



# LV8773

Bi-CMOS LSI

## PWM Constant-Current Control Stepping Motor Driver

ON Semiconductor®

<http://onsemi.com>

### Overview

The LV8773 is a 2-channel H-bridge driver IC, which supports forward, reverse, brake, and standby of a motor. It is ideally suited for driving brushed DC motors and stepping motors used in office equipment and amusement applications.

### Features

- BiCDMOS process IC
- Low on resistance (upper side :  $0.3\Omega$  ; lower side :  $0.25\Omega$  ; total of upper and lower :  $0.55\Omega$  ;  $T_a = 25^\circ\text{C}$ ,  $I_O = 2\text{A}$ )
- Motor current selectable in two steps
- Output short-circuit protection circuit (selectable from latch-type or auto-reset-type) incorporated
- Unusual condition warning output pins
- No control power supply required

### Specifications

#### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	$V_M$ max		36	V
Output peak current	$I_O$ peak	$t_w \leq 10\text{ms}$ , duty 20%	2.5	A
Output current	$I_O$ max		2	A
Logic input voltage	$V_{IN}$		-0.3 to +6	V
EMO1/EMO2 input voltage	$V_{emo1}/V_{emo2}$		-0.3 to +6	V
Allowable power dissipation	$P_d$ max1	1 unit	3.0	W
	$P_d$ max2	*	6.2	W
Operating temperature	$T_{opr}$		-20 to +85	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-55 to +150	$^\circ\text{C}$

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

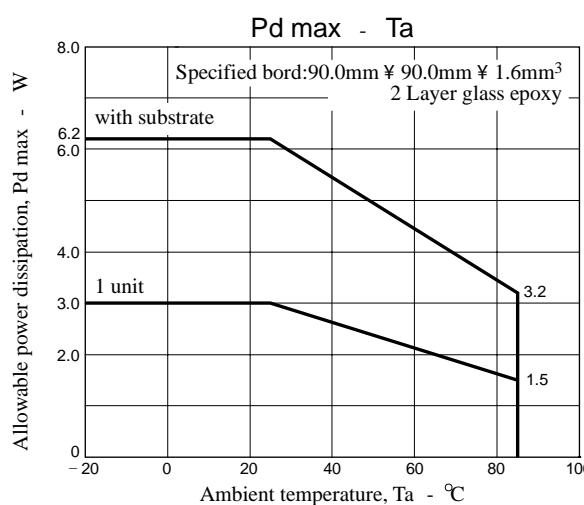
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

**Allowable Operating Ratings** at  $T_a = 25^\circ\text{C}$ 

Parameter	Symbol	Conditions	Ratings		Unit
Supply voltage range	$V_M$		9 to 32		V
Logic input voltage	$V_{IN}$		0 to 5.5		V
VREF input voltage range	$V_{REF}$		0 to 3		V

