

LV8741V



ON Semiconductor®

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Bi-CMOS LSI

PWM Current Control Stepper Motor Driver Application Note

Overview

The LV8741V is a 2-channel H-bridge driver IC that can switch a stepper motor driver, which is capable of micro-step drive and supports Full-step, Half-step (full torque), Half-step, and Quarter-step resolution, and two channels of a brushed motor driver, which supports forward, reverse, brake, and standby of a motor.

Function

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

Typical Applications

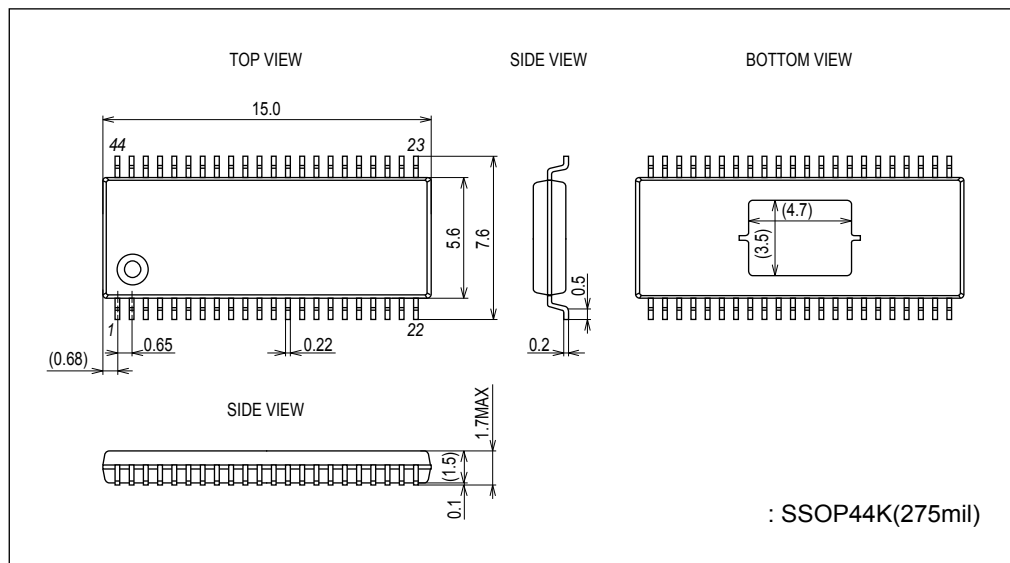
- MFP (Multi Function Printer)
- PPC (Plain Paper Copier)
- LBP (Laser Beam Printer)
- Photo printer
- Scanner
- Industrial
- Cash Machine
- Amusement
- Textile

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Package Dimensions

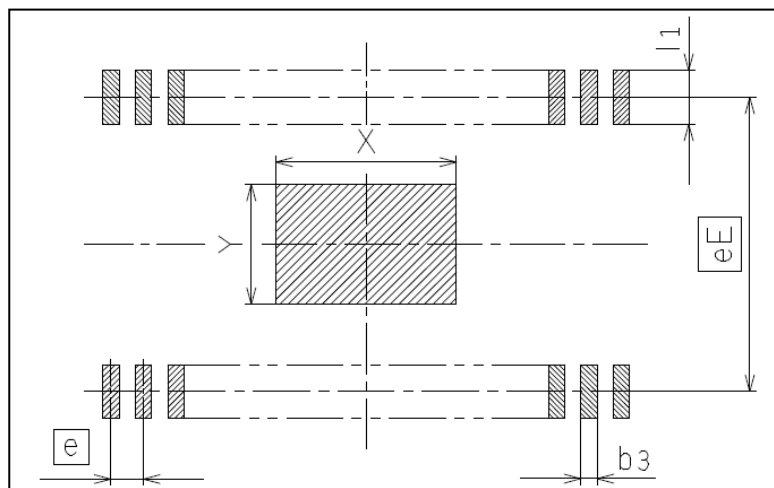
unit: mm (typ)

3333



Caution: The package dimension is a reference value, which is not a guaranteed value.

Recommended Soldering Footprint

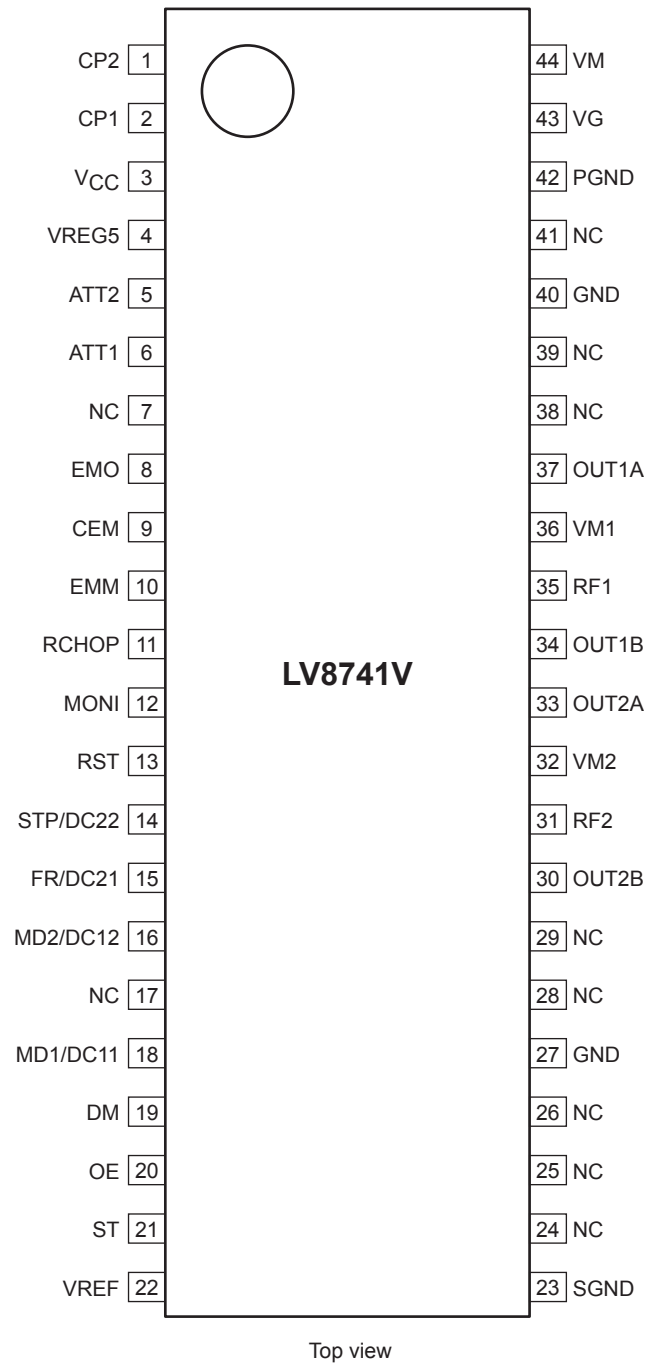


(Unit:mm)

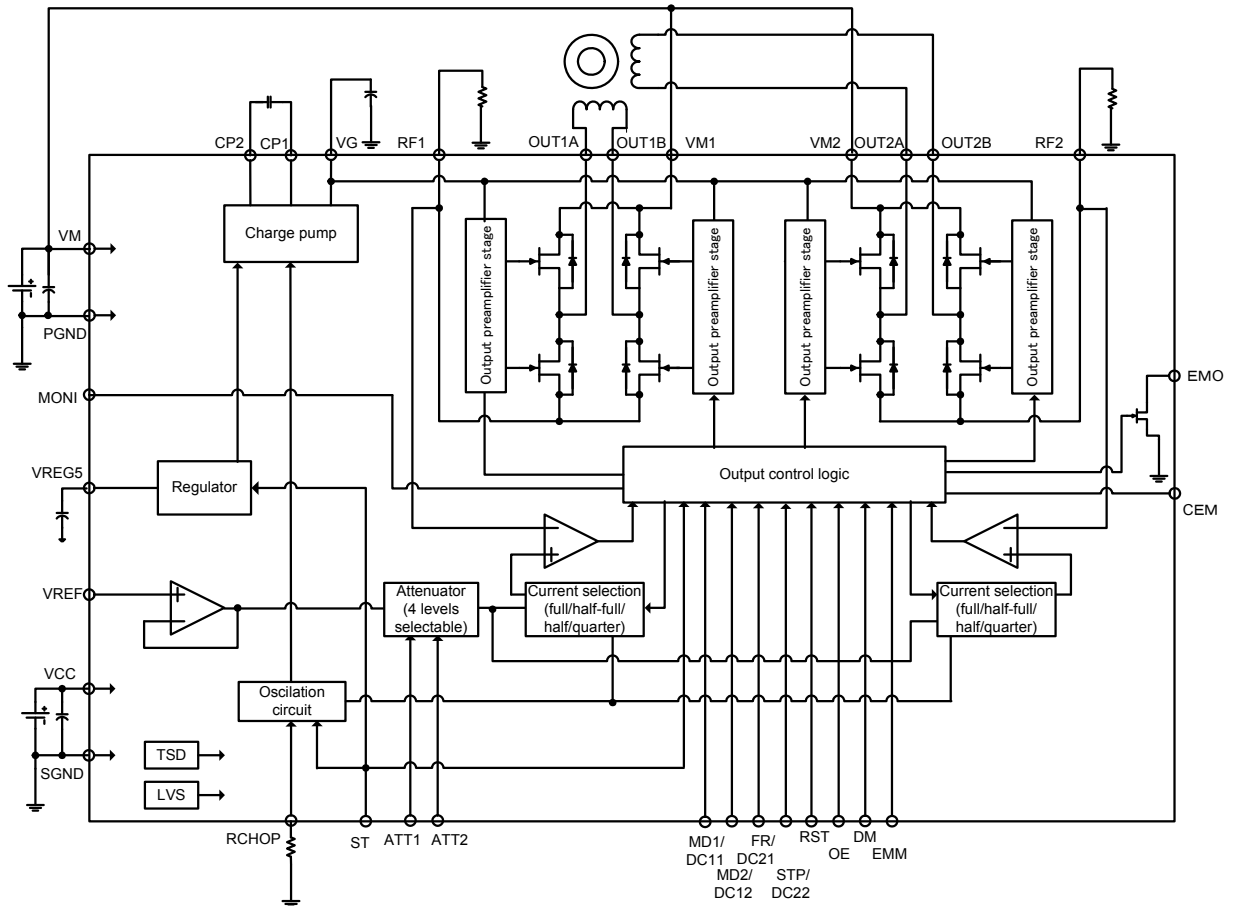
Reference symbol	SSOP44K(275mil)
eE	7.00
e	0.65
$b3$	0.32
$l1$	1.00
X	(4.7)
Y	(3.5)

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Pin Assignment



Block Diagram



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Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage 1	V _M max		38	V
Supply voltage 2	V _{CC} max		6	V
Output peak current	I _O peak	tw ≤ 10ms, duty 20%	1.75	A
Output current	I _O max		1.5	A
Logic input voltage	V _{IN}		-0.3 to V _{CC} +0.3	V
EMO input voltage	V _{EMO}		-0.3 to V _{CC} +0.3	V
Allowable power dissipation 1	Pd max1	Independent IC	0.55	W
Allowable power dissipation 2	Pd max2	* Our recommended two-layer substrate *1, *2	2.9	W
Operating temperature	T _{opr}		-20 to +85	°C
Storage temperature	T _{stg}		-55 to +150	°C

*1 Specified circuit board : 90×90×1.7mm³ : glass epoxy printed circuit board

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

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 1	V _M		9.5		35	V
Supply voltage range 2	V _{CC}		2.7		5.5	V
VREF input voltage range	VREF		0		V _{CC} -1.8	V

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

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain 1	I _{Mstn}	ST = "L"		150	200	μA
Current drain 1	I _M	ST = "H", OE = "H", no load		0.75	1	mA
Standby mode current drain 2	I _{CCstn}	ST = "L"		110	160	μA
Current drain 2	I _{CC}	ST = "H", OE = "H", no load		2.5	3	mA
V _{CC} low-voltage cutoff voltage	V _{thVCC}		2.2	2.35	2.5	V
Low-voltage hysteresis voltage	V _{thHIS}		100	150	200	mV
Thermal shutdown temperature	TSD	Design guarantee		180		°C
Thermal hysteresis width	ΔTSD	Design guarantee		40		°C
Output on-resistance	R _{onu}	I _O = 1.5A, Upper-side on resistance		0.5	0.7	Ω
	R _{ond}	I _O = 1.5A, Lower-side on resistance		0.5	0.6	Ω
Output leakage current	I _{Oleak}				50	μA
Diode forward voltage 1	V _{D1}	ID = -1.0A		1	1.3	V
Diode forward voltage 2	V _{D2}	ID = -1.5A		1.1	1.5	V
Logic pin input current	I _{INL}	V _{IN} = 0.8V	3	8	15	μA
	I _{INH}	V _{IN} = 5V	30	50	70	μA
Logic high-level input voltage	V _{INH}		2.0			V
Logic low-level input voltage	V _{INL}				0.8	V

