



# LV8774Q

Bi-CDMOS LSI

## PWM Constant-Current Control Stepper Motor Driver

ON Semiconductor®

<http://onsemi.com>

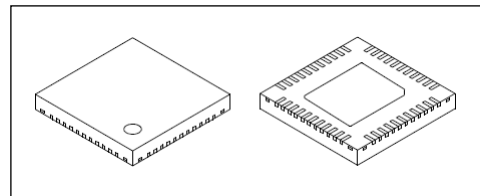
### Overview

The LV8774 is a 2-channel H-bridge driver IC, and can drive a stepper motor or two brushed DC motors.

A stepper motor driver supports micro-step drive with 1/16-step resolution, and two brushed motor drivers support forward, reverse, brake, and standby functions. It is ideally suited for driving brushed DC motors and stepper motors used in office equipment and amusement applications.

### Function

- Single-channel PWM current control stepper motor driver (or two DC motor driver)
- BiCDMOS process IC
- Low on resistance (upper side : 0.3Ω ; lower side : 0.25Ω ; total of upper and lower : 0.55Ω ; Ta = 25°C, IO = 2A)
- 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 with stepper motor
- Motor current selectable in four steps
- Output short-circuit protection circuit (selectable from latch-type or auto-reset-type)
- Unusual condition warning output pins
- No control power supply required



VQFN44L ( 6x6 )

### 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         | IO peak    | Tw ≤ 10ms , duty 20% , Per 1ch   | 2.5         | A    |
| Output current              | IO max     | Per 1ch  | 2           | A    |
| Logic input voltage         | VIN        | ATT1, ATT2, EMM, RST/BLK, STEP/DC22, FR/DC21, MD2/DC12, MD1/DC11, DM, OE, ST | -0.3 to +6  | V    |
| MONI/EMO input voltage      | Vmoni/Vemo |  | -0.3 to +6  | V    |
| Allowable power dissipation | Pd max     | *  | 3.60        | W    |
| Operating temperature       | Topr       |  | -20 to +85  | °C   |
| Storage temperature         | Tstg       |  | -55 to +150 | °C   |

\*Specified circuit board : 57.0mmx57.0mmx1.6mm, glass epoxy 4-layer board, with backside mounting.

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 those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### ORDERING INFORMATION

See detailed ordering and shipping information on page 28 of this data sheet.

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## Recommended Operating Conditions at Ta = 25°C

| Parameter                | Symbol          | Conditions   | Ratings  | Unit |
|--------------------------|-----------------|--|----------|------|
| Supply voltage range     | VM              | VM, VM1, VM2   | 9 to 32  | V    |
| Logic input voltage      | V <sub>IN</sub> | ATT1, ATT2, EMM, RST/BLK, STEP/DC22, FR/DC21, MD2/DC12, MD1/DC11, DM, OE, ST | 0 to 5.5 | V    |
| VREF input voltage range | VREF            |  | 0 to 3   | V    |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

## 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", I(VM)+I(VM1)+I(VM2)  |  | 100   | 400   | μA    |   |
| Current drain   | IM                   | ST = "H", OE = "L", with no load<br>I(VM)+I(VM1)+I(VM2)  |  | 3.2   | 5     | mA    |   |
| VREG5 output voltage  | Vreg5                | I <sub>O</sub> = -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    |   |
| <b>Motor driver</b>   |                      |  |  |       |       |       |   |
| Output on resistance  | Ronu                 | I <sub>O</sub> = 2A, Upper-side on resistance  |  | 0.3   | 0.4   | Ω     |   |
|   | Rond                 | I <sub>O</sub> = 2A, Lower-side on resistance  |  | 0.25  | 0.33  | Ω     |   |
| Output leakage current  | I <sub>O</sub> leak  |  |  |       | 50    | μA    |   |
| Diode forward voltage   | VD                   | ID = -2A   |  | 1.2   | 1.4   | V     |   |
| Logic pin input current   | I <sub>IN</sub> L    | ATT1, ATT2, EMM, RST/BLK, STEP/DC22, FR/DC21, MD2/DC12, MD1/DC11, DM, OE, ST, V <sub>IN</sub> = 0.8V | 4  | 8     | 12    | μA    |   |
|   | I <sub>IN</sub> H    | ATT1, ATT2, EMM, RST/BLK, STEP/DC22, FR/DC21, MD2/DC12, MD1/DC11, DM, OE, ST, V <sub>IN</sub> = 5V   | 30   | 50    | 70    | μA    |   |
| Logic input voltage   | High                 | V <sub>INh</sub>   | ATT1, ATT2, EMM, RST/BLK, STEP/DC22, FR/DC21, MD2/DC12, MD1/DC11, DM, OE, ST | 2.0   |       | 5.5   | V |
|   | Low                  | V <sub>INl</sub>   |  | 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     |   |

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| Parameter   |                      | Symbol   | Conditions  | Ratings |      |       | Unit |
|---|----------------------|--|---|---------|------|-------|------|
|   |                      |  |   | min     | typ  | max   |      |
| Current setting comparator threshold voltage (current step switching)             | 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 = 200pF  | 40  | 50      | 60   | 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    |      |
| <b>Charge pump</b>  |                      |  |   |         |      |       |      |
| VG output voltage   | VG                   |  | 28  | 28.7    | 29.8 | V     |      |
| Rise time   | tONG                 | VG = 0.1μF , Between CP1-CP2 0.1uF<br>ST="H" →VG=VM+4V |   | 200     | 500  | μS    |      |
| Oscillator frequency  | Fosc                 |  | 90  | 125     | 150  | kHz   |      |
| <b>Output short-circuit protection</b>  |                      |  |   |         |      |       |      |
| EMO pin saturation voltage  | Vsatemo              | Iemo = 1mA   |   |         | 400  | mV    |      |
| CEM pin charge current  | Icem                 | Vcem = 0V  | 7   | 10      | 13   | μA    |      |
| CEM pin threshold voltage   | Vtcem                |  | 0.8   | 1       | 1.2  | V     |      |

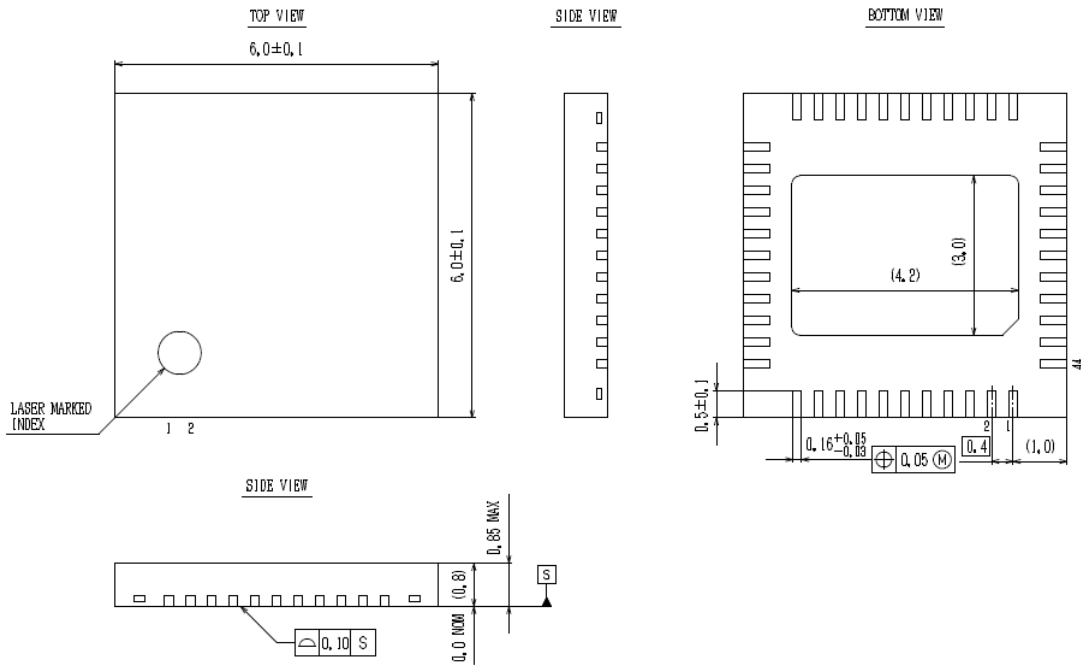
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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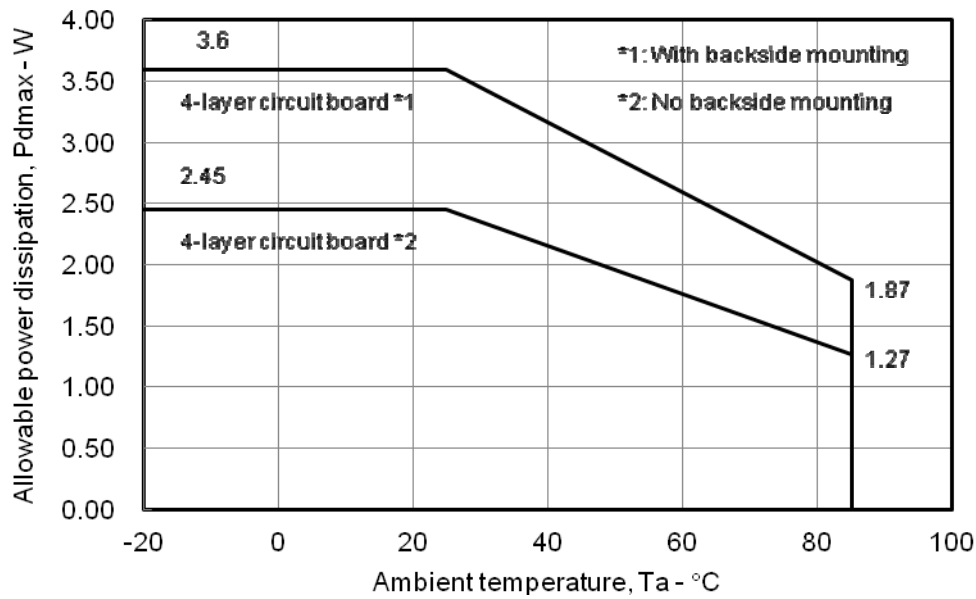
## Package Dimensions

unit : mm (typ)