**Electrical Characteristics** at  $T_a = 25^\circ\text{C}$ ,  $V_M = 24\text{V}$ ,  $V_{REF} = 1.5\text{V}$ 

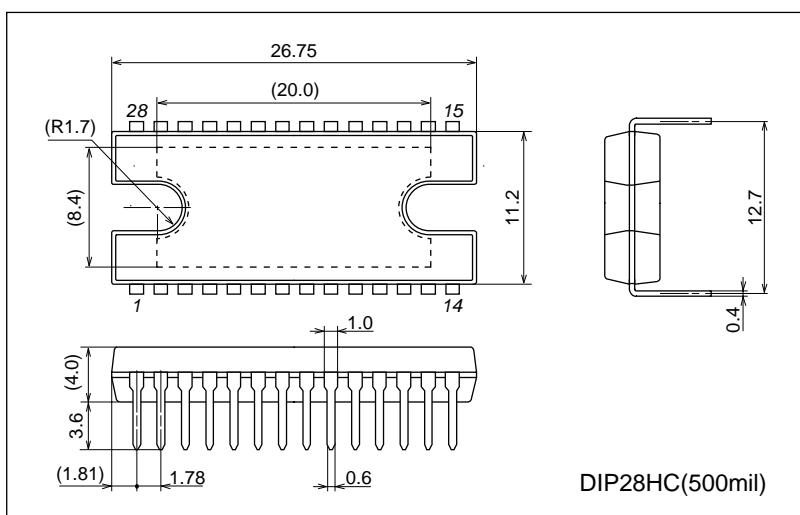
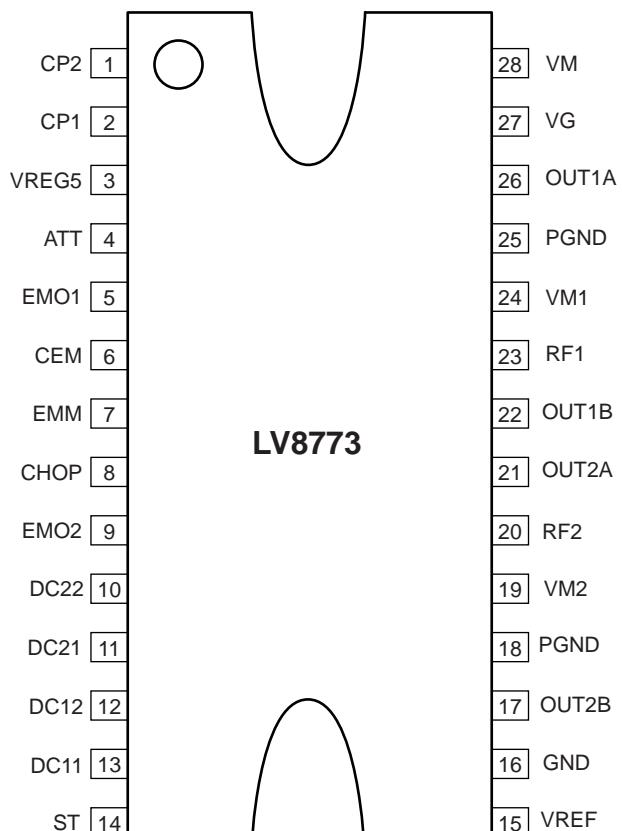
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain	$I_{MST}$	$ST = \text{"L"}$		100	400	$\mu\text{A}$
Current drain	$I_M$	$ST = \text{"H"}, OE = \text{"L"}$ , with no load		3.2	5	mA
VREG5 output voltage	$V_{REG5}$	$I_O = -1\text{mA}$	4.5	5	5.5	V
Thermal shutdown temperature	$T_{SD}$	Design guarantee	150	180	200	$^\circ\text{C}$
Thermal hysteresis width	$\Delta T_{SD}$	Design guarantee		40		$^\circ\text{C}$
<b>Motor driver</b>						
Output on resistance	$R_{ONU}$	$I_O = 2\text{A}$ , Upper-side on resistance		0.3	0.4	$\Omega$
	$R_{OND}$	$I_O = 2\text{A}$ , Lower-side on resistance		0.25	0.33	$\Omega$
Output leakage current	$I_{OLeak}$				50	$\mu\text{A}$
Diode forward voltage	$V_D$	$I_D = -2\text{A}$		1.2	1.4	V
Logic pin input current	$I_{INL}$	$V_{IN} = 0.8\text{V}$	4	8	12	$\mu\text{A}$
	$I_{INH}$	$V_{IN} = 5\text{V}$	30	50	70	$\mu\text{A}$
Logic high-level input voltage	$V_{INH}$		2.0			V
Logic low-level input voltage	$V_{INL}$				0.8	V
Current setting comparator threshold voltage (current attenuation rate switching)	$V_{TATT0}$	$ATT = \text{L}$	0.291	0.3	0.309	V
	$V_{TATT1}$	$ATT = \text{H}$	0.143	0.15	0.157	V
Chopping frequency	$F_{CHOP}$	$C_{CHOP} = 220\text{pF}$	36.3	45.4	54.5	kHz
CHOP pin charge/discharge current	$I_{CHOP}$		7	10	13	$\mu\text{A}$
Chopping oscillation circuit threshold voltage	$V_{TUP}$		0.8	1	1.2	V
	$V_{TDOWN}$		0.4	0.5	0.6	V
VREF pin input current	$I_{REF}$	$V_{REF} = 1.5\text{V}$	-0.5			$\mu\text{A}$
<b>Charge pump</b>						
VG output voltage	$V_G$		28	28.7	29.8	V
Rise time	$t_{ONG}$	$V_G = 0.1\mu\text{F}$		200		$\mu\text{s}$
Oscillator frequency	$F_{OSC}$		90	125	150	kHz
<b>Output short-circuit protection</b>						
EMO1/EMO2 pin saturation voltage	$V_{SATEMO}$	$I_{EMO} = 1\text{mA}$			400	mV
CEM pin charge current	$I_{CEM}$	$V_{CEM} = 0\text{V}$	7	10	13	$\mu\text{A}$
CEM pin threshold voltage	$V_{TCEM}$		0.8	1	1.2	V