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Current selection comparator threshold voltage (Current step switch)	Quarter-step drive	Vtdac0_W	Step 0(When initialized : channel 1 comparator level)	0.485	0.5	0.515	V
		Vtdac1_W	Step 1 (Initial state+1)	0.485	0.5	0.515	V
		Vtdac2_W	Step 2 (Initial state+2)	0.323	0.333	0.343	V
		Vtdac3_W	Step 3 (Initial state+3)	0.155	0.167	0.179	V
	Half-step drive	Vtdac0_H	Step 0 (When initialized: channel 1 comparator level)	0.485	0.5	0.515	V
		Vtdac2_H	Step 2 (Initial state+1)	0.323	0.333	0.343	V
	Half-step (full torque) drive	Vtdac0_HF	Step 0 (Initial state, channel 1 comparator level)	0.485	0.5	0.515	V
		Vtdac2_HF	Step 2 (Initial state+1)	0.485	0.5	0.515	V
	Full-step drive	Vtdac2_F	Step 2	0.485	0.5	0.515	V
Chopping frequency		Fchop	RCHOP = 20k Ω	45	62.5	75	kHz
Current setting reference voltage		VRF00	ATT1 = L, ATT2 = L	0.485	0.5	0.515	V
		VRF01	ATT1 = H, ATT2 = L	0.323	0.333	0.343	V
		VRF10	ATT1 = L, ATT2 = H	0.237	0.25	0.263	V
		VRF11	ATT1 = H, ATT2 = H	0.155	0.167	0.179	V
VREF pin input current		Iref	VREF = 1.5V	-0.5			μ A
Charge pump							
VREG5 output voltage		Vreg5	I _O = -1mA	4.5	5	5.5	V
VG output voltage		VG		28	28.7	29.8	V
Rise time		tONG	VG = 0.1 μ F			0.5	ms
Oscillator frequency		Fosc	RCHOP = 20k Ω	90	125	150	kHz
Output short-circuit protection							
EMO pin saturation voltage		Vsatemo	Iemo = 1mA		50	100	mV

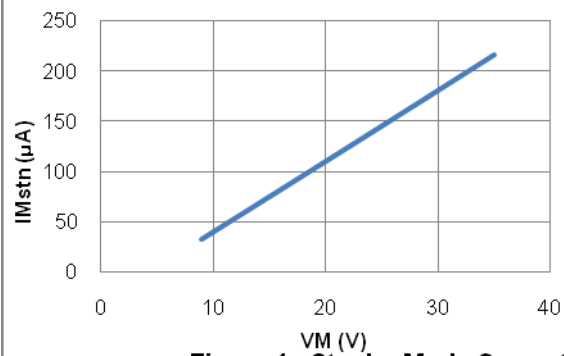


Figure 1. Standby Mode Current Drain 1 vs. VM Voltage

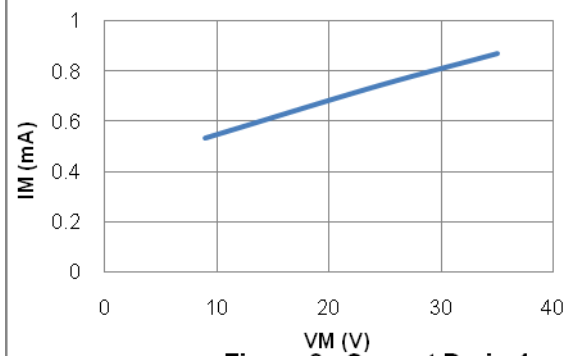


Figure 2. Current Drain 1 vs. VM Voltage

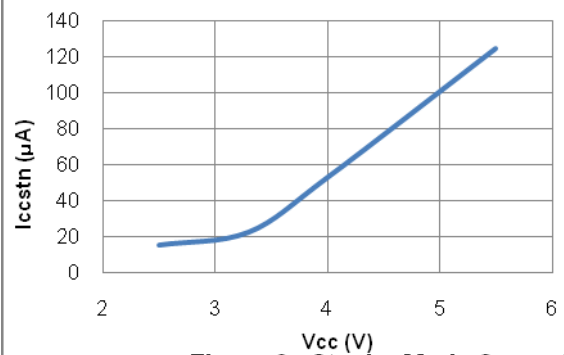


Figure 3. Standby Mode Current Drain 2 vs. Vcc Voltage

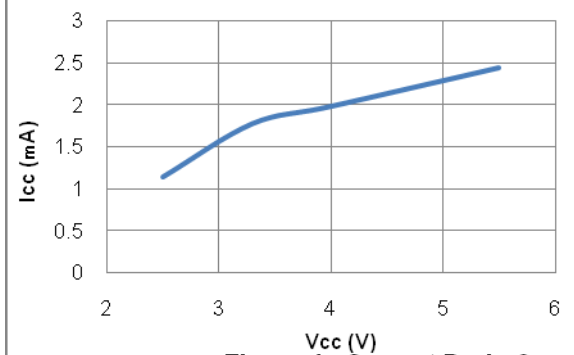


Figure 4. Current Drain 2 vs. Vcc Voltage

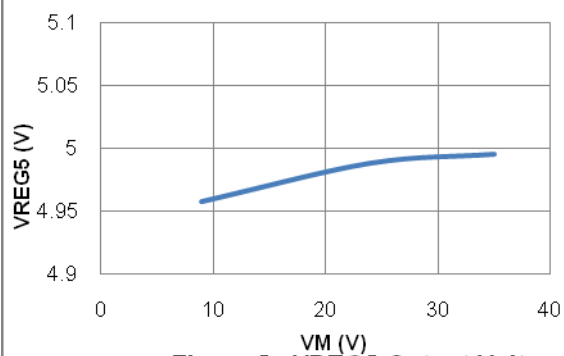


Figure 5. VREG5 Output Voltage vs. VM Voltage

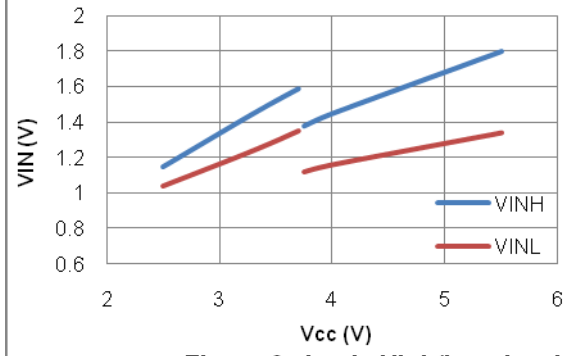


Figure 6. Logic High/Low-level input Voltage vs. Vcc Voltage

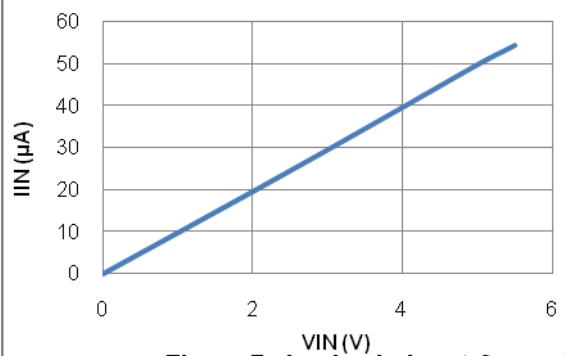


Figure 7. Logic pin input Current vs. Logic input Voltage

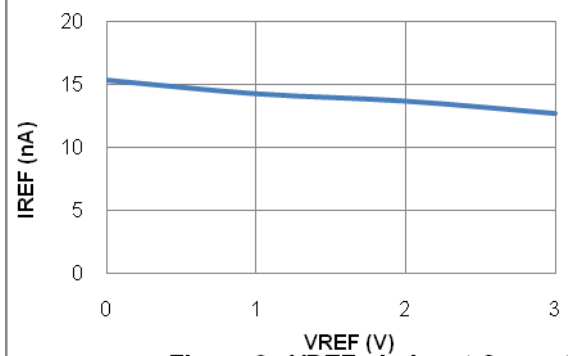


Figure 8. VREF pin input Current vs. VREF Voltage

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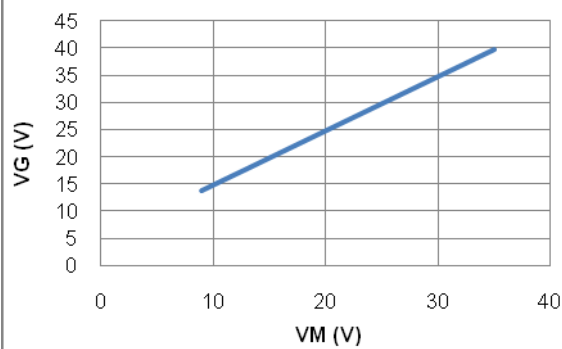