VQFN44L(6mm x 6mm)



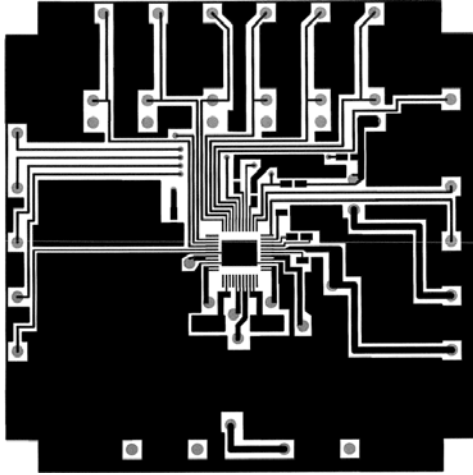
## Pdmax-Ta



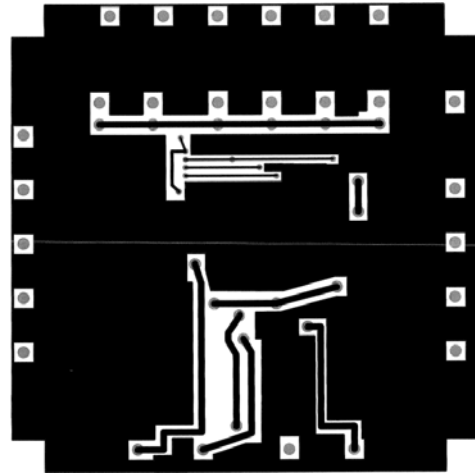
## LV8774Q

### Substrate Specifications (Substrate recommended for operation of LV8774Q)

|                       |  |
|-----------------------|--|
| Size                  | : 57mm × 57mm × 1.6mm (four-layer substrate) |
| Material              | : Glass epoxy                                |
| Copper wiring density | : L1 = 75% / L4 = 85%                        |



L1 : Copper wiring pattern diagram



L4 : Copper wiring pattern diagram

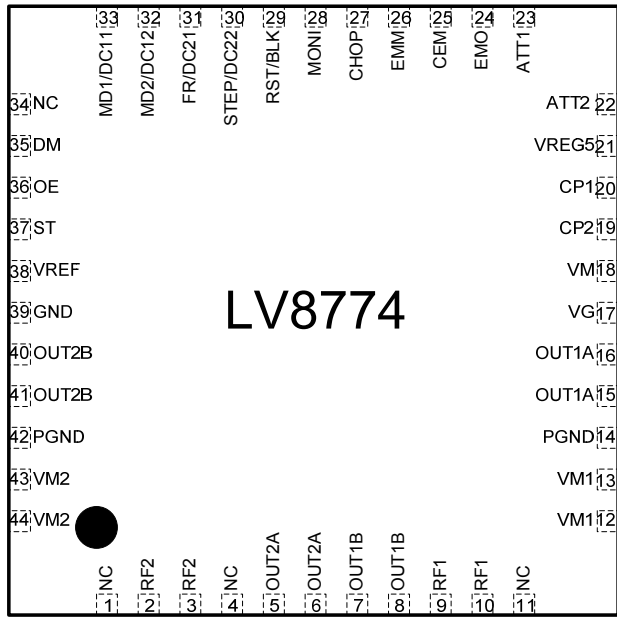
### Cautions

- 1) The data for the case with the back side 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.

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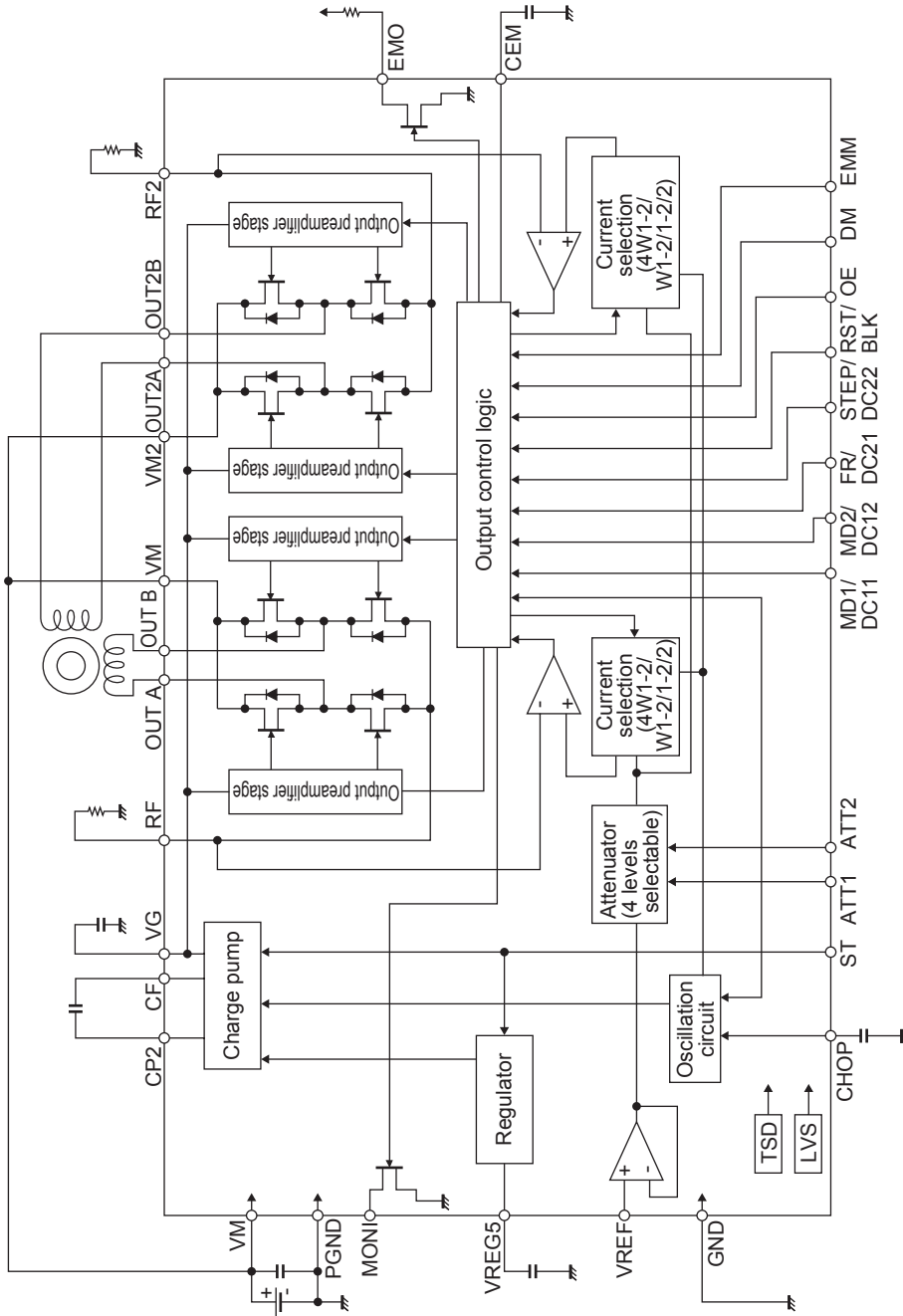
## Pin Assignment

VQFN44L(6mm×6mm)



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## Block Diagram



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## Pin Functions

| Pin No.   | Pin Name   | Pin Function  | Equivalent Circuit |
|---|--|---|--------------------|
| 22<br>23<br>26<br>29<br>30<br>31<br>32<br>33<br>35<br>36                        | ATT2<br>ATT1<br>EMM<br>RST/BLK<br>STEP/DC22<br>FR/DC21<br>MD2/DC12<br>MD1/DC11<br>DM<br>OE | Motor holding current switching pin.<br>Motor holding current switching pin.<br>Output short-circuit protection mode switching pin.<br>RESET input pin (STM) / Blanking time switching pin (DCM).<br>STEP signal input pin (STM) / Channel 2 output control input pin 2 (DCM).<br>CW / CCW signal input pin (STM) / Channel 2 output control input pin 1 (DCM).<br>Excitation mode switching pin 2 (STM) / Channel 1 output control input pin 2 (DCM).<br>Excitation mode switching pin 1 (STM) / Channel 1 output control input pin 1 (DCM).<br>Drive mode (STM/DCM) switching pin.<br>Output enable signal input pin. |                    |
| 37  | ST   | Chip enable pin.  |                    |
| 40, 41<br>14, 42<br>43, 44<br>2, 3<br>5, 6<br>7, 8<br>9, 10<br>12, 13<br>15, 16 | OUT2B<br>PGND<br>VM2<br>RF2<br>OUT2A<br>OUT1B<br>RF1<br>VM1<br>OUT1A                       | Channel 2 OUTB output pin.<br>Power system ground.<br>Channel 2 motor power supply connection pin.<br>Channel 2 current-sense resistor connection pin.<br>Channel 2 OUTA output pin.<br>Channel 1 OUTB output pin.<br>Channel 1 current-sense resistor connection pin.<br>Channel 1 motor power supply pin.<br>Channel 1 OUTA output pin.   |                    |

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| Pin No.              | Pin Name               | Pin Function  | Equivalent Circuit |
|----------------------|------------------------|---|--------------------|
| 17<br>18<br>19<br>20 | VG<br>VM<br>CP2<br>CP1 | Charge pump capacitor connection pin.<br>Motor power supply connection pin.<br>Charge pump capacitor connection pin.<br>Charge pump capacitor connection pin. |                    |
| 38                   | VREF                   | Constant current control reference voltage input pin.   |                    |
| 21                   | VREG5                  | Internal power supply capacitor connection pin.   |                    |
| 24<br>28             | EMO<br>MONI            | Output short-circuit state warning output pin.<br>Position detection monitor pin.   |                    |

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| Pin No.       | Pin Name | Pin Function  | Equivalent Circuit |
|---------------|----------|---|--------------------|
| 25            | CEM      | Pin to connect the output short-circuit state detection time setting capacitor. |                    |
| 27            | CHOP     | Chopping frequency setting capacitor connection pin.                            |                    |
| 39            | GND      | Ground.   |                    |
| 1,4,11,<br>34 | NC       | No Connection<br>(No internal connection to the IC)                             |                    |
| Exposed-Pad   |          | Exposed-Pad connects signal GND or floating.*                                   |                    |

\*Recommendation is to connect Exposed-pad to signal GND.