**Package Dimensions**

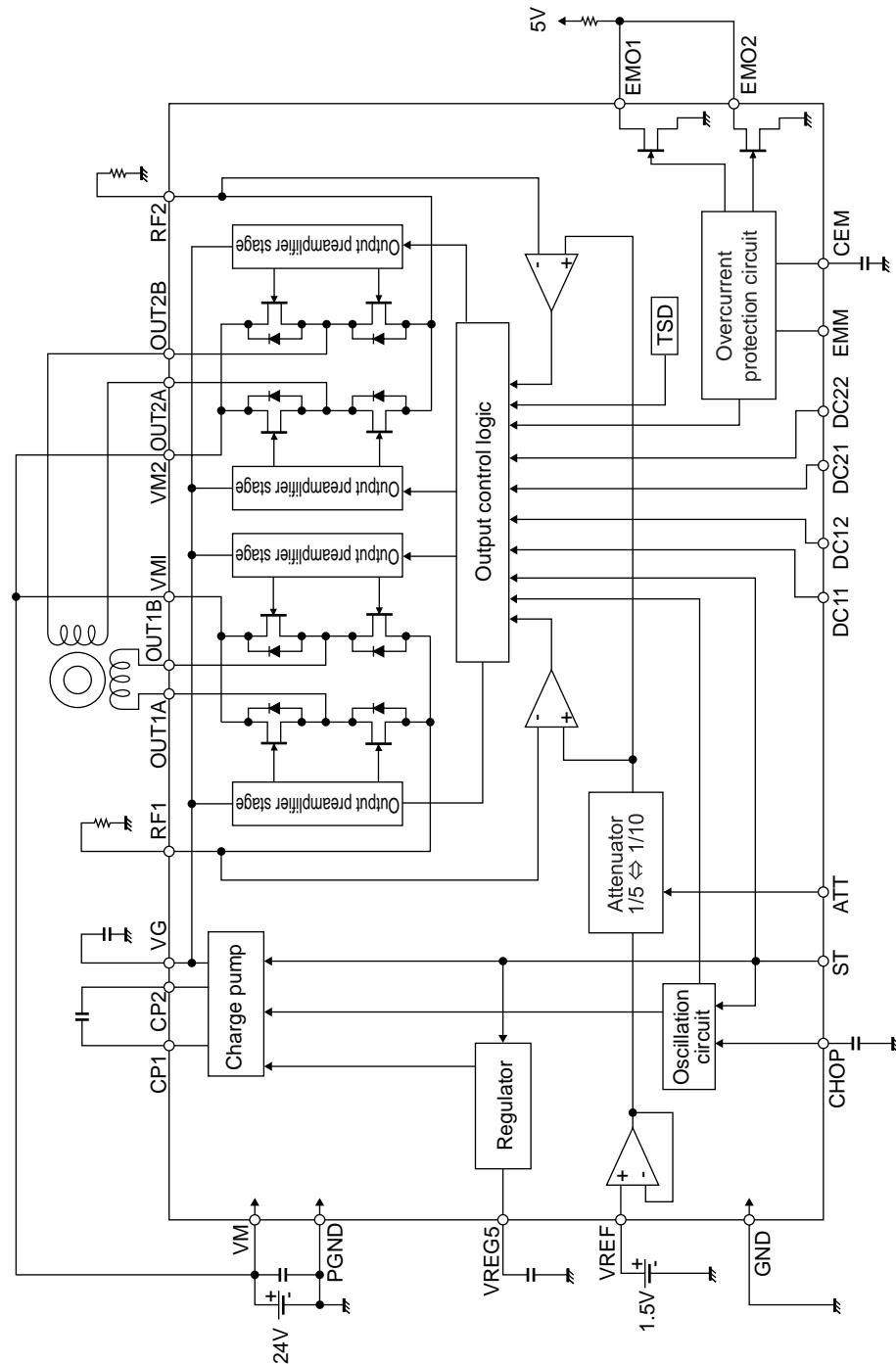
unit : mm (typ)

3241A

**Pin Assignment**

Top view

## Block Diagram



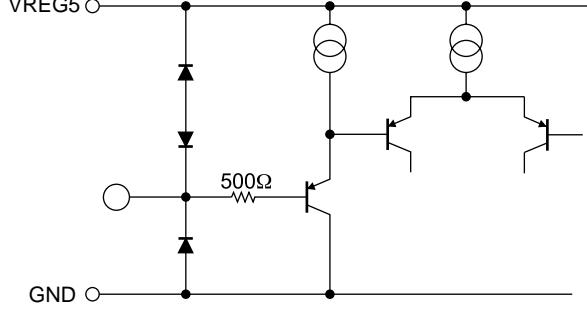
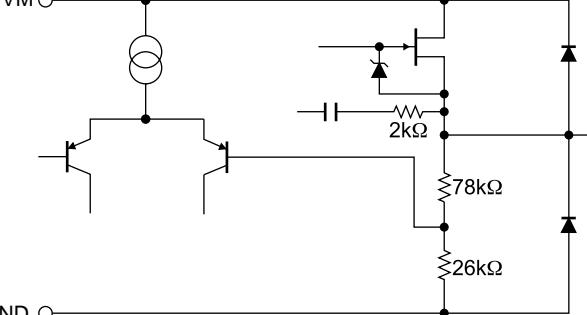
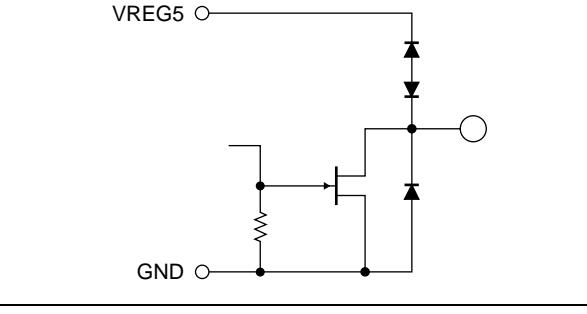
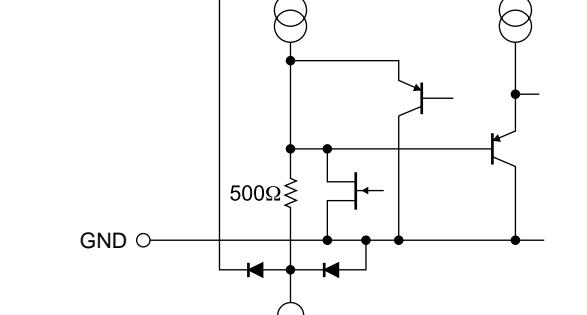
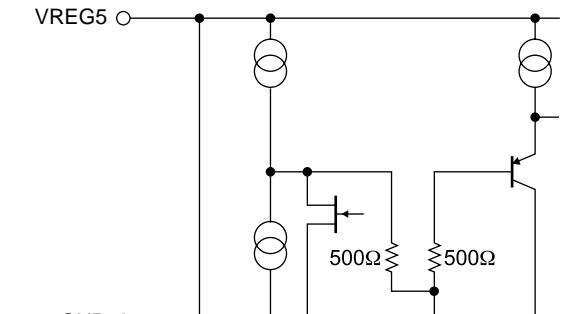
## Pin Functions