Figure 9. VG Output Voltage vs. VM Voltage

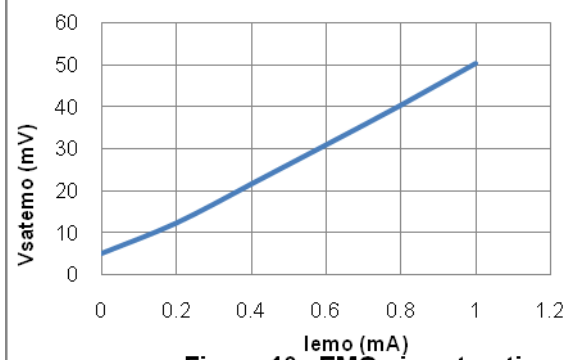


Figure 10. EMO pin saturation voltage vs. EMO pin input current

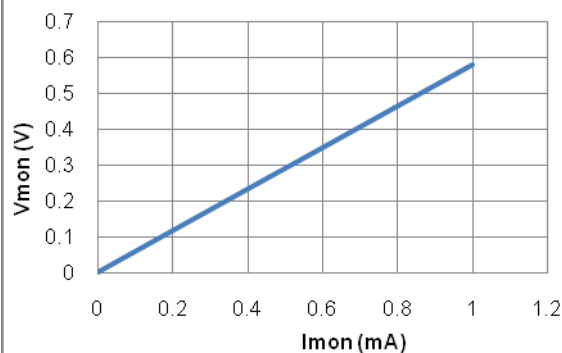


Figure 11. MONI pin Low-Level voltage vs. MONI pin input current

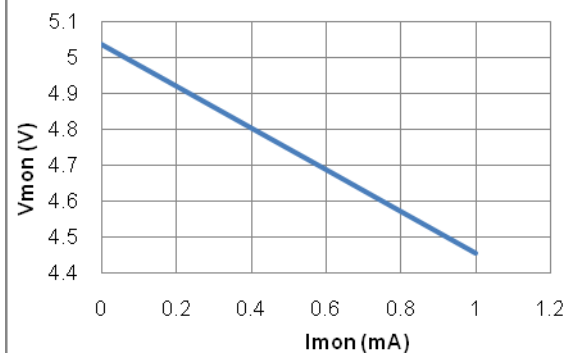


Figure 12. MONI pin High-Level voltage vs. MONI pin output current

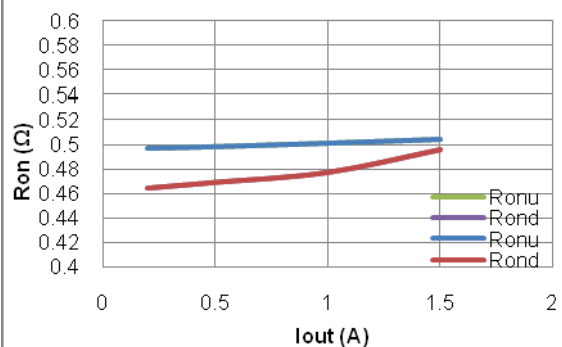


Figure 13. Output on Resistance vs. Output Current

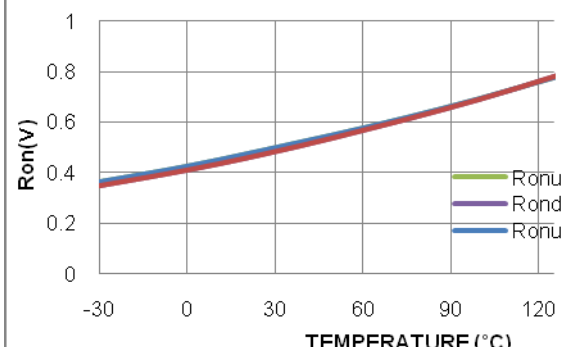


Figure 14. Output on Resistance vs. Junction Temperature

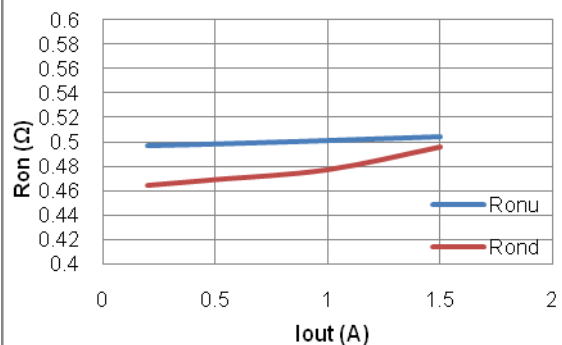


Figure 15. Output on Resistance vs. Output Current

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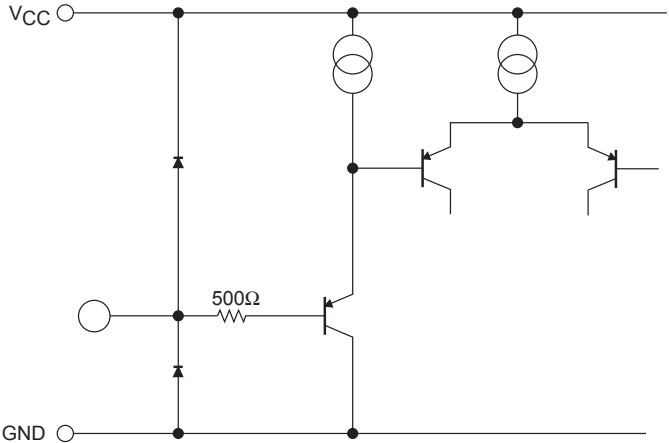
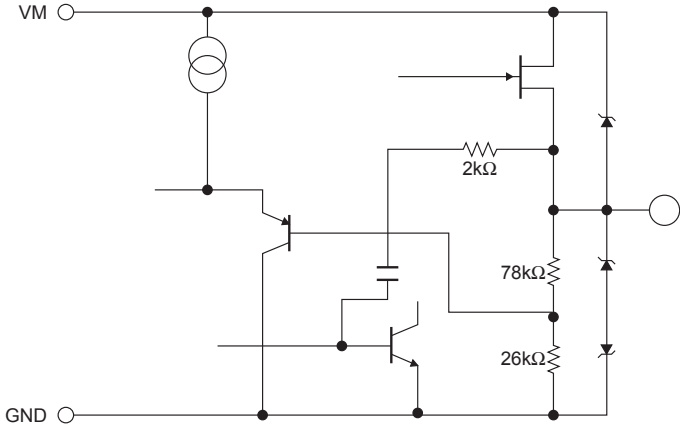
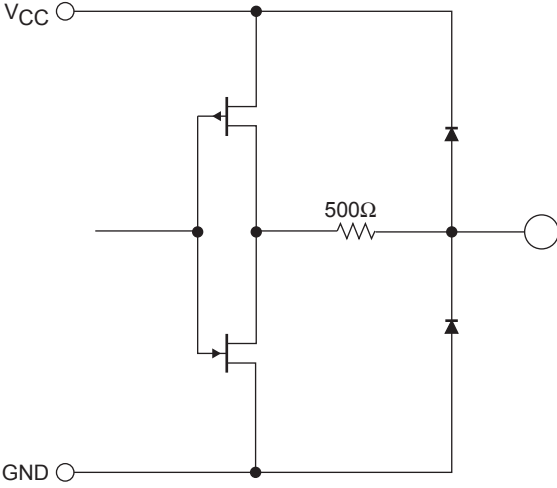
Pin Functions

Pin No.	Pin name	Pin Function	Equivalent Circuit
5 6 10 13 14 15 16 18 19 20 21	ATT2 ATT1 EMM RST STP/DC22 FR/DC21 MD2/DC12 MD1/DC11 DM OE ST	Motor holding current switching pin. Motor holding current switching pin. Output short-circuit protection mode switching pin. RESET signal input pin STEP signal input pin (STM) / Channel 2 output control input pin 2 (DCM). CW / CCW signal input pin (STM) / Channel 2 output control input pin 1 (DCM). Excitation mode switching pin 2 (STM) / Channel 1 output control input pin 2 (DCM). Excitation mode switching pin 1 (STM) / Channel 1 output control input pin 1 (DCM). Drive mode (STM/DCM) switching pin. Output enable signal input pin. Chip enable pin.	
30 31 32 33 34 35 36 37 42	OUT2B RF2 VM2 OUT2A OUT1B RF1 VM1 OUT1A PGND	Channel 2 OUTB output pin. Channel 2 current-sense resistor connection pin. Channel 2 motor power supply connection pin. Channel 2 OUTA output pin. Channel 1 OUTB output pin. Channel 1 current-sense resistor connection pin. Channel 1 motor power supply pin. Channel 1 OUTA output pin. Power system ground.	
1 2 43 44	CP2 CP1 VG VM	Charge pump capacitor connection pin. Charge pump capacitor connection pin. Charge pump capacitor connection pin. Motor power supply connection pin.	

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Pin No.	Pin Name	Pin Function	Equivalent Circuit
22	VREF	Constant current control reference voltage input pin.	
4	VREG5	Internal power supply capacitor connection pin.	
12	MONI	Position detection monitor pin.	

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Pin No.	Pin Name	Pin Function	Equivalent Circuit
8	EMO	Output short-circuit state warning output pin.	
9	CEM	Pin to connect the output short-circuit state detection time setting capacitor.	
11	RCHOP	Chopping frequency setting capacitor connection pin.	
27, 40	GND	Ground.	
7, 17 24, 25 26, 28 29, 38 39, 41	NC	No Connection (No internal connection to the IC)	

Description of operation

Input Pin Function

(1) Chip enable function

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

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



(2) Drive mode switching pin function

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

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

STM mode (DM = Low or Open)

(1) STP pin function

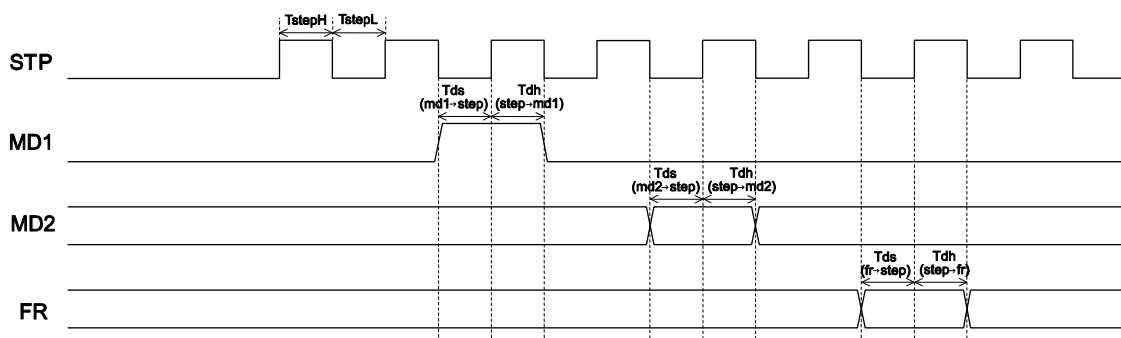
Input		Operating mode
ST	STP	
Low	*	Standby mode
High		Excitation step proceeds
High		Excitation step is kept

STP 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 resistor connected between RCHOP and GND. You need to perform chopping more than once per step. For this reason, for the actual STP frequency, you need to take chopping frequency and chopping count into consideration.

For example, if chopping frequency is 62.5kHz (16μs) and chopping is performed twice per step, the maximum STP frequency is obtained as follows: $f = 1/(16\mu s \times 2) = 31\text{kHz}$.

(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)

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(3) Positional detection monitor function

MONI pin is a Positional detection monitor output pin. When the excitation position is an initial position, the MONI output becomes Low, the other position, the MONI output becomes High.
Please refer to (example of current wave type in each excitation mode).

(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:

$$I_{OUT} = (VREF/3)/RF \text{ resistance}$$

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

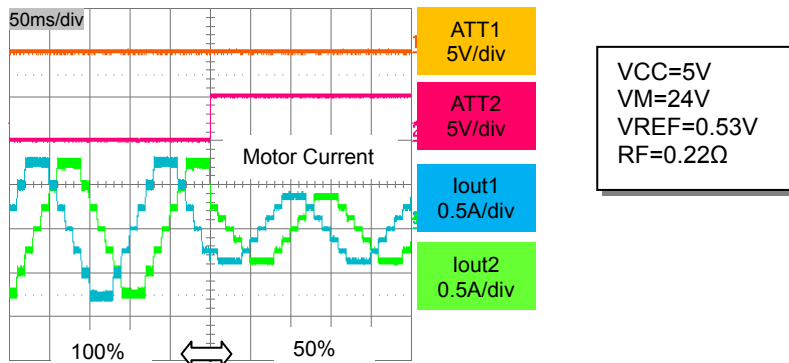
If VREF is open or the setting is out of the recommendation operating range, VREF is set around 5V. As a result, output current will increase and you cannot set constant current under normal condition. Hence, make sure that VREF is set in accordance with the specification.

However, if current control is not performed (if the IC is used without saturation drive or current limit) make sure that the setting is as follows: VREF=5V or VREF=VREG5

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	66.7%
Low	High	50%
High	High	33.3%



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

$$I_{OUT} = (VREF/3) \times (\text{attenuation ratio})/RF \text{ resistance}$$

Example: At VREF of 0.66V, a reference voltage setting of 100% [(ATT1, ATT2) = (L, L)] and an RF resistance of 0.22Ω, the output current is set as shown below.

$$I_{OUT} = 0.66V/3 \times 100\%/0.22\Omega = 1.0A$$

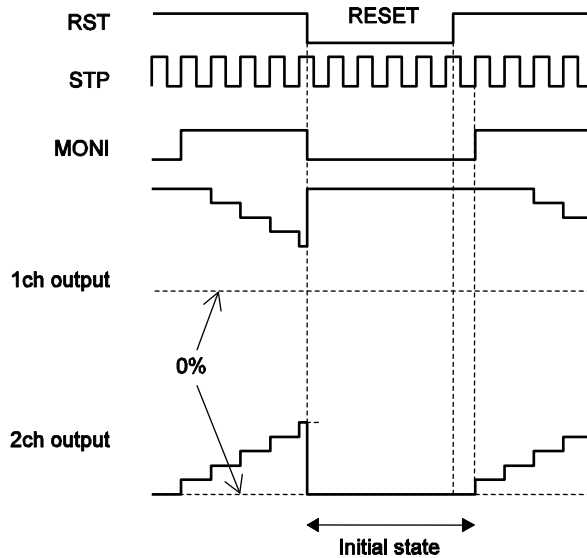
If, in this state, (ATT1, ATT2) is set to (H, H), IOUT will be as follows:

$$I_{OUT} = 1.0A \times 33.3\% = 0.33A$$

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
High	Normal operation
Low	Reset state

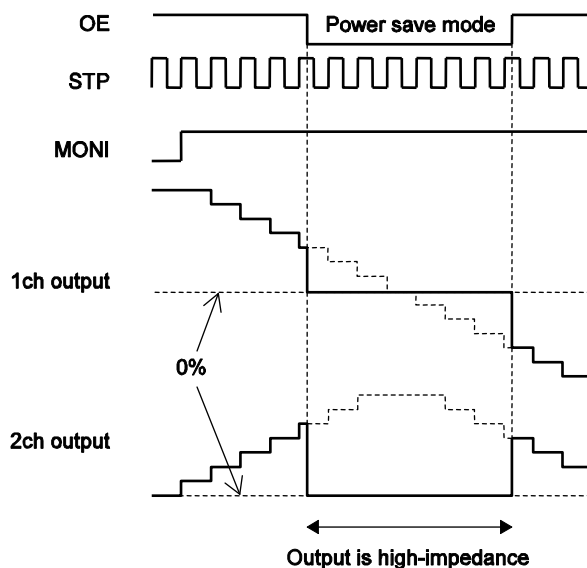


When the RST pin is set Low, the output excitation position is forced to the initial state, and the MONI output also goes Low.

When RST is set High after that, the excitation position proceeds to the next STP input.