Since IC may generate heat when using it by floating, be careful of a thermal design enough.

**Description of operation**

1. Input Pin Function

Each input terminal has the function to prevent the flow of the current from an input to a power supply. Therefore, Even if a power supply (VM) is turned off in the state that applied voltage to an input terminal, the electric current does not flow into the power supply.

1-1) 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   |



1-2) Drive mode switching pin function

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

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

2. STM mode (DM = Low or Open)

2-1) STEP pin function

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

2-2) Excitation mode setting function

| MD1  | MD2  | Micro-step resolution<br>(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<br>(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.

2-3) 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 "2-12.Examples of current waveforms in each micro-step mode.")

2-4) 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 :

$$I_{OUT} = (V_{REF}/5)/R_F \text{ resistance}$$

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

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%   |

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

$$I_{OUT} = (V_{REF}/5) \times (\text{attenuation ratio})/R_F \text{ resistance}$$

Example : At VREF of 1.5V, a reference voltage setting of 100% [(ATT1, ATT2) = (L, L)] and an RF resistance of 0.3Ω, the output current is set as shown below.

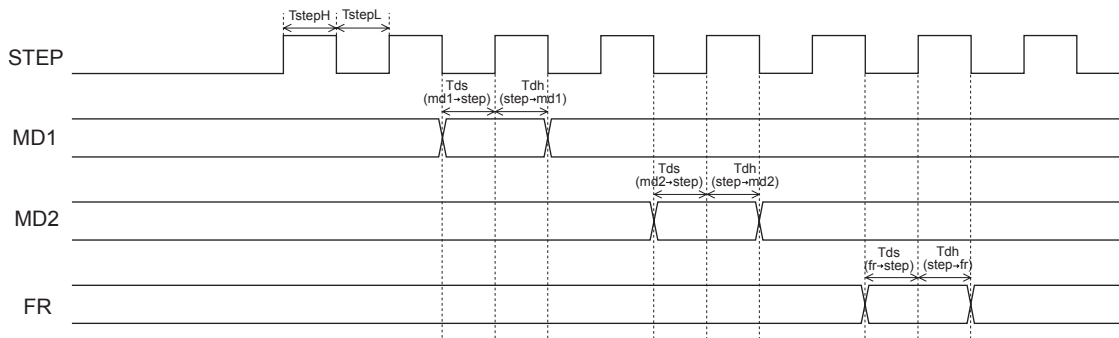
$$I_{OUT} = 1.5V/5 \times 100\%/0.3\Omega = 1.0A$$

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

$$I_{OUT} = 1.0A \times 20\% = 200mA$$

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

2-5) Input Timing



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

2-6) Blanking period

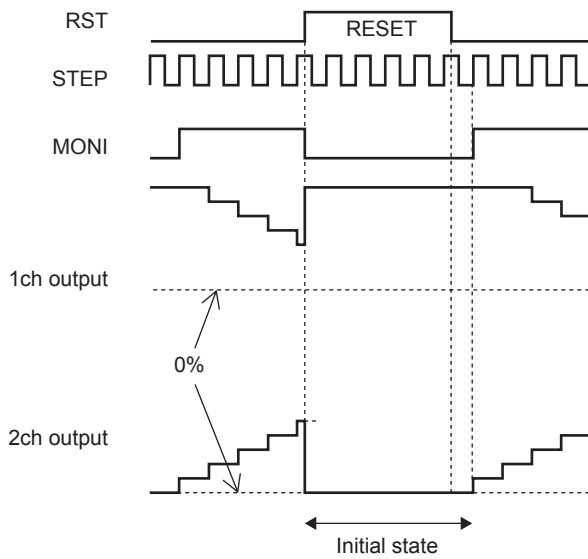
During normal operation switching transient noise from the parasitic diode may flow to the current sensing resistance, resulting in erroneous detection. To prevent this erroneous detection, a blanking period is provided to prevent the noise from being received.

In the stepper motor driver mode (DM = Low or Open) of this IC, the blanking time is fixed at approximately 1μs.

In the DC motor driver mode (DM = High), the blanking time can be switched to one of two levels using the RST/BLK pin. (Refer to "Blanking time switching function.")

2-7) Reset function

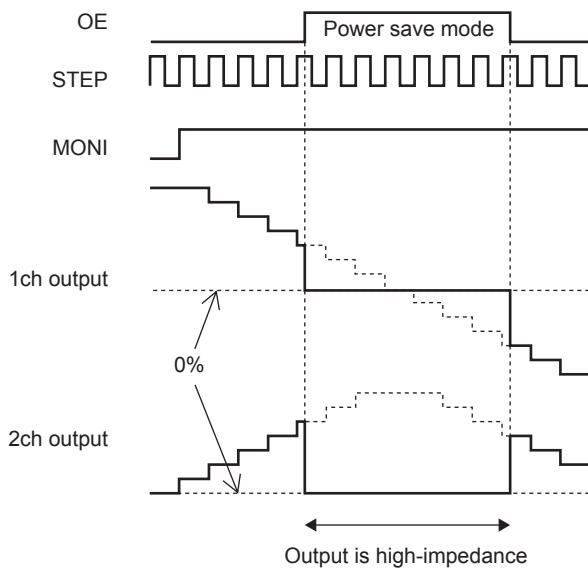
| RST  | Operating mode   |
|------|------------------|
| Low  | Normal operation |
| High | Reset state      |



When the RST pin is set to High, the excitation position of the output is forcibly set to the initial state, 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.

2-8) Output enable function

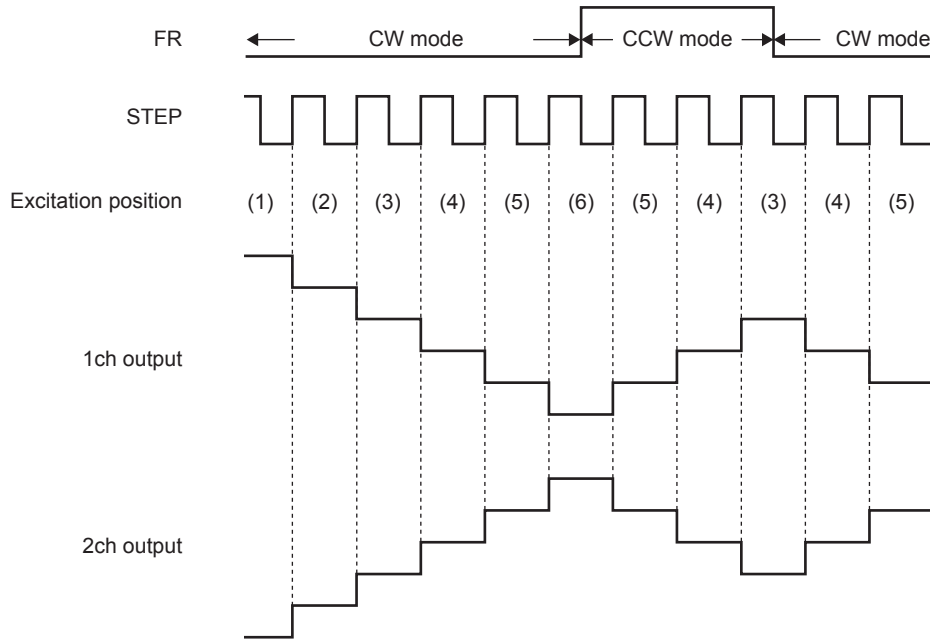
| OE   | Operating mode |
|------|----------------|
| Low  | Output ON      |
| High | Output OFF     |



When the OE pin is set High, the output is forced OFF and goes to high impedance. The internal logic circuits remain operating, and the excitation position proceeds when the STEP signal is inputted.

2-9) 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.