Pin No.	Pin Name	Pin Function	Equivalent Circuit
4	ATT2	Motor holding current switching pin.	
7	EMM	Output short-circuit protection mode switching pin.	
10	DC22	Channel 2 output control input pin 2	
11	DC21	Channel 2 output control input pin 1	
12	DC12	Channel 1 output control input pin 2	
13	DC11	Channel 1 output control input pin 1	
14	ST	Chip enable pin.	
17	OUT2B	Channel 2 OUTB output pin.	
18, 25	PGND	Power system ground.	
19	VM2	Channel 2 motor power supply connection pin.	
20	RF2	Channel 2 current-sense resistor connection pin.	
21	OUT2A	Channel 2 OUTA output pin.	
22	OUT1B	Channel 1 OUTB output pin.	
23	RF1	Channel 1 current-sense resistor connection pin.	
24	VM1	Channel 1 motor power supply pin.	
26	OUT1A	Channel 1 OUTA output pin.	
27	VG	Charge pump capacitor connection pin.	
28	VM	Motor power supply connection pin.	
1	CP2	Charge pump capacitor connection pin.	
2	CP1	Charge pump capacitor connection pin.	
16	GND	Ground.	

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Pin No.	Pin Name	Pin Function	Equivalent Circuit
15	VREF	Constant current control reference voltage input pin.	
3	VREG5	Internal power supply capacitor connection pin.	
5 9	EMO1 EMO2	Channel 1 output short-circuit state warning output pin. Channel 2 output short-circuit state warning output pin.	
6	CEM	Pin to connect the output short-circuit state detection time setting capacitor	
8	CHOP	Copping frequency setting capacitor connection pin.	

**Description of operation****(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) Output control logic**

input		output		mode
DC11(21)	DC12(22)	OUT1(2)A	OUT1(2)B	
L	L	OFF	OFF	Stand-by
H	L	H	L	CW ( Forward )
L	H	L	H	CCW ( reverse )
H	H	L	L	brake

**(3) 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.

This IC is the blanking time is fixed at approximately 2μs.

**(4) 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

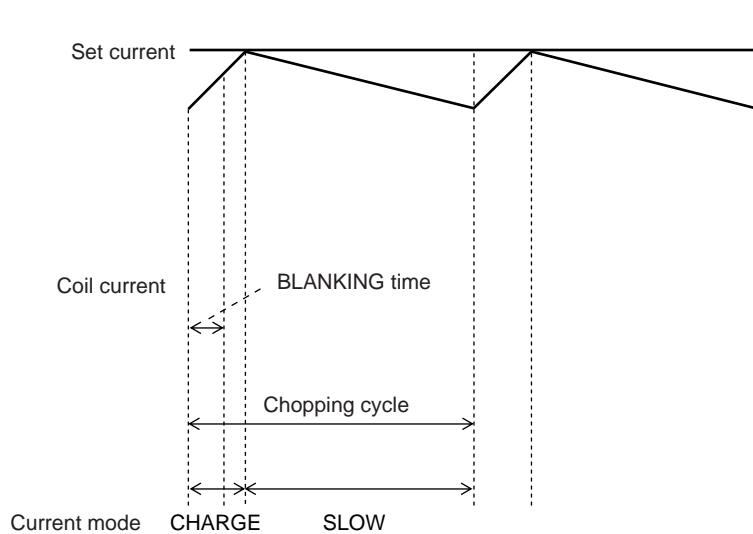
$V_{tchop}$  : Charge/discharge hysteresis voltage ( $V_{tup} - V_{tdown}$ ), typ 0.5V

For instance, when Cchop is 220pF, the chopping frequency will be as follows :

$$F_{chop} = 10\mu\text{A} / (220\text{pF} \times 0.5\text{V} \times 2) = 45.4\text{kHz}$$

## (5) Setting constant-current control

When the current of the motor reaches up to a set current by setting the output current, this IC does the short brake control by the automatic operation so that the current should not increase more than it.