(6) Output enable function

OE	Operating mode
Low	Output OFF
High	Output ON



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

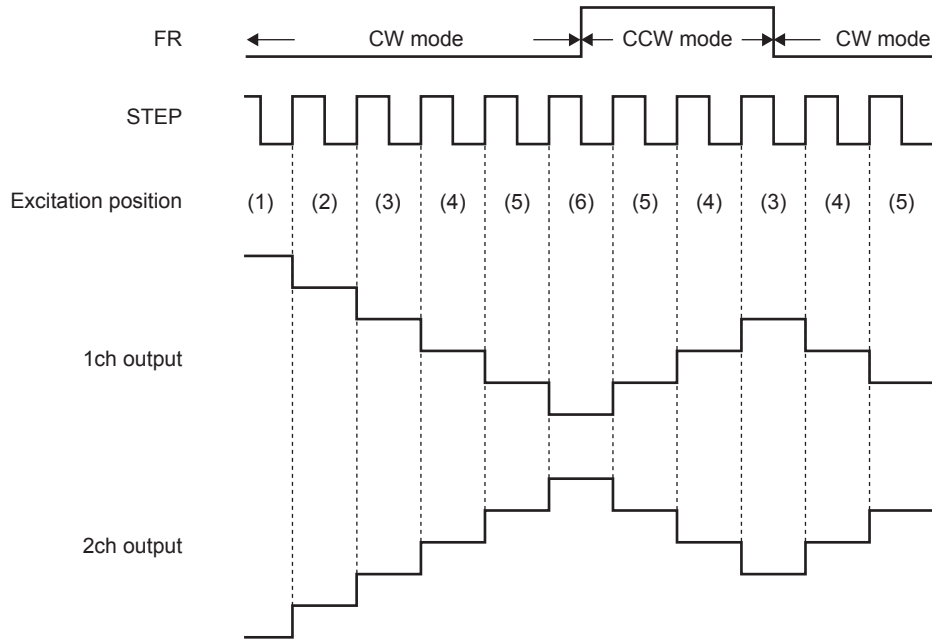
However, the internal logic circuits are operating, so the excitation position proceeds when the STEP signal is input.

Therefore, when OE is returned to High, the output level conforms to the excitation position proceeded by the STEP input.

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(7) Forward/reverse switching function

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

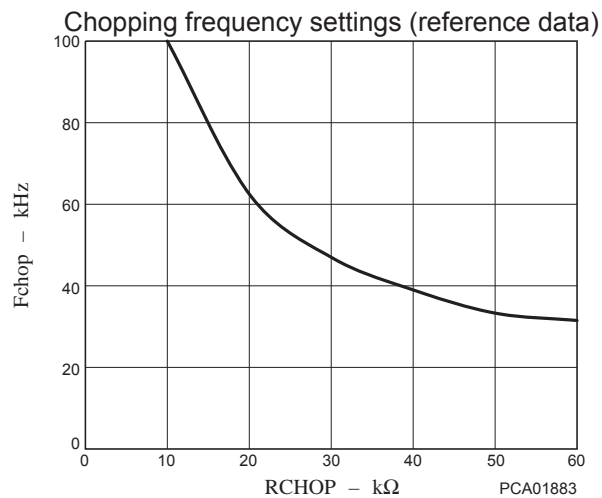


The internal D/A converter proceeds by one bit at the rising edge of the input STEP pulse.
 In addition, CW and CCW mode are switched by setting the FR pin.
 In CW mode, the channel 2 current phase is delayed by 90° relative to the channel 1 current.
 In CCW mode, the channel 2 current phase is advanced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

(8) Setting the chopping frequency

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

The chopping frequency to be set with the resistance connected to the RCHOP pin (pin 11) is as shown below.

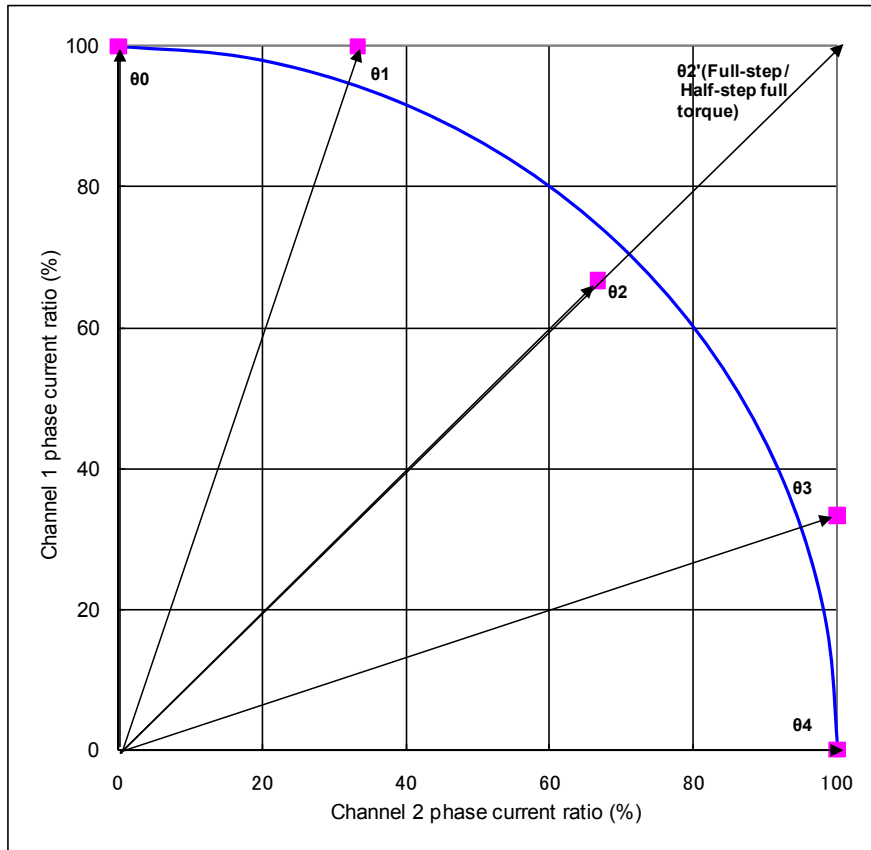


(9) Blanking period

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.

In this IC, the blanking time is fixed at 1/16 of one chopping cycle.

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



Setting current ration in each excitation mode

STEP	Quarter step (%)		Half step (%)		Half step (full torque) (%)		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	33.3						
θ2	66.7	66.7	66.7	66.7	100	100	100	100
θ3	33.3	100						
θ4	0	100	0	100	0	100		

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(11)Excitation mode setting function

The excitation mode of the stepping motor can be set as follows by setting the MD1 pin and the MD2 pin.

MD1	MD2	Microstep Resolution	Excitation mode	Initial position	
				Channel 1	Channel 2
Low	Low	Full Step	2 phase	100%	-100%
High	Low	Half Step (full torque)	1-2 phase (full torque)	100%	0%
Low	High	Half Step	1-2 phase	100%	0%
High	High	Quarter Step	W1-2 phase	100%	0%

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

(12)Excitation mode switching operation

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

Clockwise mode

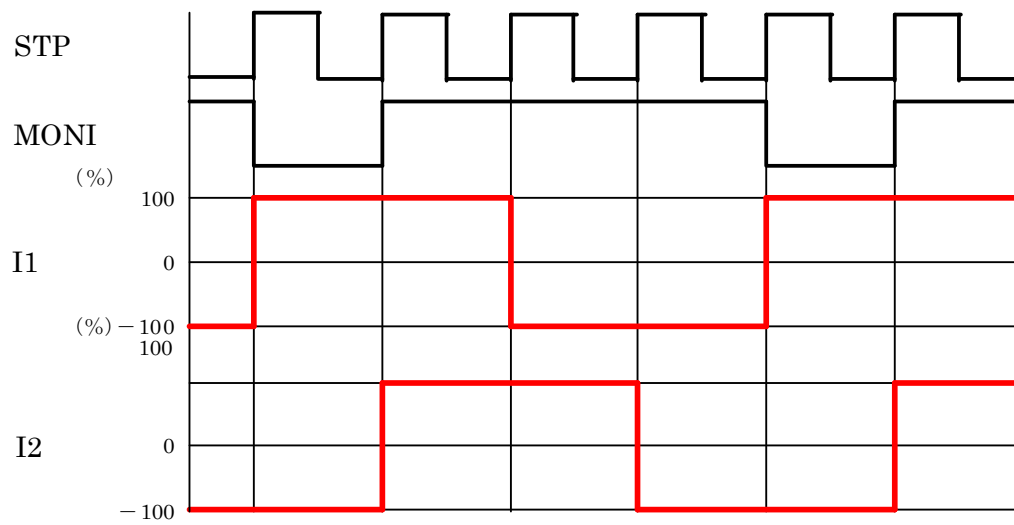
Before the Microstep Resolution changes		Position after the Microstep Resolution is changed			
Microstep Resolution	Position	Quarter Step	Half Step	Half Step (full torque)	Full Step
Quarter Step	00		02	02'	02'
	01		02	02'	02'
	02		04	04	02'
	03		02	02'	02'
	04		-02	-02'	-02'
Half Step	00	01		02'	02'
	02	03		02'	02'
	04	-03		-02'	-02'
Half Step (full torque)	00	01	02'		02'
	02'	03	04		02'
	04	-03	-02		-02'
Full Step	02'	03	04	04	

*As for 00 to 04, please refer to the step position of current ratio setting.

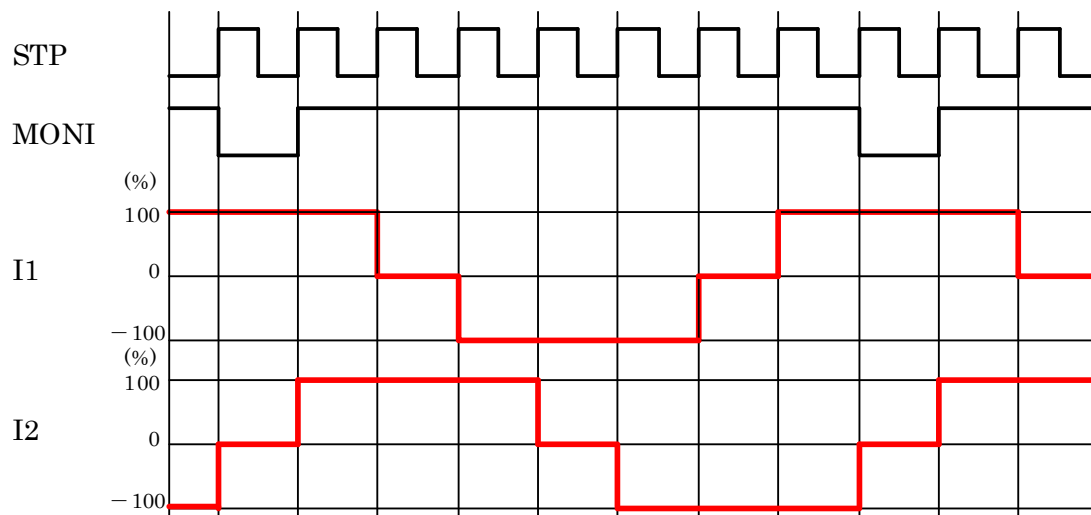
If you switch microstep mode while the motor is driving, the mode setting will be reflected from the next STEP and the motor advances to the closest excitation position at switching operation.