2-10) 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.

$$F_{chop} = I_{chop} / (C_{chop} \times V_{tchop} \times 2) \text{ (Hz)}$$

$I_{chop}$  : Capacitor charge/discharge current, typ 10μA

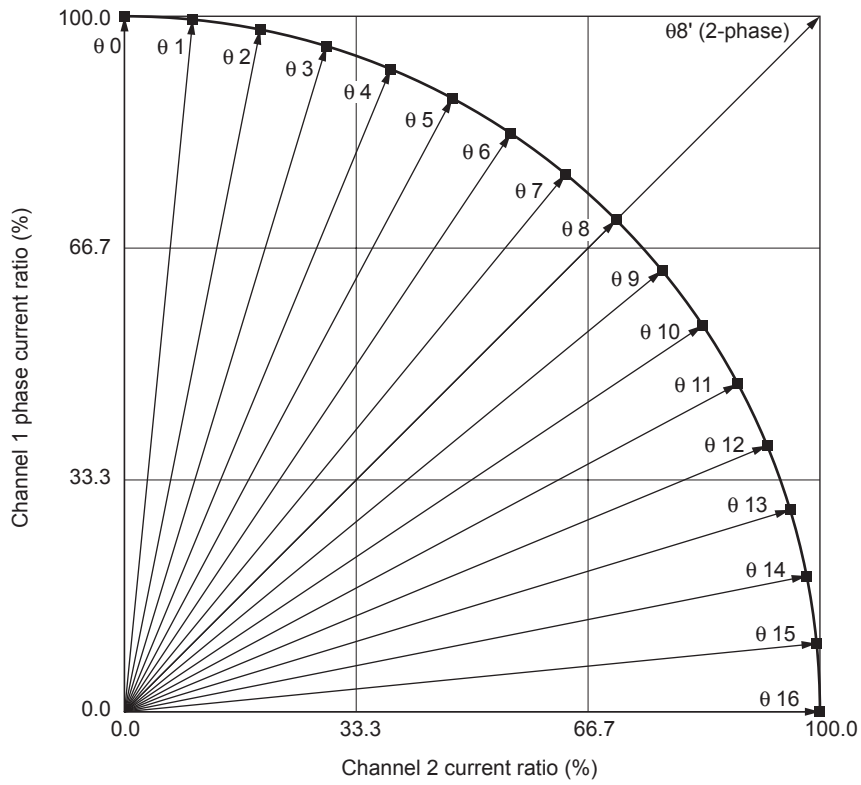
$V_{tchop}$  : Charge/discharge hysteresis voltage ( $V_{tup} - V_{tdown}$ ), typ 0.5V

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

$$F_{chop} = 10\mu A / (200pF \times 0.5V \times 2) = 50kHz$$

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## 2-11) Output current vector locus (one step is normalized to 90 degrees)

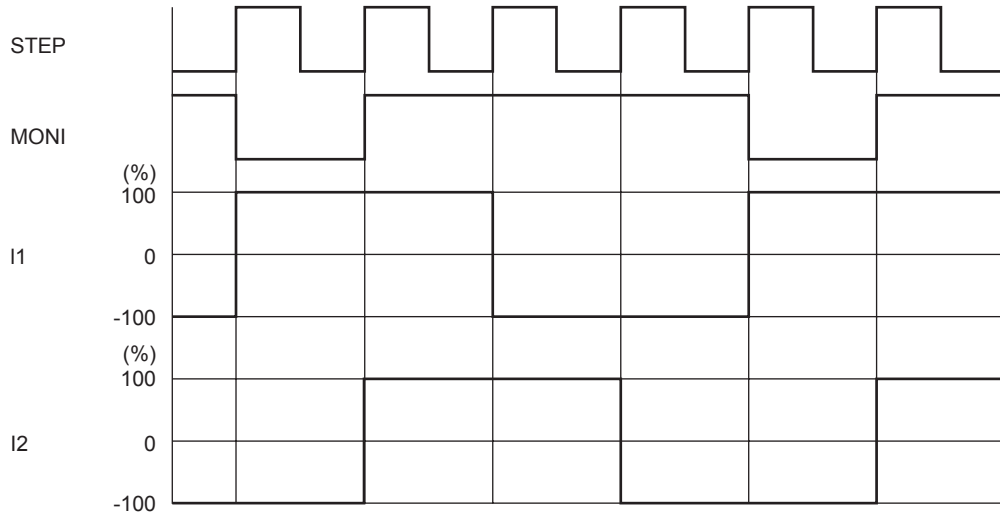


### Setting current ratio in each micro-step mode

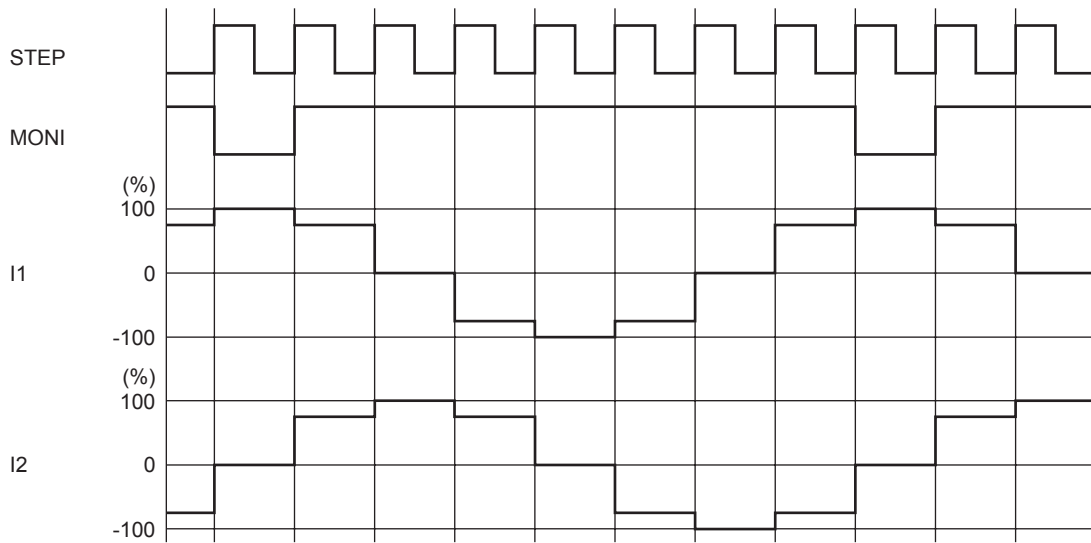
| STEP | 1/16 step (%) |           | Quarter step (%) |           | Half step (%) |           | Full step (%) |           |
|------|---------------|-----------|------------------|-----------|---------------|-----------|---------------|-----------|
|      | Channel 1     | Channel 2 | Channel 1        | Channel 2 | Channel 1     | Channel 2 | Channel 1     | Channel 2 |
| 00   | 100           | 0         | 100              | 0         | 100           | 0         |               |           |
| 01   | 100           | 10        |                  |           |               |           |               |           |
| 02   | 98            | 20        |                  |           |               |           |               |           |
| 03   | 96            | 29        |                  |           |               |           |               |           |
| 04   | 92            | 38        | 92               | 38        |               |           |               |           |
| 05   | 88            | 47        |                  |           |               |           |               |           |
| 06   | 83            | 55        |                  |           |               |           |               |           |
| 07   | 77            | 63        |                  |           |               |           |               |           |
| 08   | 70            | 70        | 70               | 70        | 70            | 70        | 100           | 100       |
| 09   | 63            | 77        |                  |           |               |           |               |           |
| 010  | 55            | 83        |                  |           |               |           |               |           |
| 011  | 47            | 88        |                  |           |               |           |               |           |
| 012  | 38            | 92        | 38               | 92        |               |           |               |           |
| 013  | 29            | 96        |                  |           |               |           |               |           |
| 014  | 20            | 98        |                  |           |               |           |               |           |
| 015  | 10            | 100       |                  |           |               |           |               |           |
| 016  | 0             | 100       | 0                | 100       | 0             | 100       |               |           |

2-12) Examples of current waveforms in each micro-step mode

Full step (CW mode)



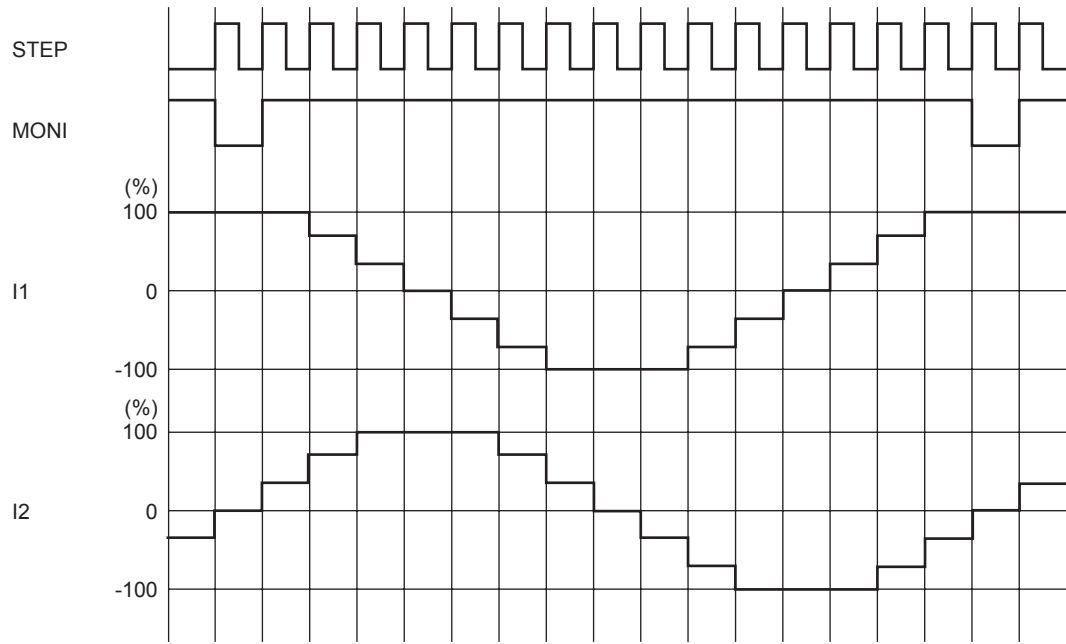
Half step (CW mode)