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 :

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

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

The voltage input to the VREF pin can be switched to two-step settings depending on the statuses of the ATT.

Attenuation function for VREF input voltage

ATT	Current setting reference voltage attenuation ratio
Low	100%
High	50%

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

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

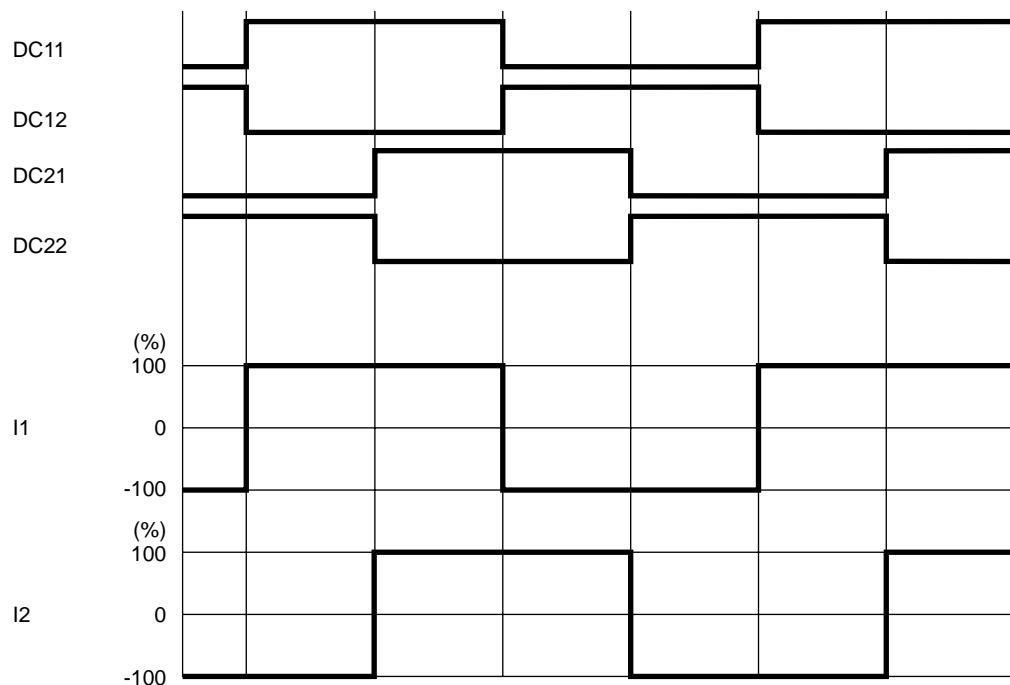
Example : At VREF of 1.5V, a reference voltage setting of 100% (ATT = L) and an RF resistance of  $0.3\Omega$ , the output current is set as shown below.

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

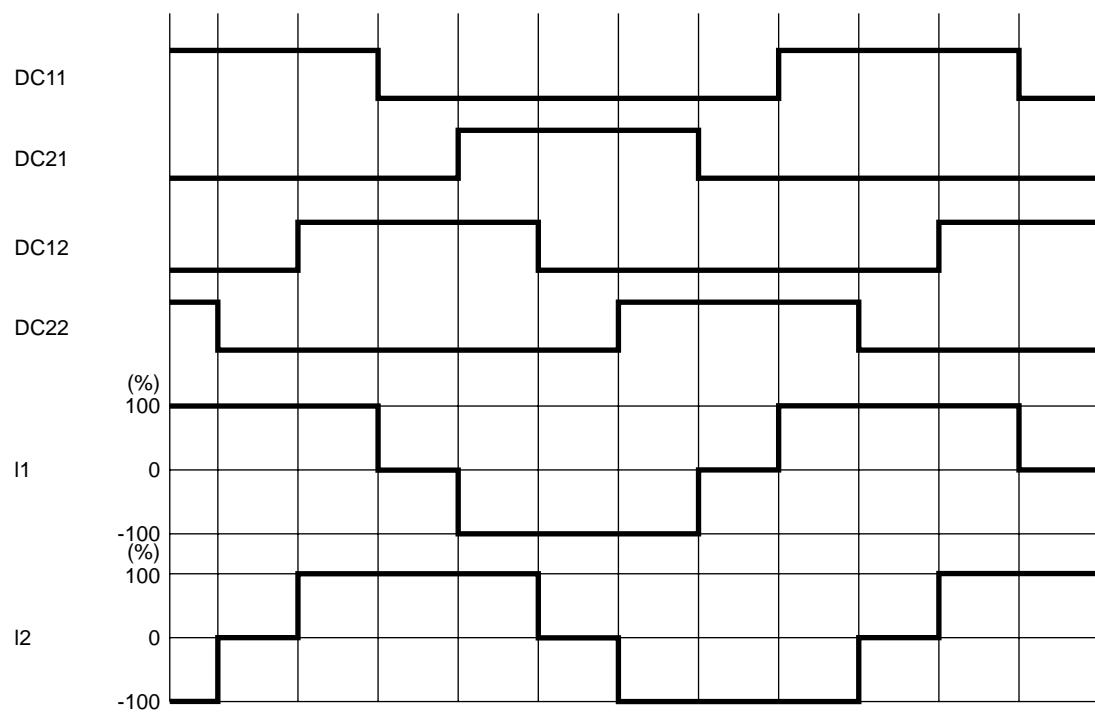
If, in this state, ATT = H will be as follows :

$$I_{OUT} = 1.0A \times 50\% = 500mA$$

(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)



## (7) 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 channels 1 and 2 operate independently. (Even if the output of channel 1 has been short-circuited, channel 2 will operate normally.)

