 2)
=10 [μA] / (180 [pF] x 0.5 [V] x 2)
=55 [kHz]

Notes in design:

●Power supply connection terminal [VM, VM1, VM2]
- ✓ Make sure to short-circuit VM, VM1 and VM2.For controller supply voltage, the internal regulator voltage of VREG5 (typ 5V) is used.
- ✓ Make sure that supply voltage does not exceed the absolute MAX ratings under no circumstance. Noncompliance can be the cause of IC destruction and degradation.
- ✓ Caution is required for supply voltage because this IC performs switching.
- ✓ The bypass capacitor of the power supply should be close to the IC as much as possible to stabilize voltage. Also if you intend to use high current or back EMF is high, please augment enough capacitance.

●GND terminal [GND, PGND]
- ✓ Since GND is the reference of the IC internal operation, make sure to connect to stable and the lowest possible potential. Since high current flows into PGND, connect it to one-point GND.

●Internal power supply regulator terminal [VREG5]
- ✓ VREG5 is the power supply for logic (typ 5V).
- ✓ When VM supply is powered and ST is"H", VREG5 operates.
- ✓ Please connect capacitor for stabilize VREG5. The recommendation value is 0.1μF.
- ✓ Since the voltage of VREG5 fluctuates, do not use it as reference voltage that requires accuracy.

●Input terminal
- ✓ When you set input pin to low voltage, please short it to GND because the input pin is vulnerable to noise.
- ✓ The input is TTL level (H: 2V or higher, L: 0.8V or lower).
- ✓ VREF pin is high impedance.

●OUT terminal [OUT1A, OUT1B, OUT2A, OUT2B]
- ✓ During chopping operation, the output voltage becomes equivalent to VM voltage, which can be the cause of noise. Caution is required for the pattern layout of output pin.
- ✓ The layout should be low impedance because driving current of motor flows into the output pin.
- ✓ Output voltage may boost due to back EMF. Make sure that the voltage does not exceed the absolute MAX ratings under no circumstance. Noncompliance can be the cause of IC destruction and degradation.

●Current sense resistor connection terminal [RF1, RF2]
- ✓ To perform constant current control, please connect resistor to RF pin.
- ✓ To perform saturation drive (without constant current control), please connect RF pin to GND.
- ✓ If RF pin is open, then short protector circuit operates. Therefore, please connect it to resistor or GND.
- ✓ The motor current flows into RF – GND line. Therefore, please connect it to common GND line and low impedance line.