(13) Typical current waveform in each excitation mode

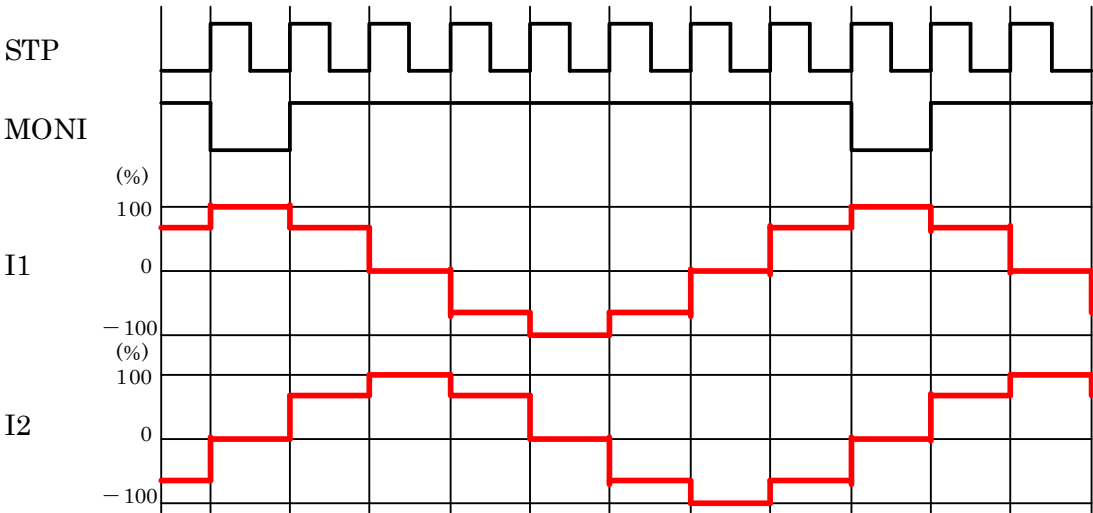
Full Step (CW mode)



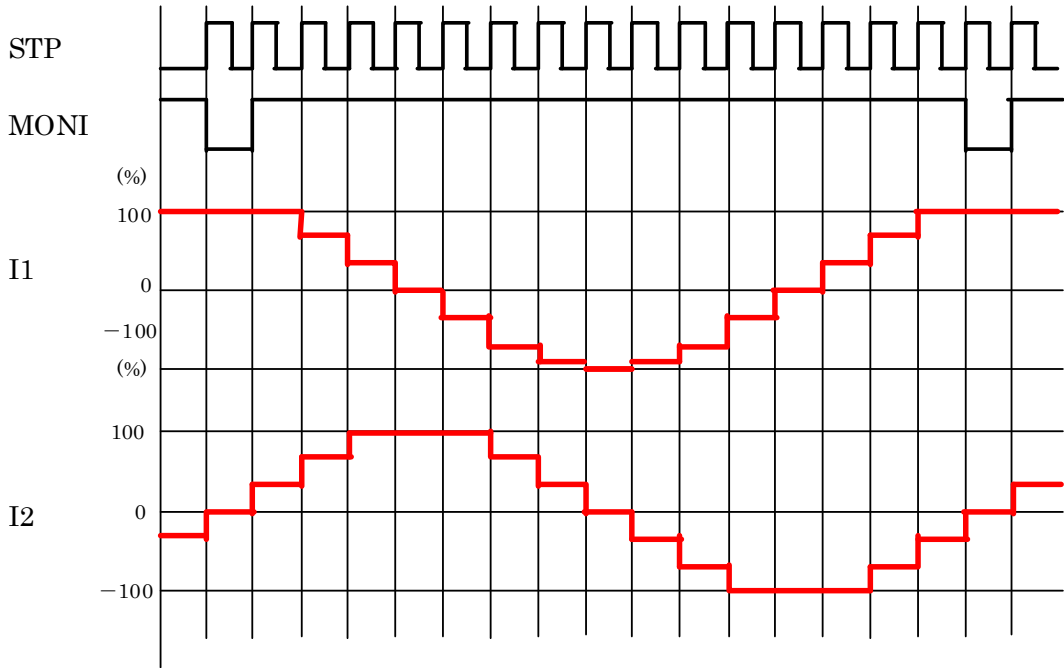
Half Step (full torque) (CW mode)



Half step (CW mode)

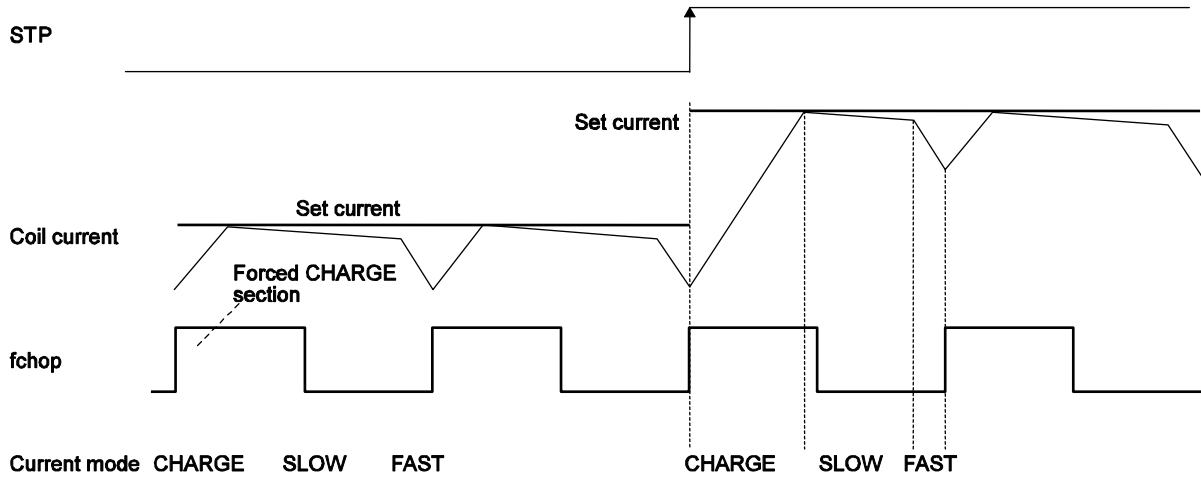


Quarter Step (CW mode)

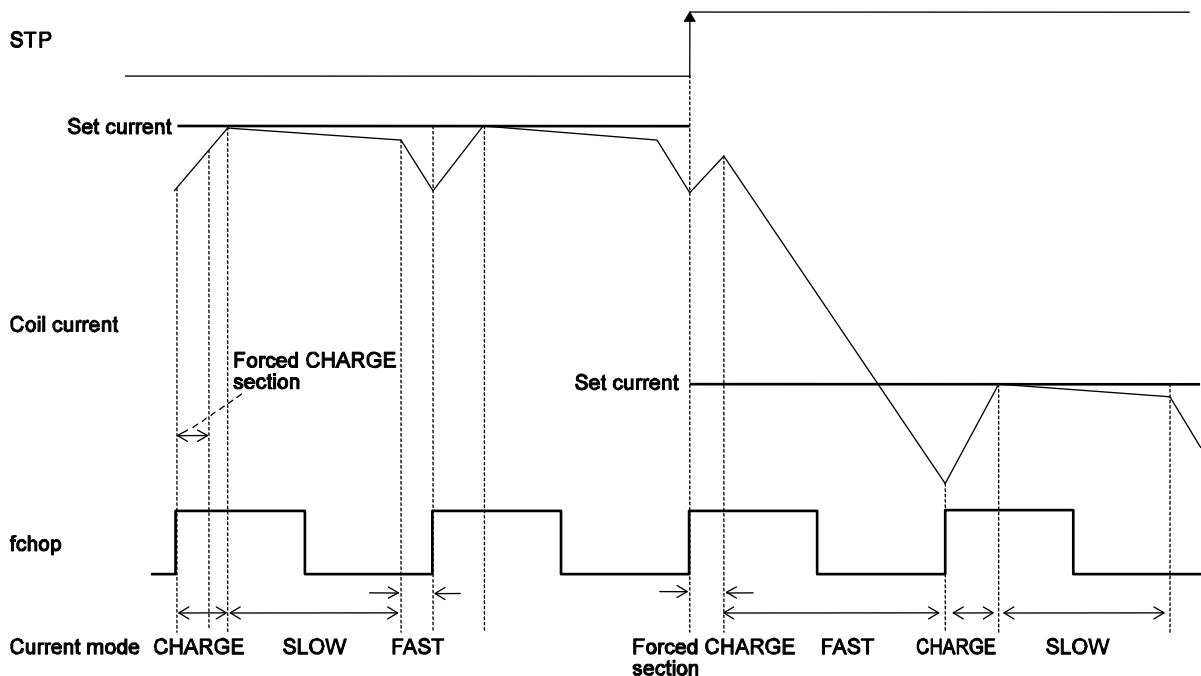


(14) Current control operation specification

(Sine wave increasing direction)



(Sine wave decreasing direction)

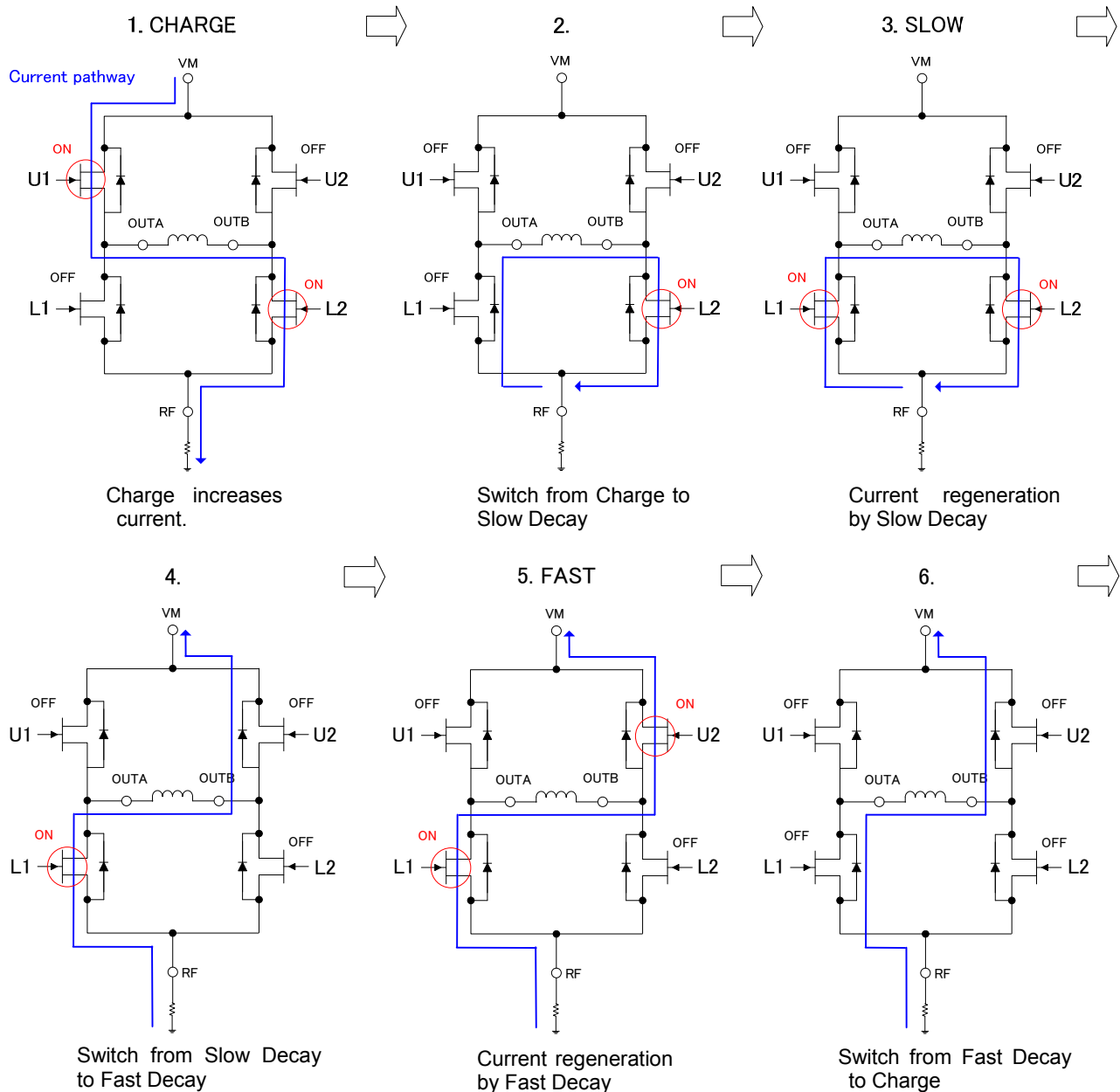


In each current mode, the operation sequence is as described below:

- At rise of chopping frequency, the CHARGE mode begins. (The section in which the CHARGE mode is forced regardless of the magnitude of the coil current (I_{COIL}) and set current (I_{REF}) exists for 1/16 of one chopping cycle.)
- The coil current (I_{COIL}) and set current (I_{REF}) are compared in this forced CHARGE section.
 - When ($I_{COIL} < I_{REF}$) state exists in the forced CHARGE section ;
CHARGE mode up to $I_{COIL} \geq I_{REF}$, then followed by changeover to the SLOW DECAY mode, and finally by the FAST DECAY mode for the 1/16 portion of one chopping cycle.
 - When ($I_{COIL} < I_{REF}$) state does not exist in the forced CHARGE section;
The FAST DECAY mode begins. The coil current is attenuated in the FAST DECAY mode till one cycle of chopping is over.