### (7-1) Output short-circuit protection operation changeover function

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

EMM	State
Low or Open	Latch method
High	Auto reset method

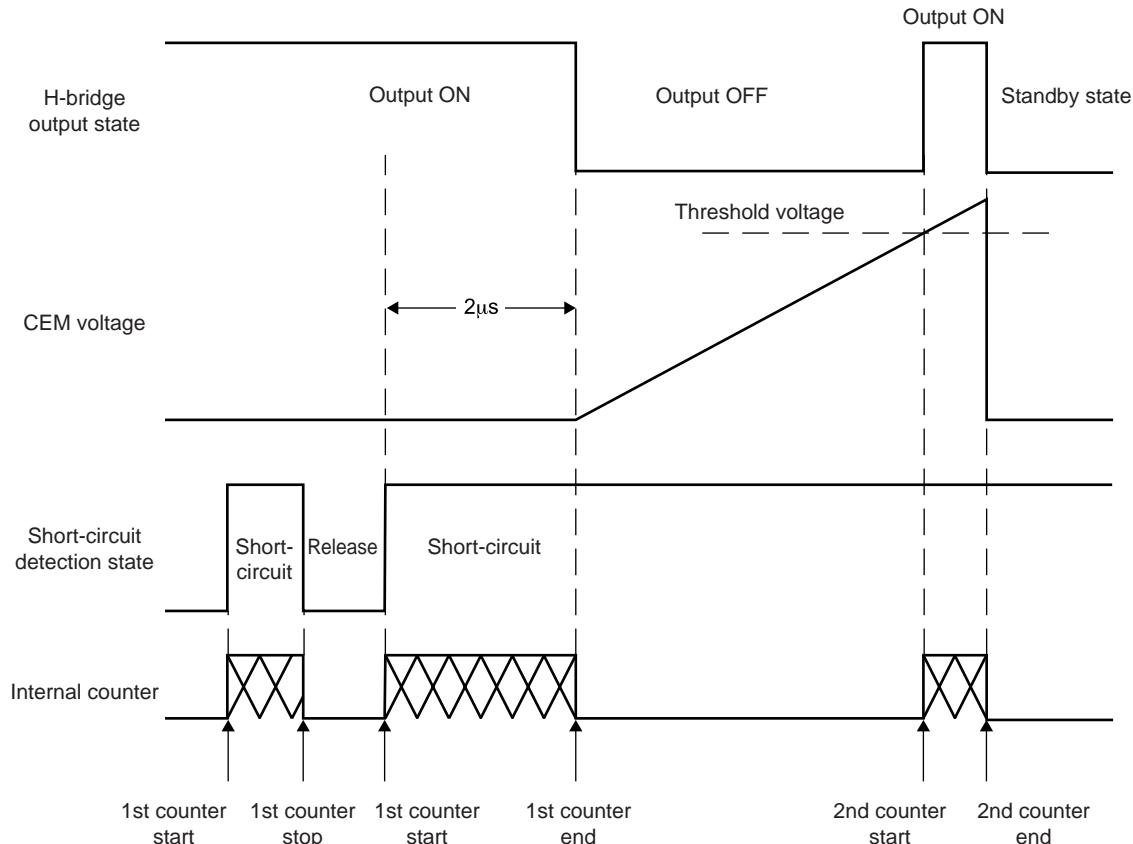
### (7-2) Latch type

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 2μs), 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.



**(7-3) 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 (Tcem) 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 overcurrent mode still continues, the switching mode described above is repeated until the overcurrent mode is canceled.

**(7-4) Unusual condition warning output pins (EMO1, EMO2)**

The LV8773 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.

The EMO1 pin and the EMO2 pin output unusual condition on 2ch side/ 1ch side respectively.

Furthermore, the EMO (EMO2) 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.