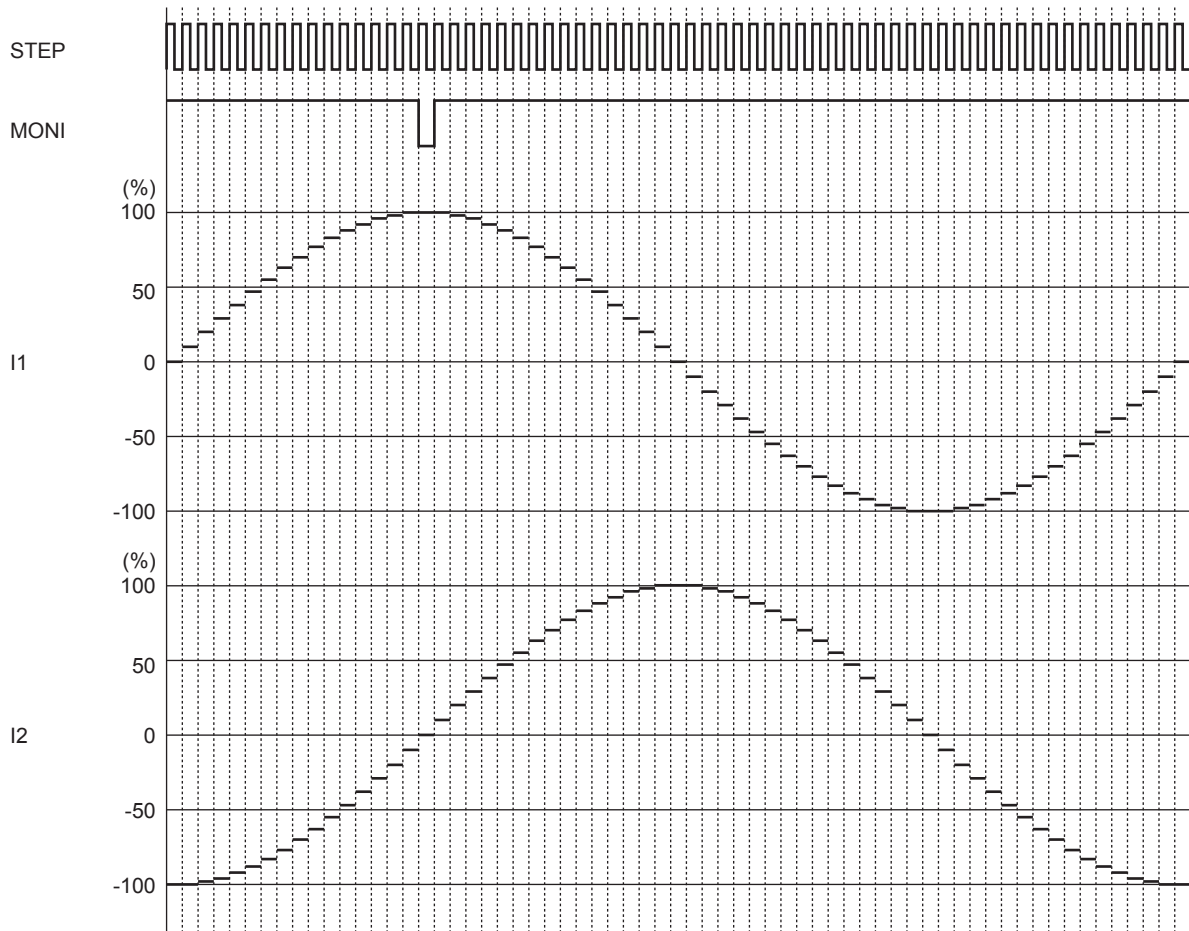


# LV8774Q

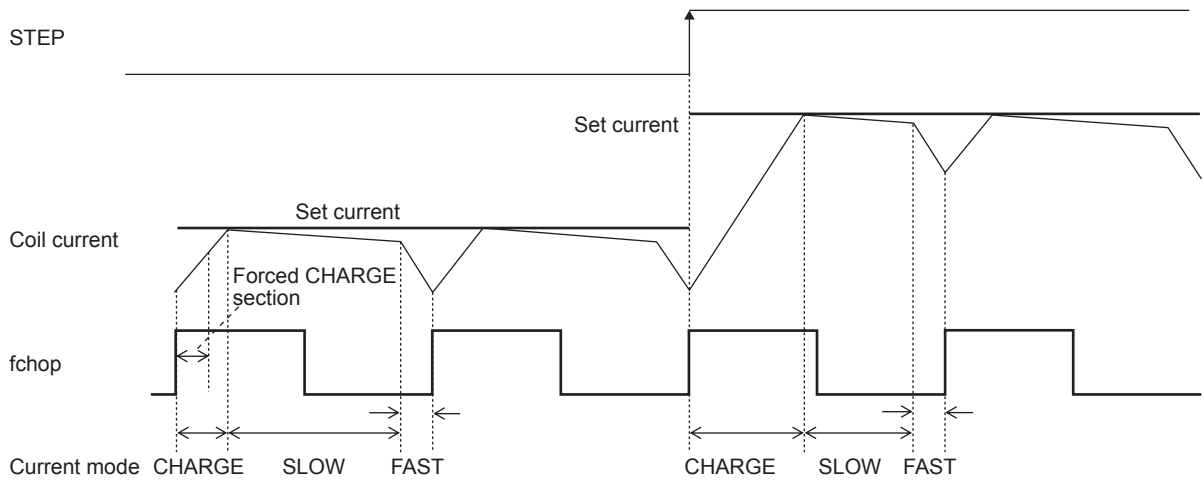
## Quarter step (CW mode)



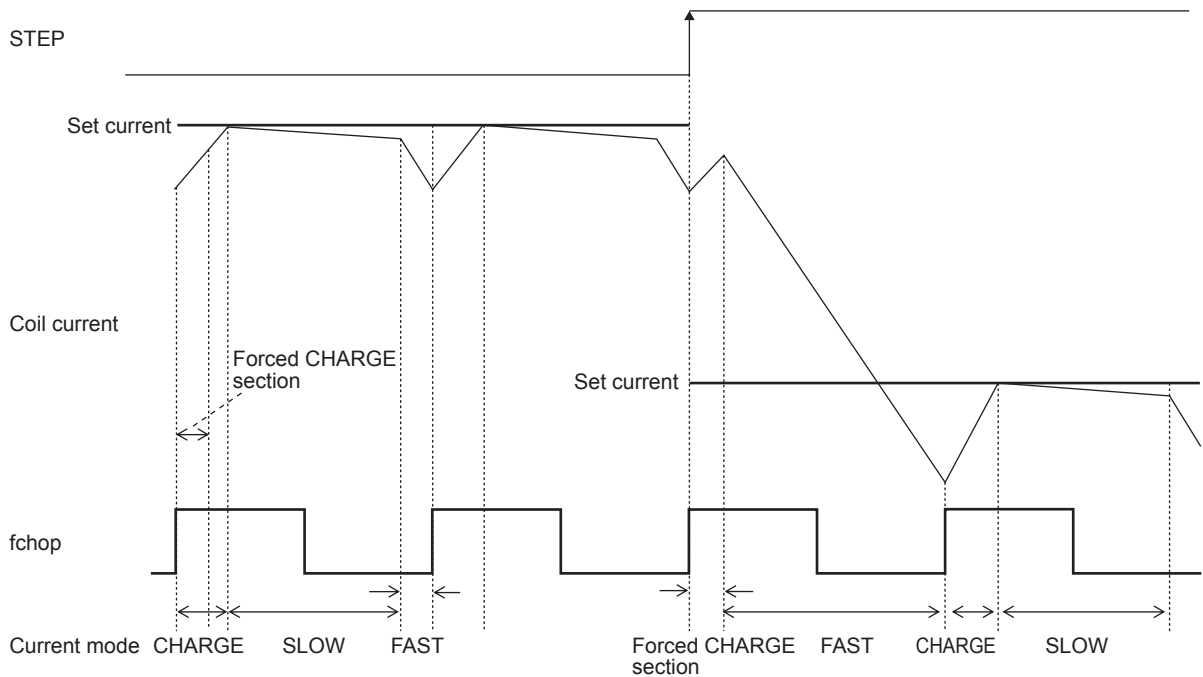
## 1/16 step (CW mode)



2-13) Current control operation specification  
 (Sine wave increasing direction)



(Sine wave decreasing direction)



For current mode control, the operation sequence is as described below :

- At rise of chopping frequency, the CHARGE mode begins. (During 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  $(ICOIL < IREF)$

the winding is charged until  $ICOIL \geq IREF$ , then changed to the SLOW DECAY mode, and finally to the FAST DECAY mode for approximately  $1\mu s$ .

When  $(ICOIL \geq IREF)$

the FAST DECAY mode begins immediately. The coil current is attenuated in the FAST DECAY for one cycle.

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, followed by the SLOW DECAY mode.