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

(15)Output transistor operation mode



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 between the transistors. This off period is set to be constant ($\approx 0.5\mu s$) 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)

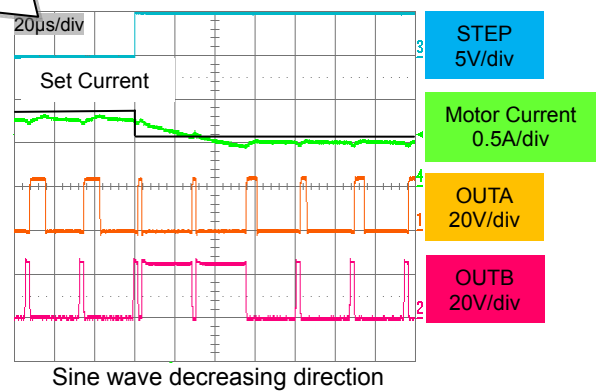
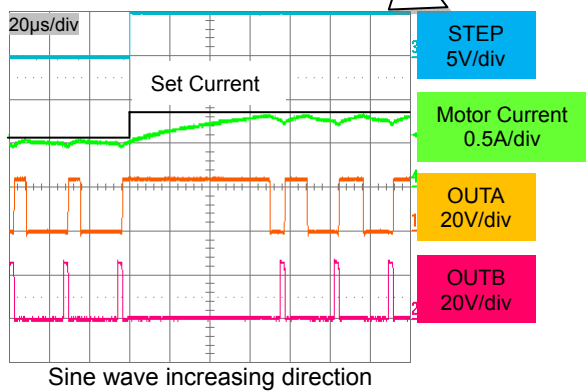
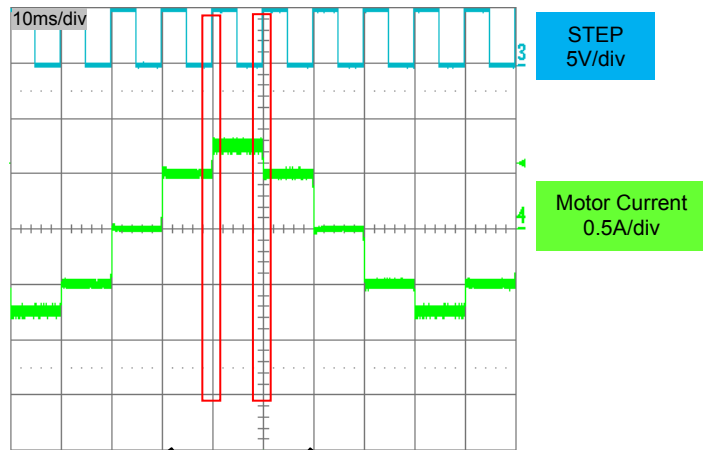
Output Tr	CHARGE	SLOW	FAST
U1	ON	OFF	OFF
U2	OFF	OFF	ON
L1	OFF	ON	ON
L2	ON	ON	OFF

OUTB→OUTA(CHARGE)

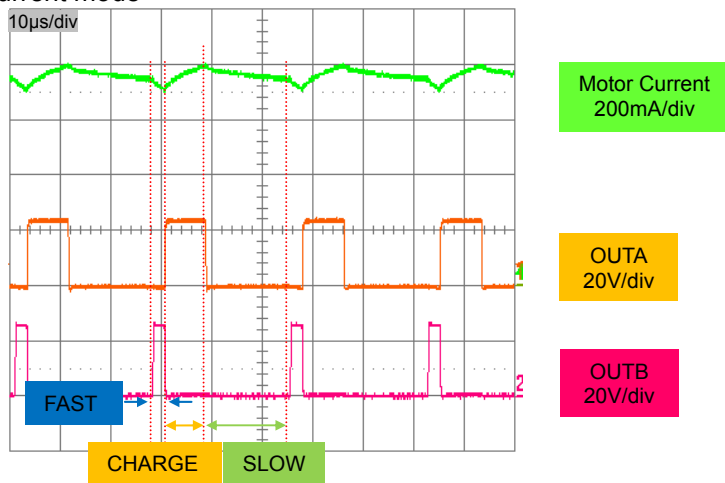
Output Tr	CHARGE	SLOW	FAST
U1	OFF	OFF	ON
U2	ON	OFF	OFF
L1	ON	ON	OFF
L2	OFF	ON	ON

LV8741V Application Note

VCC=5V
VM=24V
VREF=0.53V
RF=0.22Ω
RCHOP=43kΩ



Current mode



When the motor current reaches to the setting current, it is switched to Slow Decay mode.
Motor current switches from Slow Decay mode to Fast Decay mode for 1/16 of one chopping cycle.

DCM Mode (DM-High)

(1) DCM mode output control logic

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

When the control input switched from CW mode or CCW mode to standby mode, the current is pulled out with FAST DECAY. Afterwards, when the current becomes 0, the output is forcibly turned off. This forced OFF is released on the following condition.

- 1) Switched to CW mode or CCW mode.
- 2) Setting ST to low.

Therefore, forced OFF might not be released, If the input signal is followed in order by CW(CCW) mode, standby mode, and brake mode. When the standby mode enters the above-mentioned timing, set the input time of the standby mode less than 0.5μs.

(2) Reset function

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

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

(3) Output enable function

OE	Operating mode
Low	Output OFF
High	Output ON

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

LV8741V Application Note

(4) PWM control

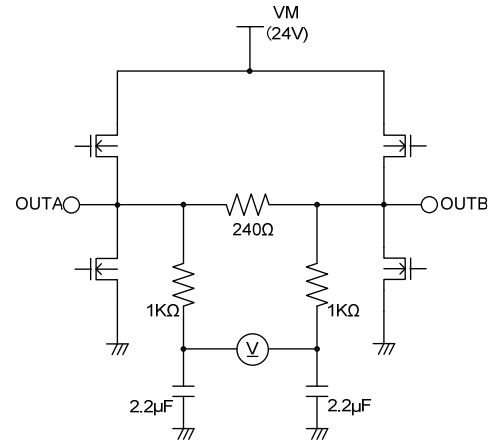
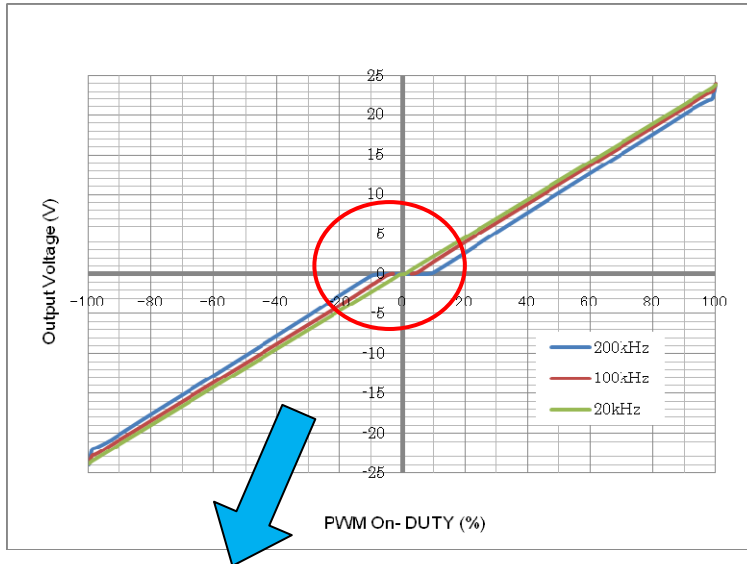
You can perform H-Bridge direct PWM control to DC11, DC12, DC21, and DC22 by inputting PWM signal. The maximum frequency of PWM signal is 200kHz. However, dead zone is generated when On-Duty is around 0%. Make sure to select optimum PWM frequency according to the target control range.

Input-Output Characteristics of H-Bridge(Reference data)

VM=24V, VREF=1.5V

Forward/Reverse↔Brake

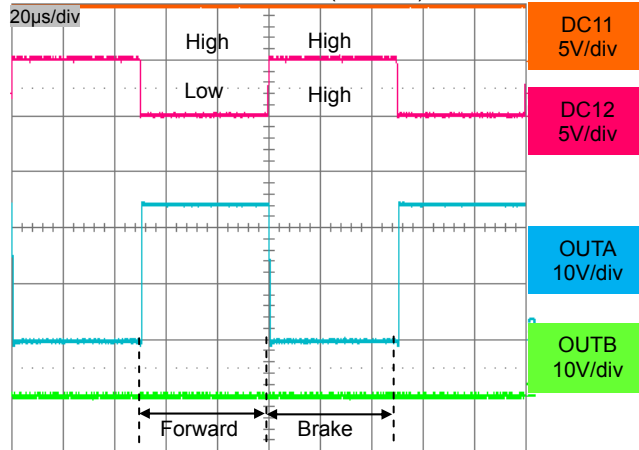
RCHOP=20kΩ



LV8741V Application Note

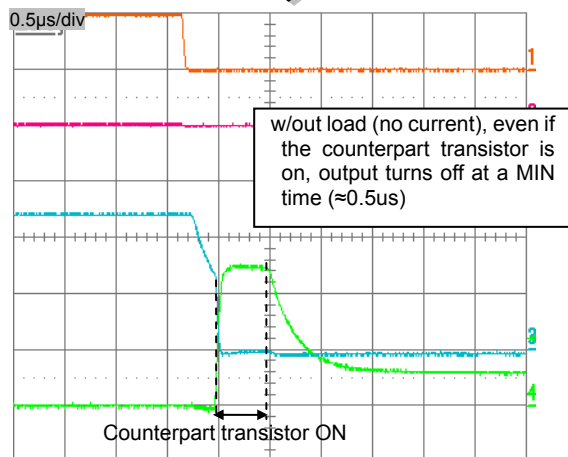
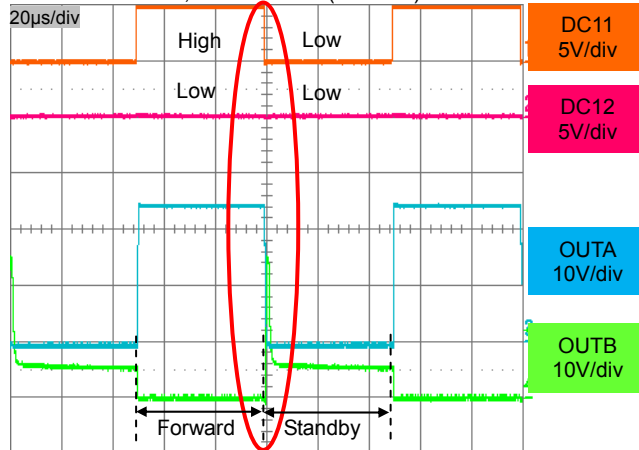
Forward↔Brake

No load VM=24V, DC12=10kHz (DC11=H)

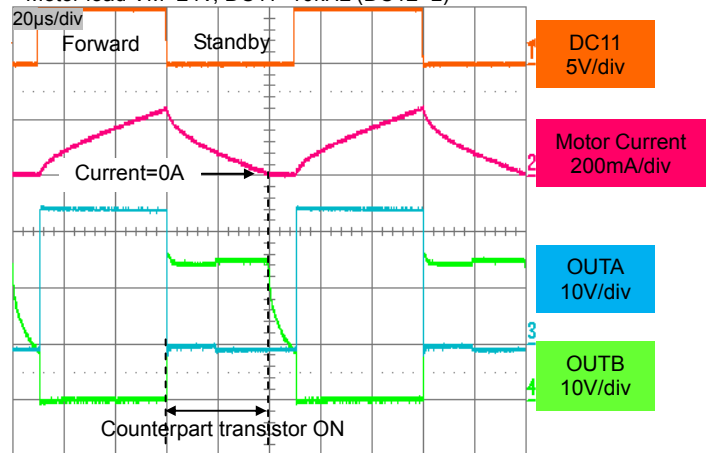


Forward↔Standby

No load VM=24V, DC11=10kHz (DC12=L)



Motor load VM=24V, DC11=10kHz (DC12=L)



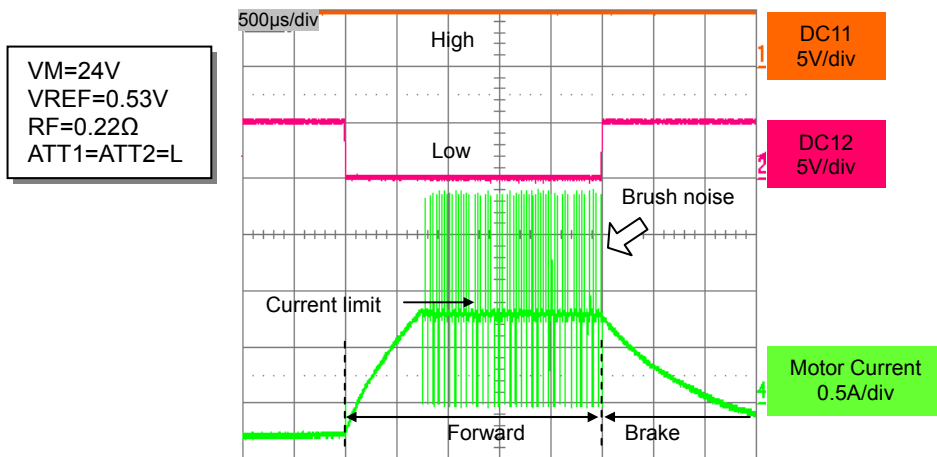
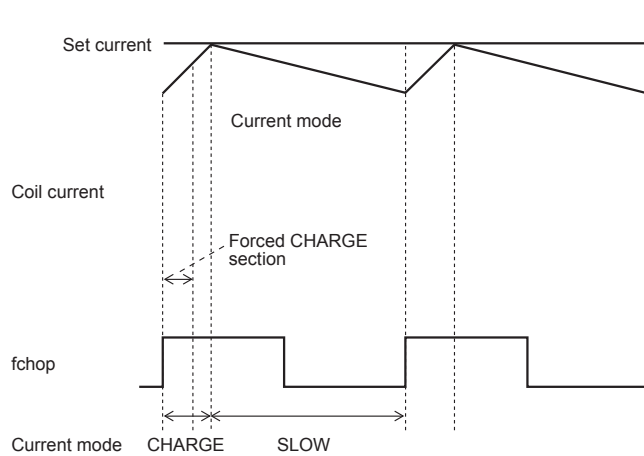
Standby mode turns on the counterpart transistor (synchronous rectification). After motor current fades off, output turns off. Synchronous rectification reduces heat generation compared to diode regeneration.