Unusual condition	EMO1	EMO2
Channel 1 short-circuit detected	ON	-
Channel 2 short-circuit detected	-	ON
Overheating condition detected	ON	ON

**(7-5) Timer latch time (Tcem)**

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

Timer latch : Tcem

$$Tcem \approx Ccem \times Vtcem/Icem \text{ [sec]}$$

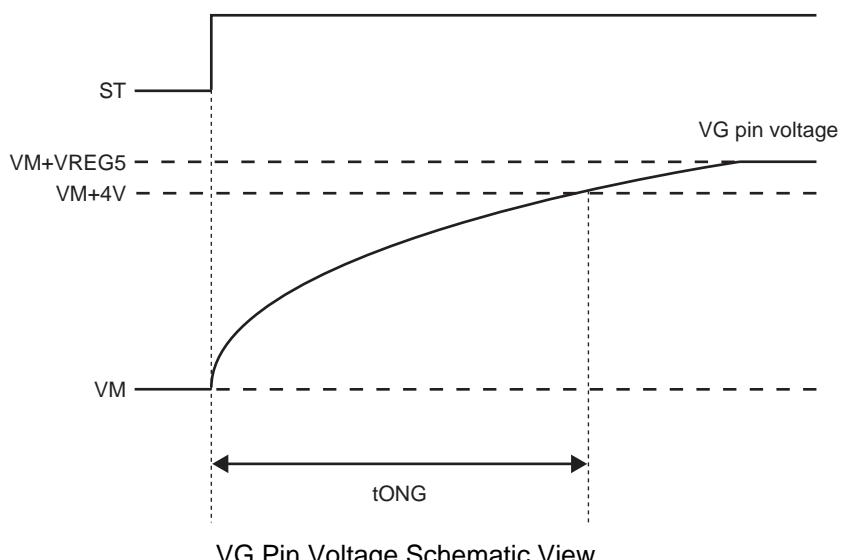
Vtcem : Comparator threshold voltage, typ 1V

Icem : CEM pin charge current, typ 10μA

**(8) Charge Pump Circuit**

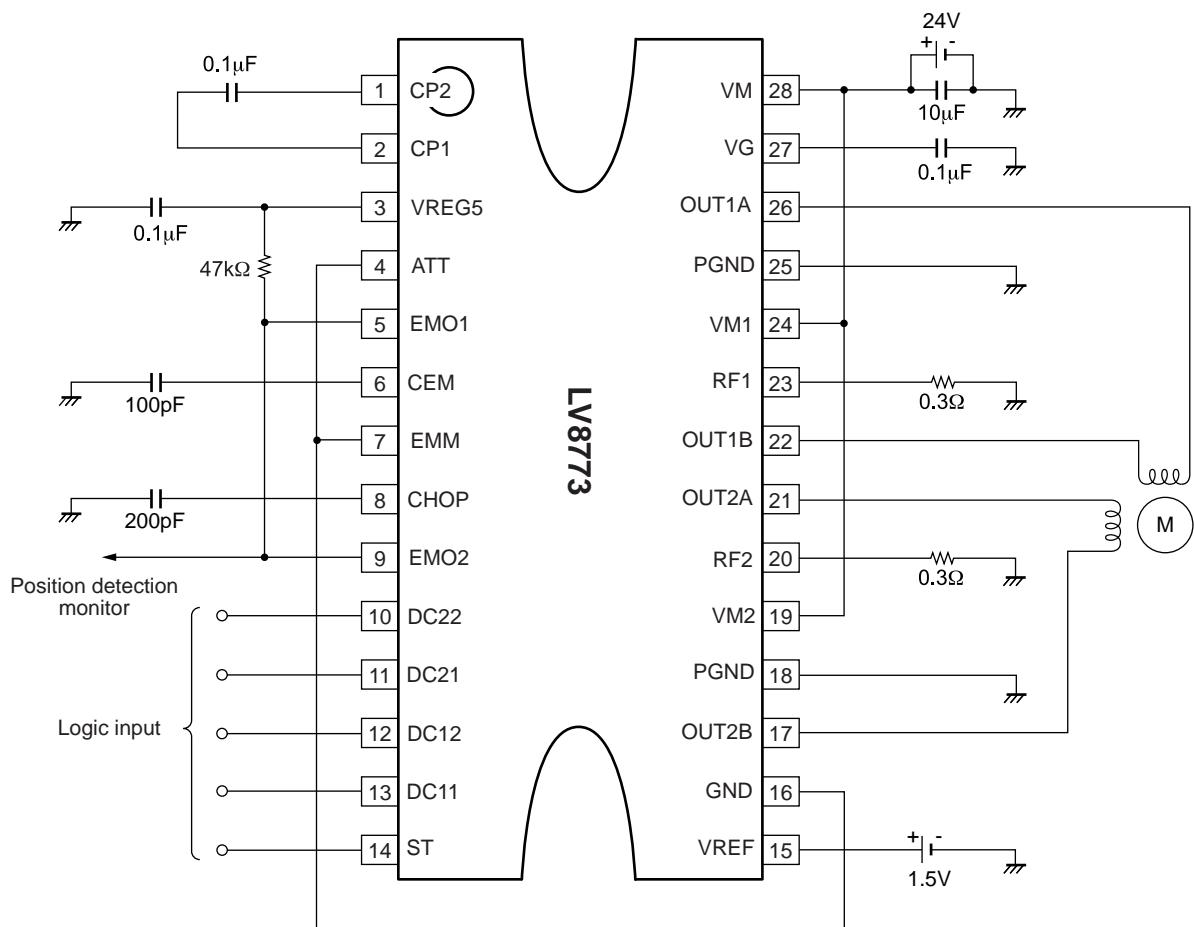
When the ST pin is set High, the charge pump circuit operates and the VG pin voltage is boosted from the VM voltage to the VM + VREG5 voltage.