**3. DCM Mode (DM=High)**

3-1) 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         |

3-2) Blanking time switching function

| BLK  | Blanking time |
|------|---------------|
| Low  | 2 $\mu$ s     |
| High | 3 $\mu$ s     |

3-3) Output enable function

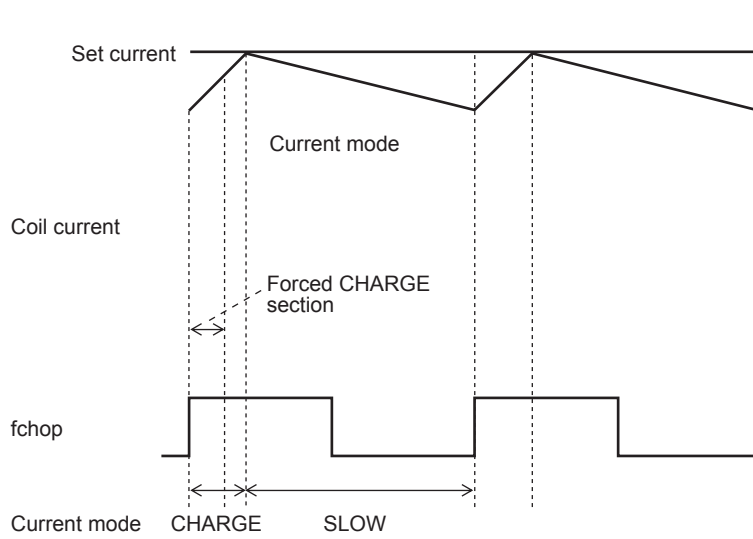
| OE   | Operating mode |
|------|----------------|
| Low  | Output ON      |
| High | Output OFF     |

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

3-4) Current limit reference voltage setting function

By setting a current limit, this IC automatically exercises shorted braking control to ensure that the motor current cannot exceed this limit.

(Current limit control time chart)



The limit current is set as calculated on the basis of the voltage input to the VREF pin and the resistance between the RF pin and GND using the formula given below.

$$I_{limit} = (VREF/5) / RF \text{ resistance}$$

The voltage applied to the VREF pin can be switched to any of the four setting levels depending on the statuses of the two inputs, ATT1 and ATT2.

Function for attenuating VREF input voltage

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

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

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

Example : At VREF of 1.5V, a reference voltage setting of 100% [(ATT1, ATT2) = (L, L)] and an RF resistance of 0.3Ω, the output current is set as shown below.

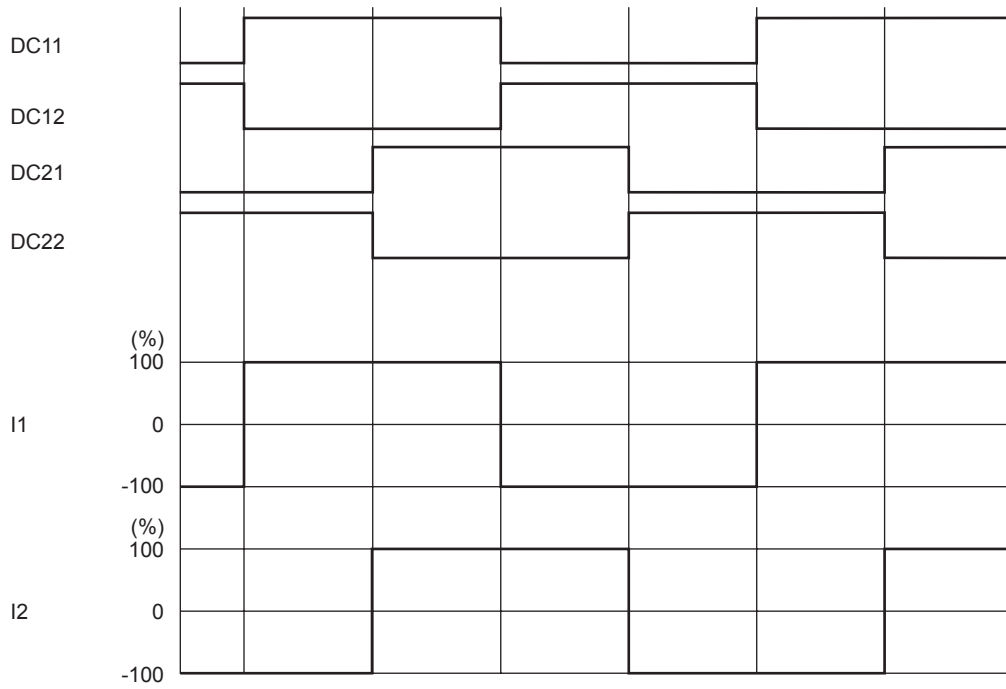
$$I_{limit} = 1.5V/5 \times 100\%/0.3\Omega = 1.0A$$

If, in this state, (ATT1, ATT2) has been set to (H, H), I<sub>limit</sub> will be as follows :

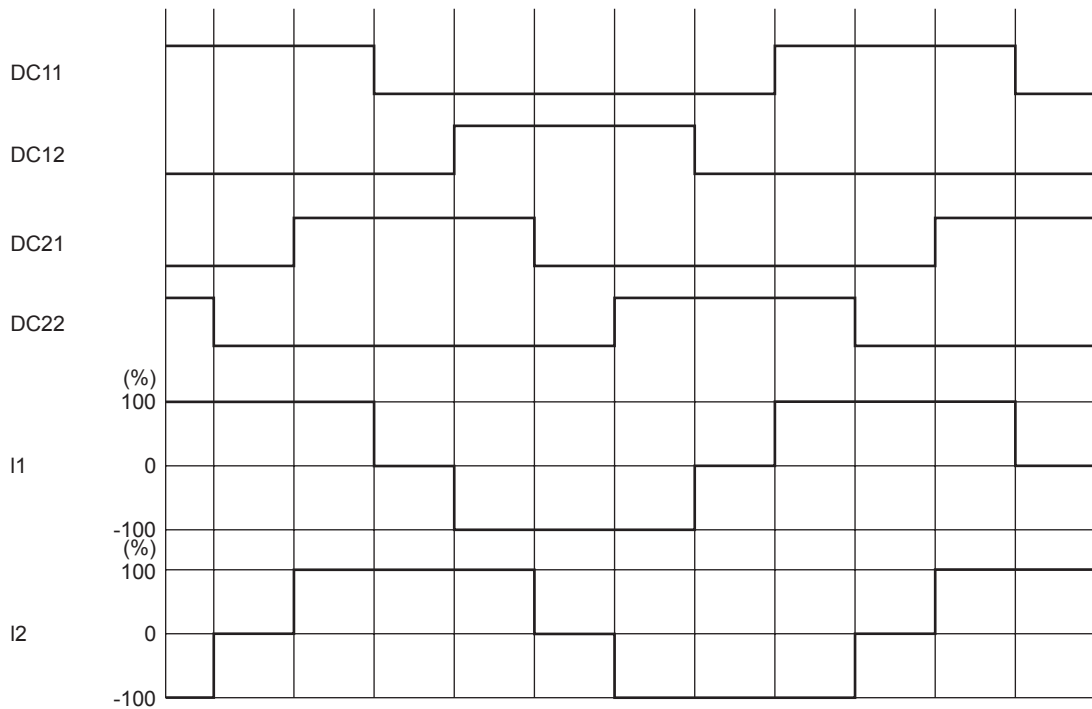
$$I_{limit} = 1.0A \times 20\% = 200mA$$

# LV8774Q

## 3-5) Examples of current waveform in each micro-step mode with stepper motor parallel input control Full step (CW mode)



## Half step full torque (CW mode)



**4. 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. In the stepper motor driver (STM) mode (DM = Low), this function sets the output to the standby mode for both channels by detecting the short-circuiting in one of the channels. In the DC motor driver mode (DM = High), channels 1 and 2 operate independently. (Even if the output of channel 1 has been short-circuited, channel 2 will operate normally.)

**4-1) Output short-circuit protection mode switching function**

Output short-circuit protection mode of IC can be switched by the setting of EMM pin.

| EMM         | State             |
|-------------|-------------------|
| Low or Open | Latch method      |
| High        | Auto reset method |

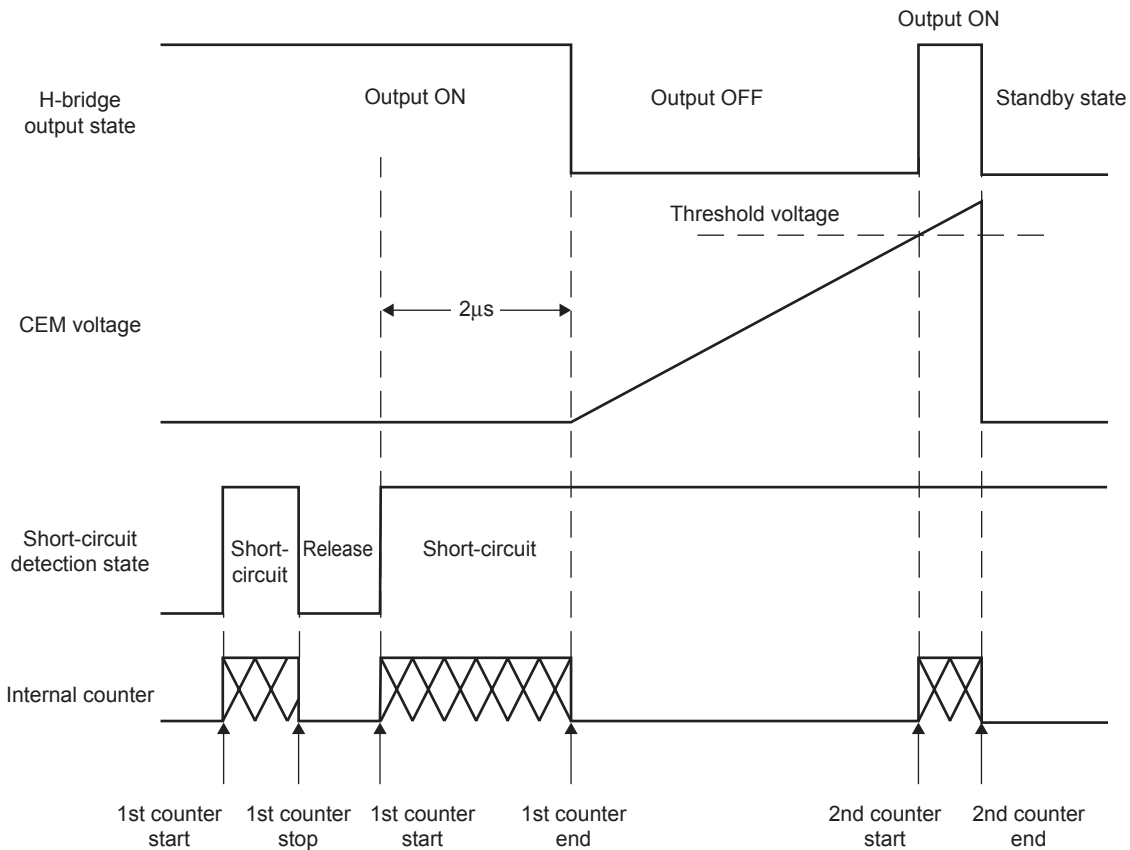
**4-2) Latch type**

In the latch mode, when the output current exceeds the detection current level, the output is turned OFF, and this state is held.