LV8741V Application Note

(5) Current limit reference voltage setting function

By setting a current limit, this IC automatically exercises short braking control to ensure that when the motor current has reached this limit, the current will not exceed it.

(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.

$$I_{\text{limit}} = (V_{\text{REF}}/3) / R_{\text{F}} \text{ resistance}$$

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	66.7%
Low	High	50%
High	High	33.3%

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

$$I_{\text{limit}} = (V_{\text{REF}}/3) \times (\text{attenuation ratio}) / R_{\text{F}} \text{ resistance}$$

Example: At VREF of 0.66V, a reference voltage setting of 100% [(ATT1, ATT2) = (L, L)] and an RF resistance of 0.22Ω, the output current is set as shown below.

$$I_{\text{limit}} = 0.66\text{V}/3 \times 100\%/0.22\Omega = 1.0\text{A}$$

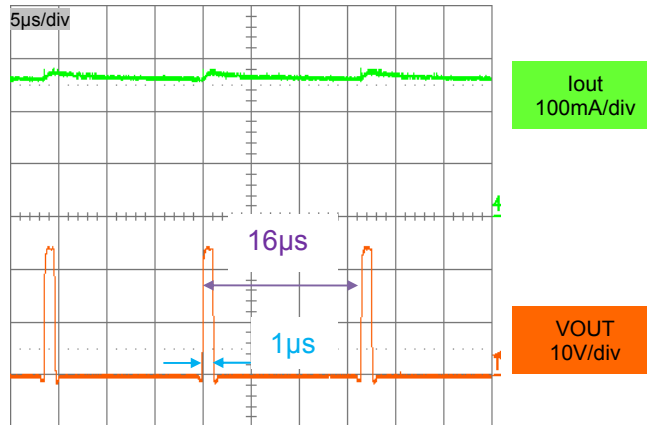
If, in this state, (ATT1, ATT2) has been set to (H, H), I_{limit} will be as follows:

$$I_{\text{limit}} = 1.5\text{A} \times 33.3\% = 0.33\text{A}$$

LV8741V Application Note

(6) Blanking period

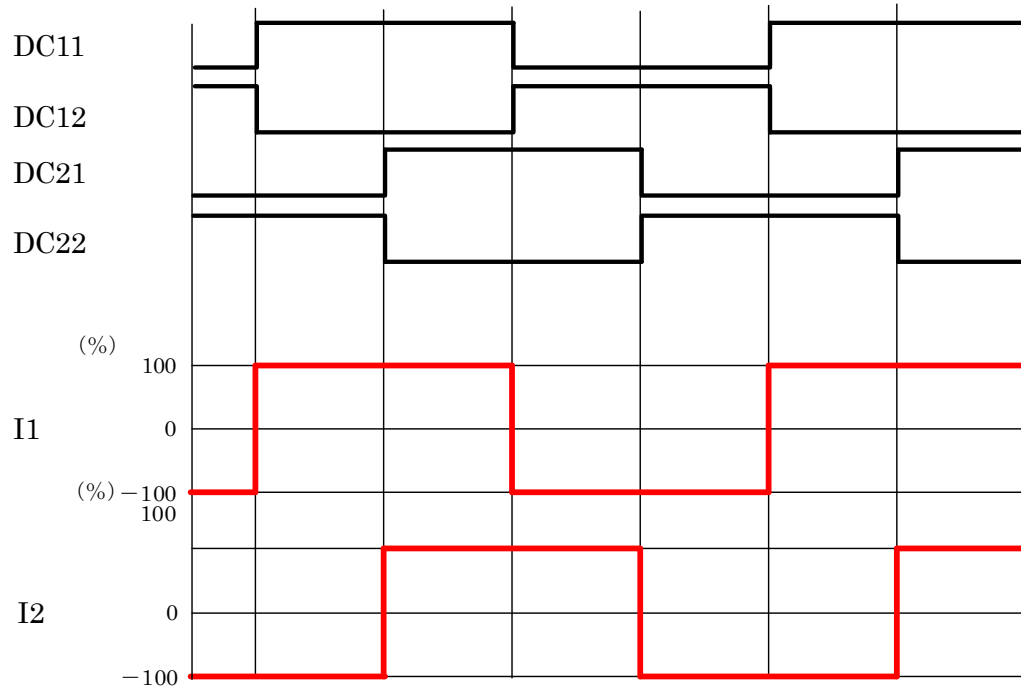
In this IC, the blanking time is fixed at 1/16 of one chopping cycle.



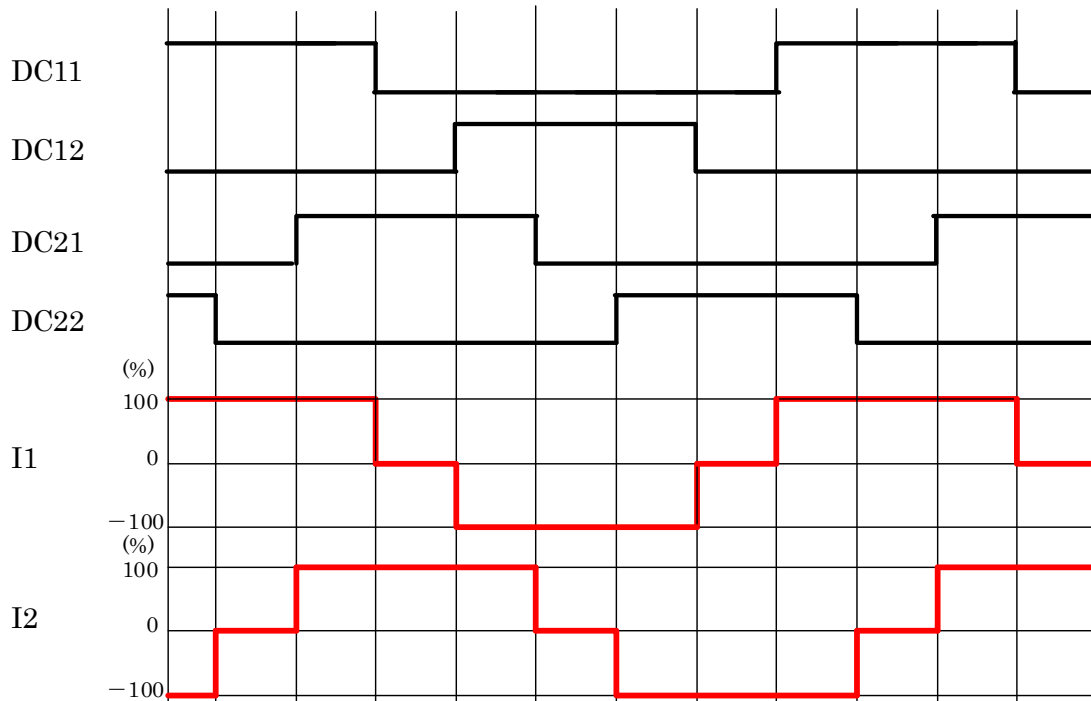
LV8741V Application Note

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

Full Step (CW mode)



Half Step (full torque) (CW mode)



Output short-circuit protection circuit

To protect the IC from damage due to short-circuit of the output caused by lightening or ground fault, the output short-circuit protection circuit to put the output in standby mode and turn on the alarm output is incorporated. The protection is detected when the potential difference between D-S of upside output Tr abnormally grows or when becoming the voltage twice or more a reference voltage for setting current in the voltage of RF. Therefore, when the RF pin is short-circuited to GND, this output short-circuit protection is not effective against shorting to power.

(1) Detect current

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

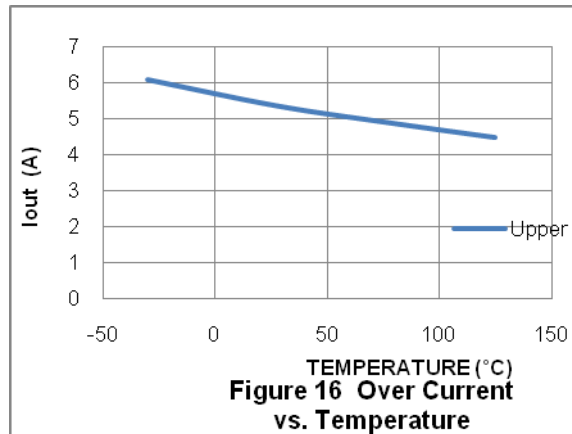
$$I_{OCPL} = (V_{REF}/3) \times (\text{attenuation ratio})/R_F \text{ resistance} \times 2$$

Example: At VREF of 0.66V, a reference voltage setting of 100% [(ATT1, ATT2) = (L, L)] and an RF resistance of 0.22Ω, the output current is set as shown below.

$$I_{OUT} = 0.66V/3 \times 100\%/0.22\Omega = 1.0A$$

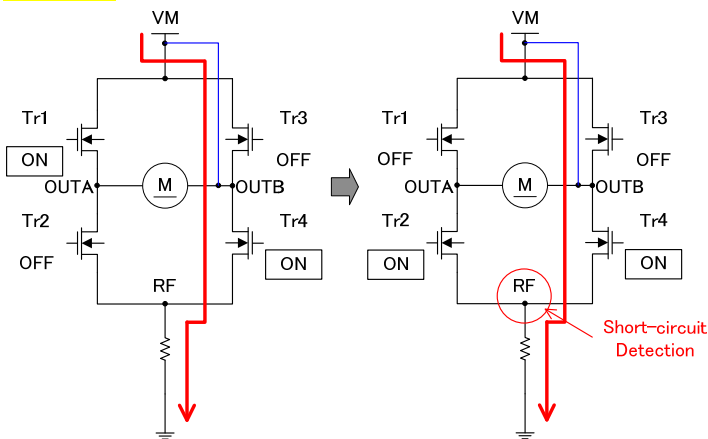
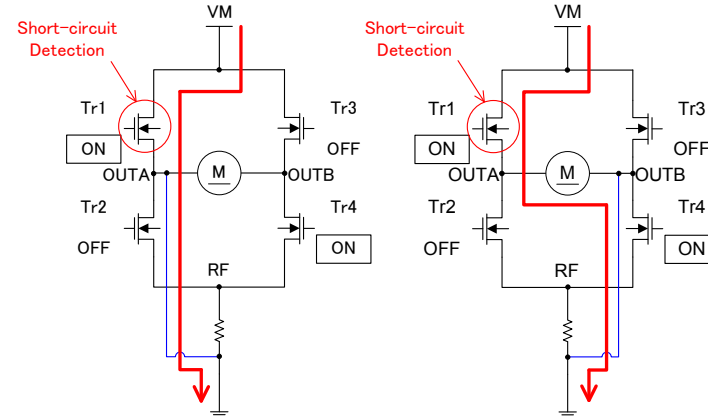
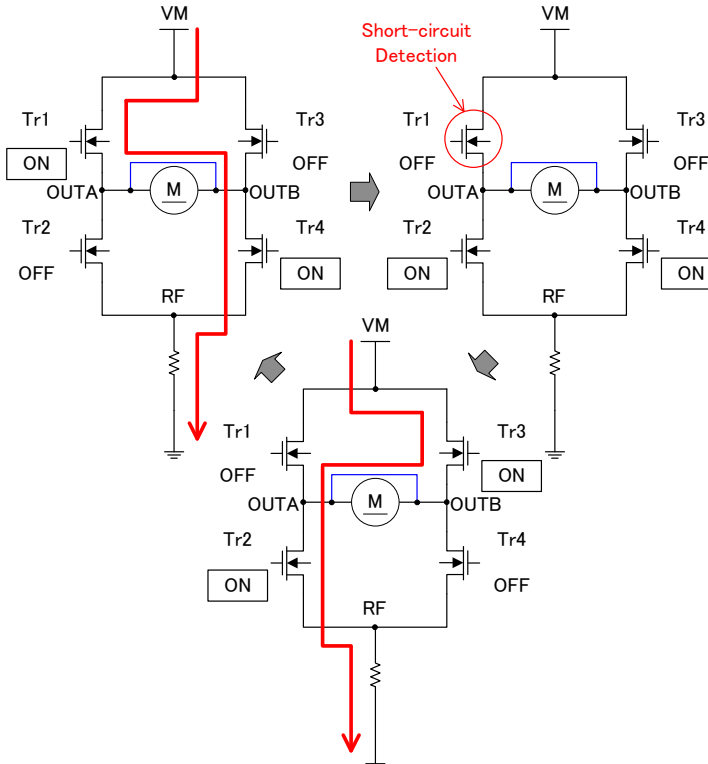
$$I_{OCPL} = (0.66V/3) \times 100\%/0.22\Omega = 2.0A$$

Detect current of the upper over-current is as shown in the figure below.