Begin the drive of the motor after the time of tONG or more because it doesn't turn on the output if the voltage of the VG pin is not pressured to VM+4V or more.



**Application Circuit Example**

- Stepping motor driver circuit



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

Constant current (100%) setting

When  $VREF = 1.5V$

$$I_{OUT} = VREF/5/RF \text{ resistance} \\ = 1.5V/5/0.3\Omega = 1.0A$$

Chopping frequency setting

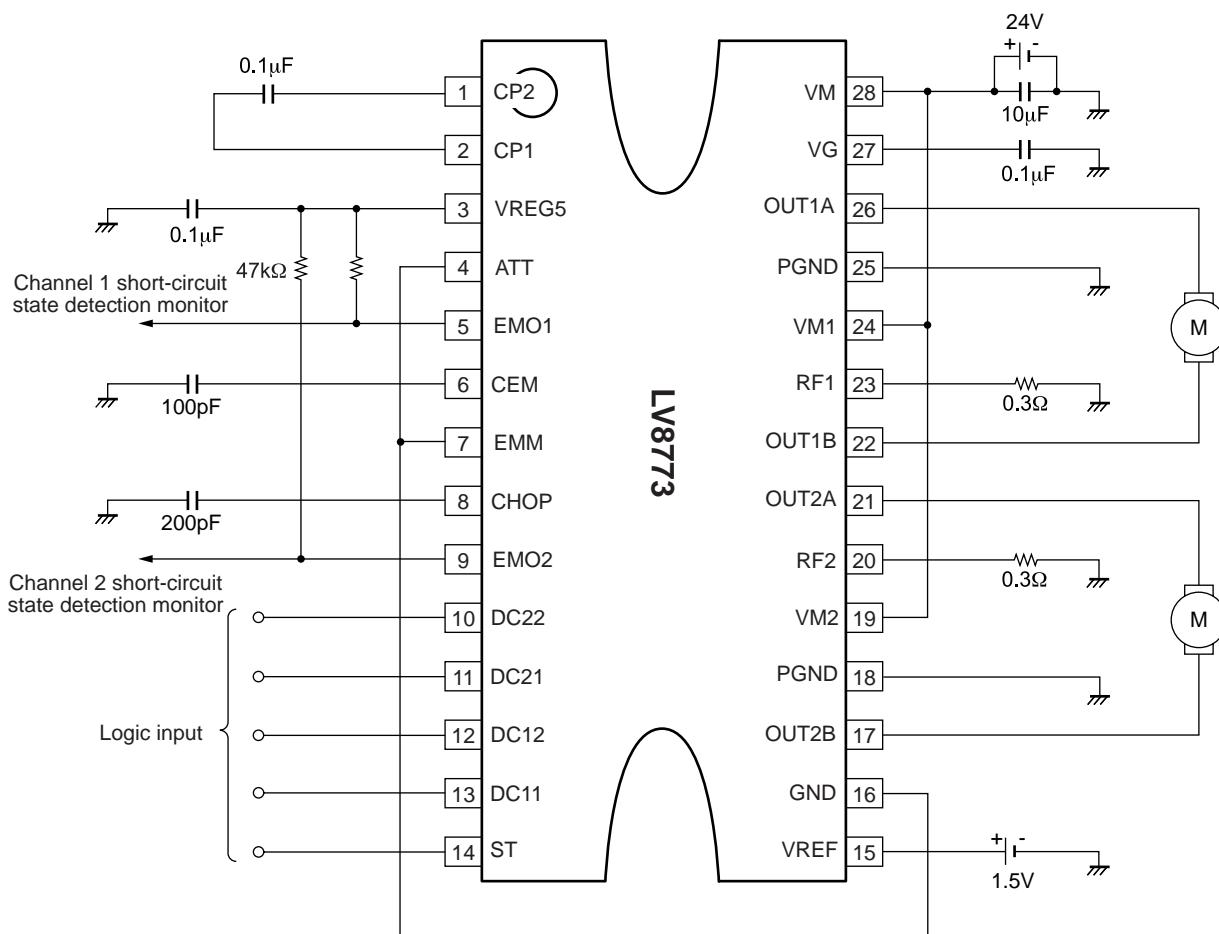
$$F_{chop} = I_{chop}/(C_{chop} \times V_{tchop} \times 2) \\ = 10\mu A/(220pF \times 0.5V \times 2) = 45.4kHz$$

Timer latch time when the output is short-circuited

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

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- DC motor driver circuit (Constant current control function is used.)



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

Constant current limit (100%) setting

When  $VREF = 1.5V$

$$I_{limit} = VREF/5/RF \text{ resistance} \\ = 1.5V/5/0.3\Omega = 1.0A$$

Chopping frequency setting

$$F_{chop} = I_{chop}/(C_{chop} \times V_{tchop} \times 2) \\ = 10\mu A/(220pF \times 0.5V \times 2) = 45.4kHz$$

Timer latch time when the output is short-circuited

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

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