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 2 $\mu$ s), 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.



## 4-3) Auto reset type

In the automatic reset mode, when the output current exceeds the detection current level, the output waveform changes to the switching waveform.

As with the latch system, when the output short-circuited state is detected, the short-circuit protection circuit is activated. When the operation of the short-circuit detection circuit exceeds the timer latch time ( $T_{cem}$ ) described later, the output is changed over to the standby mode and is reset to the ON mode again in 2ms (typ). In this event, if the over current mode still continues, the switching mode described above is repeated until the over current mode is canceled.

## 4-4) Unusual condition warning output pins (EMO, MONI)

The LV8774 is provided with the EMO pin which notifies the CPU if the protection circuit detects 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.

In the DC motor driver mode (DM = High), the MONI pin also functions as a warning output pin.

The functions of the EMO pin and MONI pin change function as shown below depending on the state of the DM pin.

When the DM is low (STM mode) :

EMO : Unusual condition warning output pin

MONI : Excitation initial position detection monitoring

When the DM is high (DCM) mode) :

EMO : Channel 1 warning output pin

MONI : Channel 2 warning output pin

The EMO (MONI) pin is also 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.

| Unusual condition                | DM = L (STM mode) |      | DM = H (DCM mode) |      |
|----------------------------------|-------------------|------|-------------------|------|
|                                  | EMO               | MONI | EMO               | MONI |
| Channel 1 short-circuit detected | ON                | -    | ON                | -    |
| Channel 2 short-circuit detected | ON                | -    | -                 | ON   |
| Overheating condition detected   | ON                | -    | ON                | ON   |

## 4-5) Timer latch time ( $T_{cem}$ )

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

Timer latch :  $T_{cem}$

$$T_{cem} \approx C_{cem} \times V_{t_{cem}} / I_{cem} \text{ [sec]}$$

$V_{t_{cem}}$  : Comparator threshold voltage, typ 1V

$I_{cem}$  : CEM pin charge current, typ 10 $\mu$ A

## 5. Thermal shutdown function

The thermal shutdown circuit is included, and the output is turned off when junction temperature  $T_j$  exceeds 180°C and the abnormal state warning output is turned on at the same time.

When the temperature falls below the hysteresis level, output is driven again (automatic restoration)

The thermal shutdown circuit doesn't guarantee protection of the set and the destruction prevention of IC, as it operates at a temperature that is higher than the rating ( $T_{jmax}=150^\circ\text{C}$ ) of the junction temperature

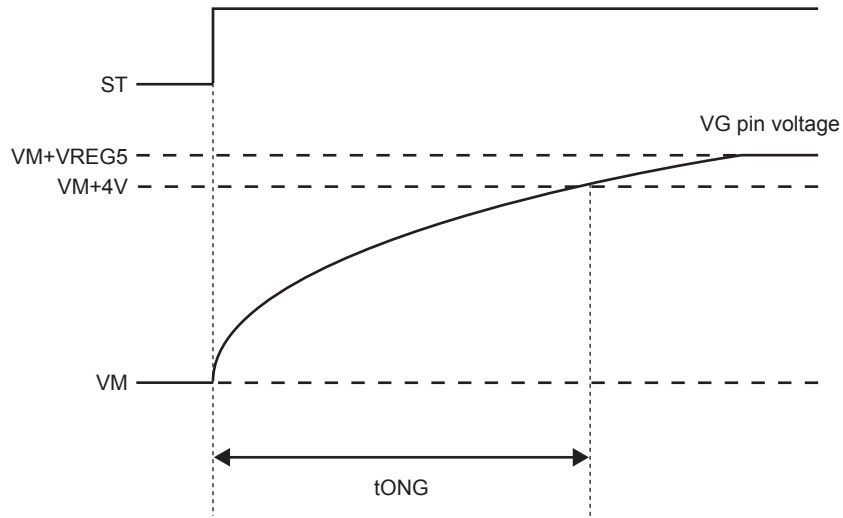
$$TTSD = 180^\circ\text{C (typ)}$$

$$\Delta TSD = 40^\circ\text{C (typ)}$$

## 6. 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 to  $VM+4V$  or more, the output pin cannot be turned on. Therefore it is recommended that the drive of motor is started after the time has passed tONG or more.

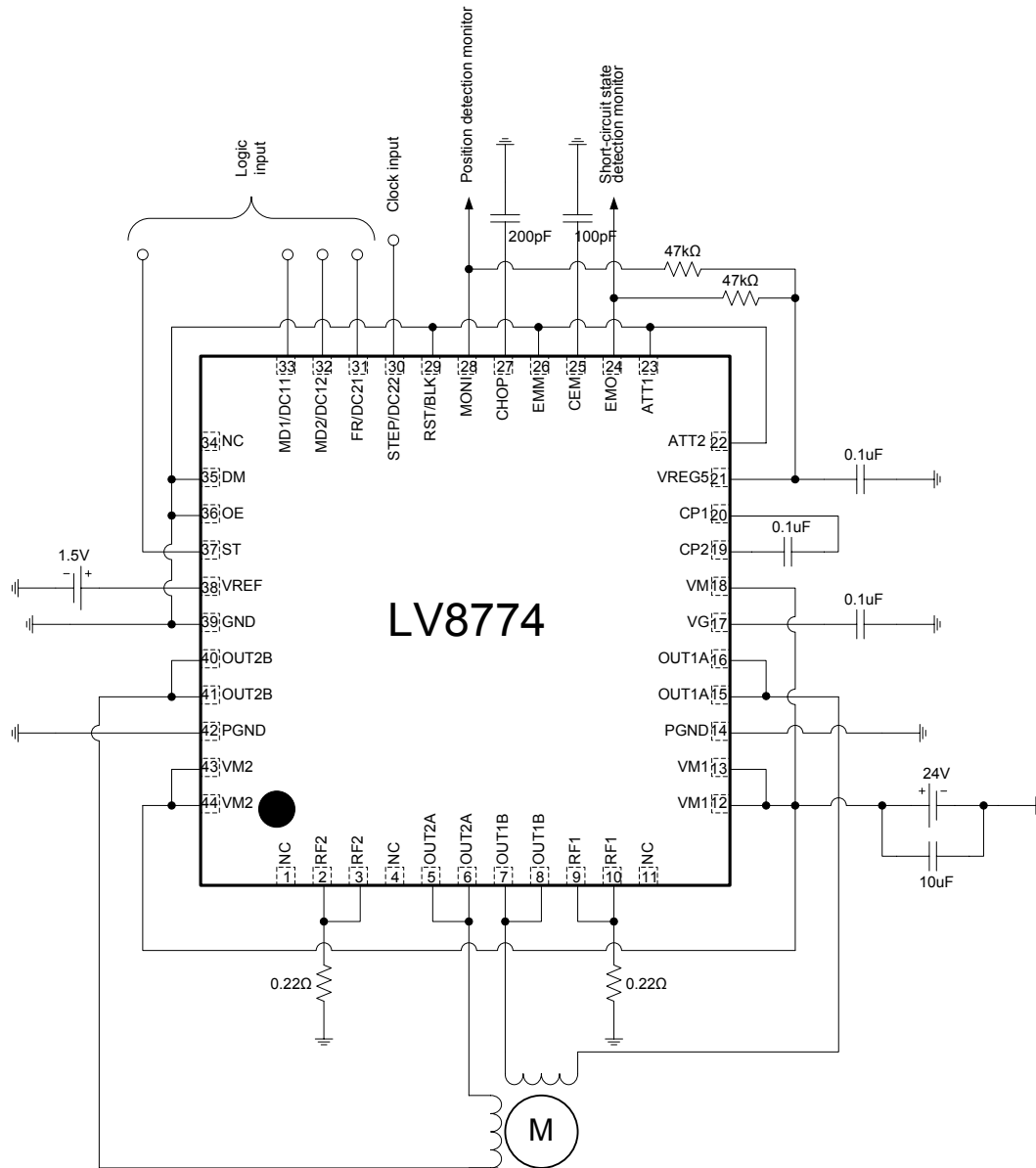


VG Pin Voltage Schematic View



## Application Circuit Example

- Stepper motor driver circuit (DM = Low)



The formulae for setting the constants in the example of the application circuit above are as follows :

Constant current (100%) setting

When  $V_{REF} = 1.5V$

$$I_{OUT} = V_{REF} / 5 / R_F \text{ resistance} \\ = 1.5V / 5 / 0.22\Omega = 1.36A$$

Chopping frequency setting

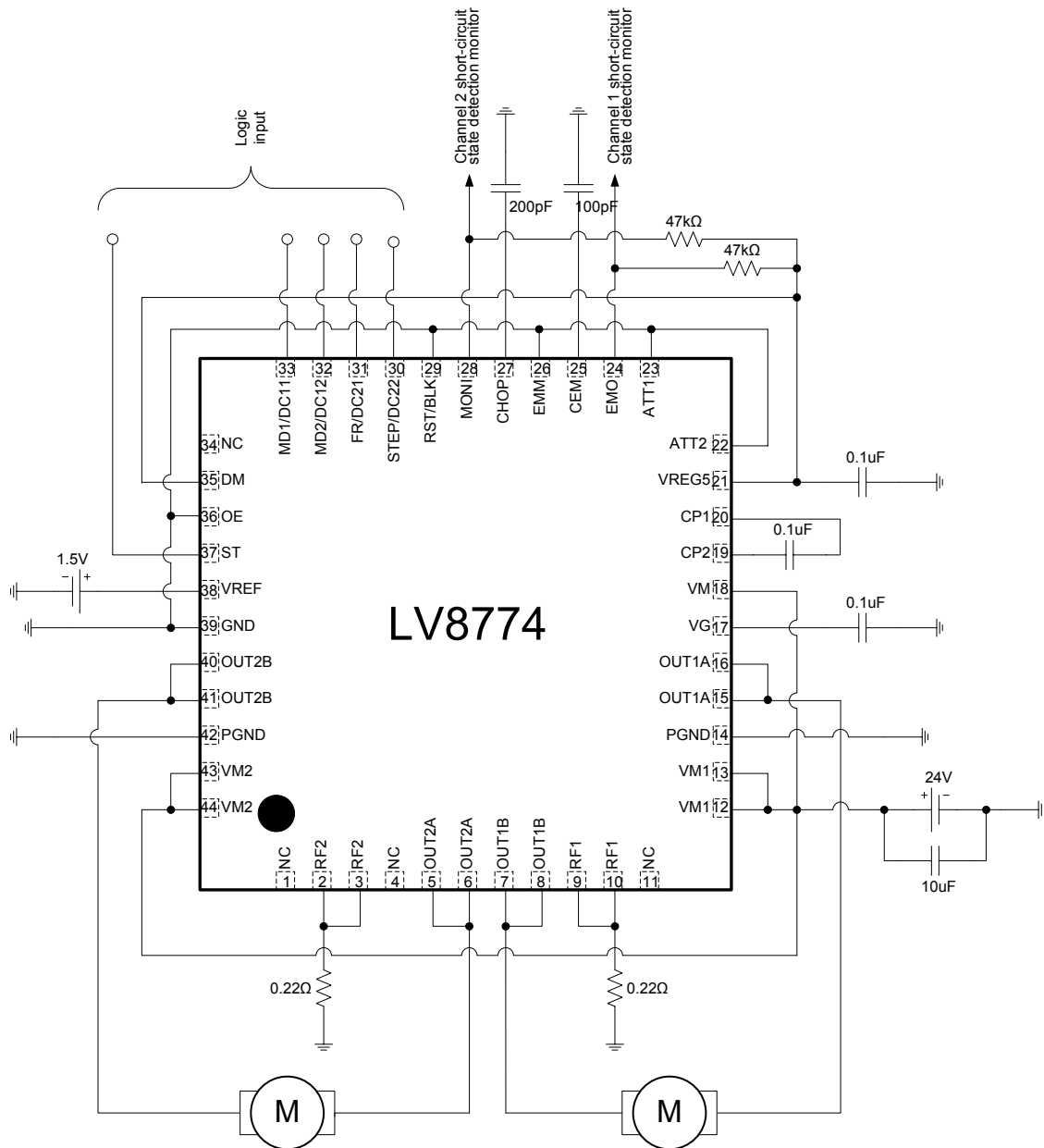
$$F_{chop} = I_{chop} / (C_{chop} \times V_{tchop} \times 2) \\ = 10\mu A / (200pF \times 0.5V \times 2) = 50kHz$$

Timer latch time when the output is short-circuited

$$T_{cem} = C_{cem} \times V_{tcem} / I_{cem} \\ = 100pF \times 1V / 10\mu A = 10\mu s$$

# LV8774Q

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



The formulae for setting the constants in the example of the application circuit above are as follows :

Constant current limit (100%) setting

When  $V_{REF} = 1.5V$

$$I_{limit} = V_{REF} / 5 / R_F \text{ resistance} \\ = 1.5V / 5 / 0.22\Omega = 1.36A$$

Chopping frequency setting

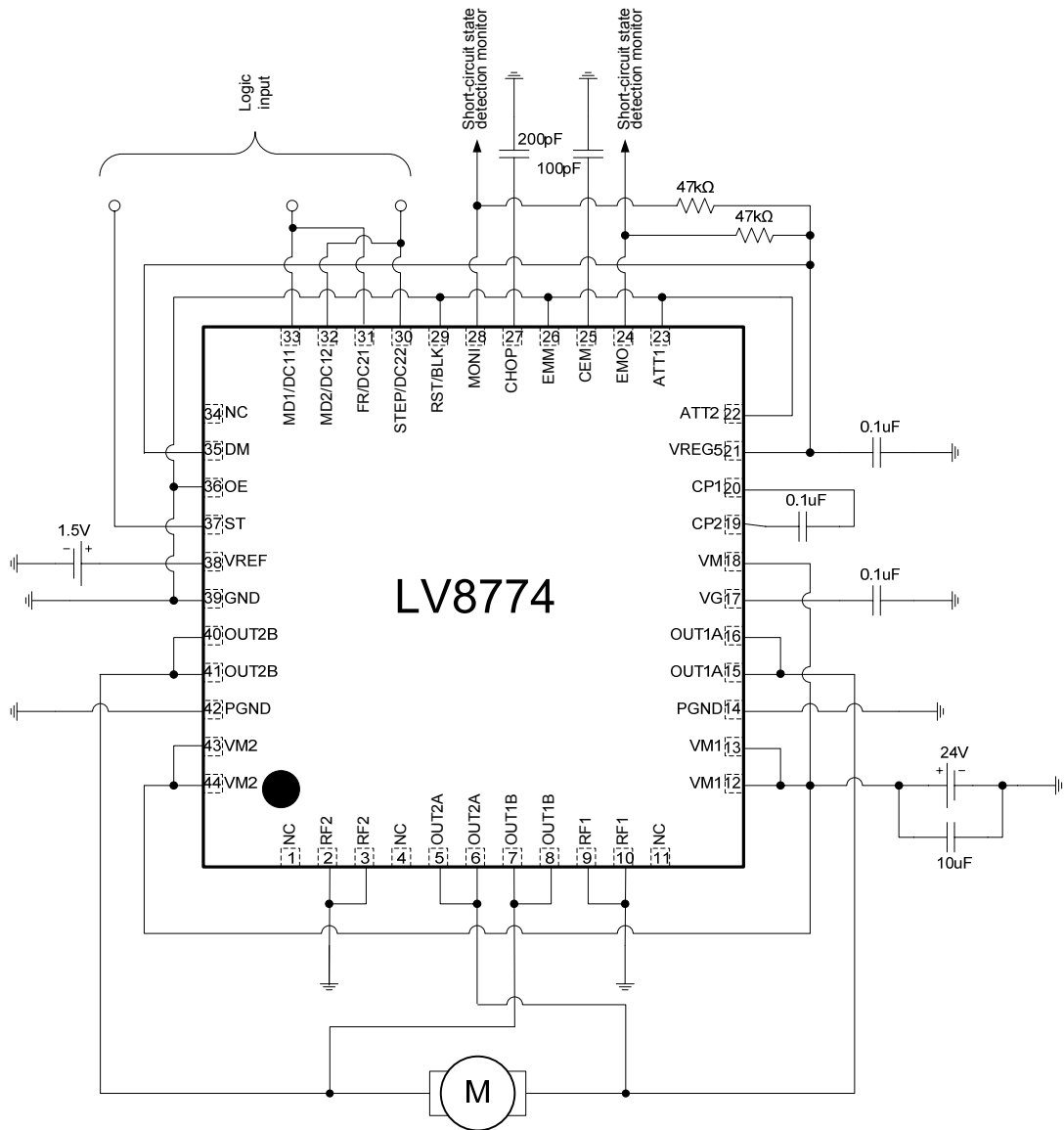
$$f_{chop} = I_{chop} / (C_{chop} \times V_{tchop} \times 2) \\ = 10\mu A / (200pF \times 0.5V \times 2) = 50kHz$$

Timer latch time when the output is short-circuited

$$T_{cem} = C_{cem} \times V_{tcem} / I_{cem} \\ = 100pF \times 1V / 10\mu A = 10\mu s$$

# LV8774Q

- High current DC motor driver circuit (DM = High, and the current limit function cannot be used.)



LV8774Q can drive a large current DC motor by connecting two H-bridges to parallel.

$I_{max} = 4A$

$I_{peak} = 5A$  ( $t_w \leq 10ms$ , duty 20%)

When it connects two H-bridges to parallel, LV8774Q cannot use the internal PWM constant current control function. Please connect the RF1 pin and RF2 pin to GND.

**ORDERING INFORMATION**

| Device     | Package   | Shipping (Qty / Packing) |
|------------|---|--------------------------|
| LV8774Q-AH | VQFN44L (6mm x 6mm)<br>(Pb-Free / Halogen Free) | 1000 / Tape & Reel       |

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