(2) Output short-circuit detection operation

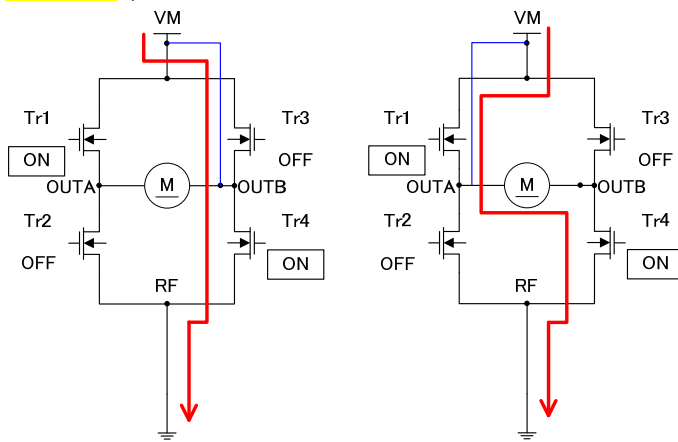
Resistance exists between RF and GND.

<p>VM short</p> 	<ol style="list-style-type: none"> 1.High current flows if Tr1 and Tr4 are ON. 2.If RF voltage> setting voltage, then the mode switches to SLOW decay. 3.If the RF voltage exceeds the reference voltage for Tscp, short status is detected.
<p>GND short</p> 	<p>(left schematic)</p> <ol style="list-style-type: none"> 1.High current flows if Tr1 and Tr4 are ON 2. If the voltage between D and S of Tr1 exceeds the reference voltage for Tscp, short status is detected. <p>(right schematic)</p> <ol style="list-style-type: none"> 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 Tscp, short status is detected.
<p>Load short (short status is not detected)</p> 	<ol style="list-style-type: none"> 1.Without L load, high current flows. 2. If RF voltage> setting voltage, then the mode switches to SLOW decay. 3.During load short state in SLOW decay mode, current does not flow and overcurrent status is not detected. Then the mode is switched to FAST decay according to chopping cycle. 4. Since FAST state is short ($\approx 1\mu s$), switches to CHARGE mode before short is detected. 5. Because 2-4 is repeated, short status is not detected.

LV8741V Application Note

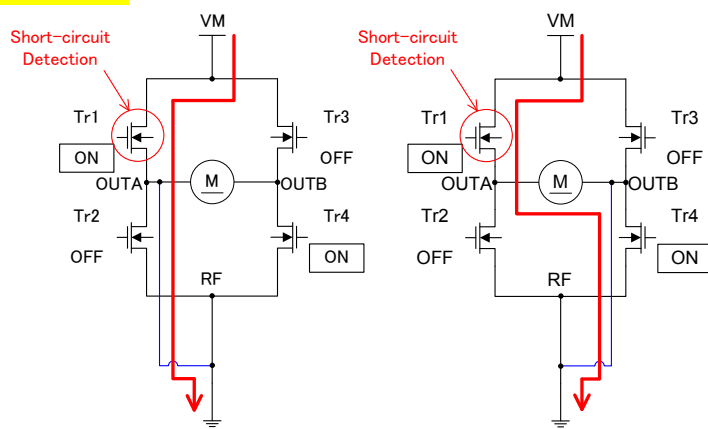
Resistance doesn't exist between RF and GND.

VM short (short status is not detected)



1. High current flows if Tr1 and Tr4 are ON.
2. Because RF voltage is GND level, short status is not detected.

GND short



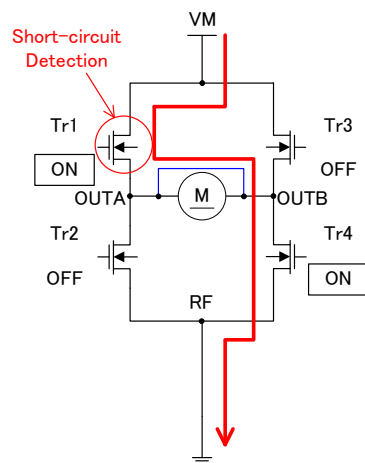
(left schematic)

1. High current flows if Tr1 and Tr4 are ON
2. If the voltage between D and S of Tr1 exceeds the reference voltage for Tscp, 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 Tscp, short status is detected.

Load short (short is not detected)



1. Without L load, high current flows.
2. If the voltage between D and S of Tr1 exceeds the reference voltage for Tscp, short status is detected.

LV8741V Application Note

(3) Output short-circuit protection operation changeover function

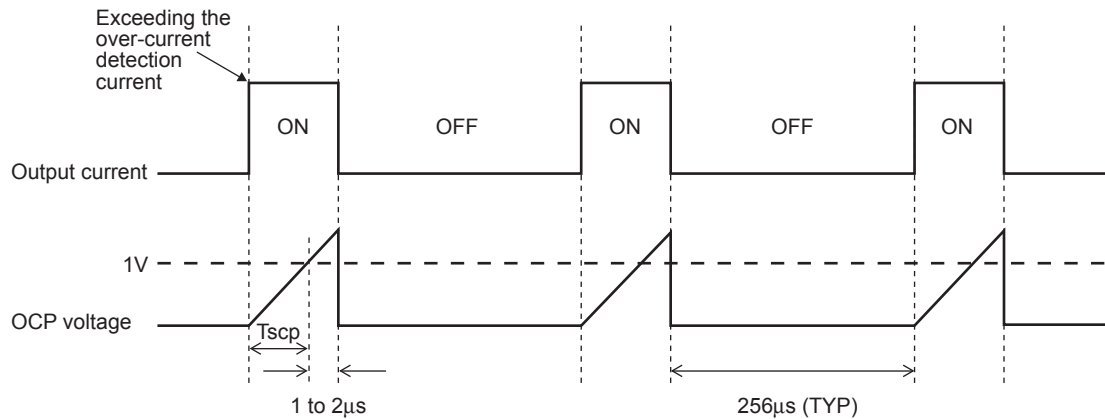
Changeover to the output short-circuit protection of IC is made by the setting of OCPM pin.

EMM	State
Low or Open	Auto reset method
High	Latch method

(4) Auto reset method

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

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



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

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

(5) Latch method

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

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

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

(6) Output short-circuit condition warning output pin

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

EMO outputs ON when output short-circuit is detected.

LV8741V Application Note

(7) Timer latch time (Tscp)

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

Timer latch: Tscp

$$T_{scp} \approx T_d + C \times V / I \text{ [sec]}$$

Td : Internal delay time TYP 4μs

V : Threshold voltage of comparator TYP 1V

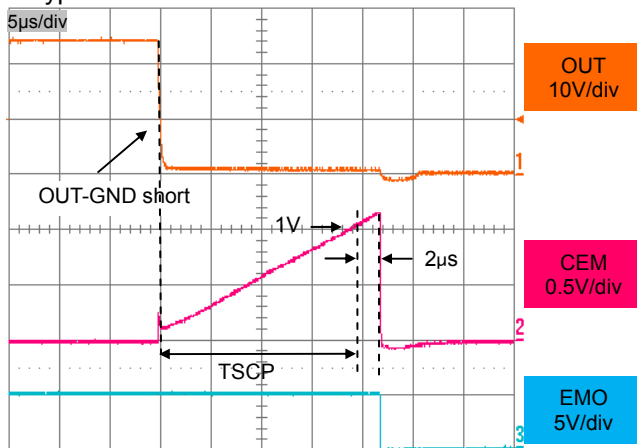
I : CEM charge current TYP 2.5μA

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

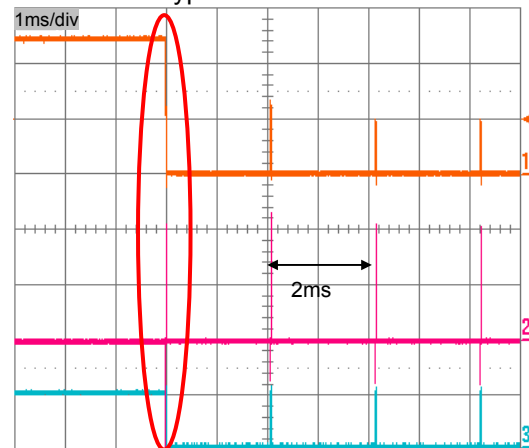
The CEN pin must be connected to (S) GND when the output short protection function is not to be used.

Unusual condition	EMO	Channel 1 Output	Channel 2 Output
Channel 1 short-circuit detected	ON	OFF	OFF
Channel 2 short-circuit detected	ON	OFF	OFF
Overheating condition detected	-	OFF	OFF

Latch type



Auto reset type



Thermal shutdown function

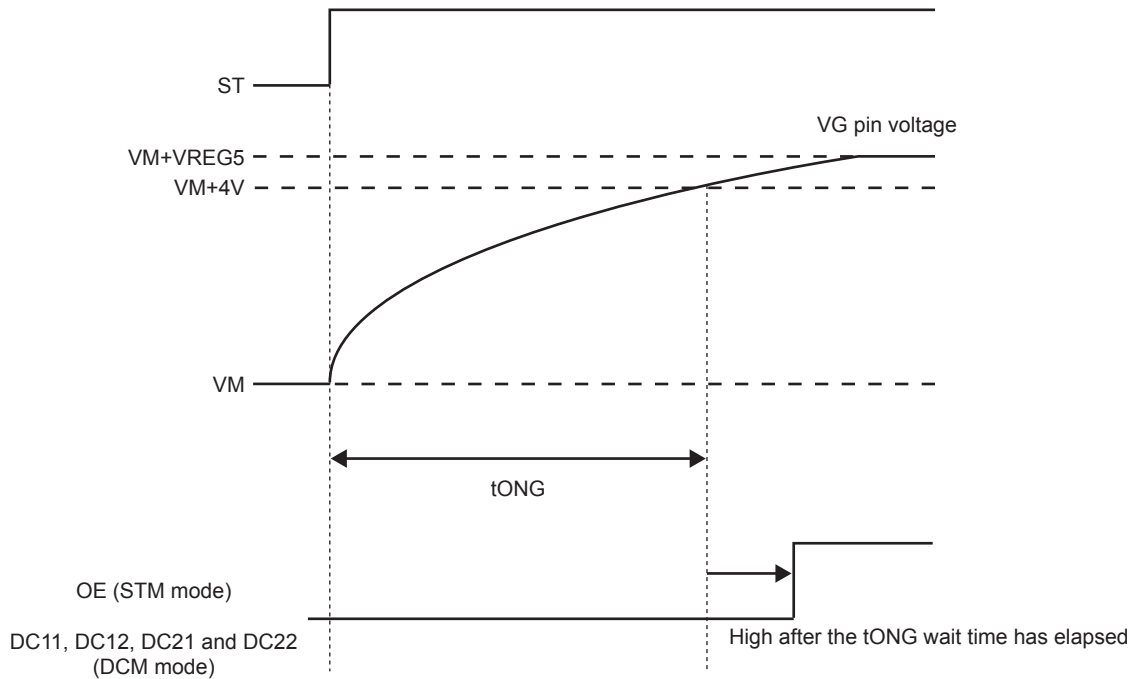
The thermal shutdown circuit is incorporated and the output is turned off when junction temperature T_j exceeds 180°C. As the temperature falls by hysteresis, the output turned on again (automatic restoration). The thermal shutdown circuit does not guarantee the protection of the final product because it operates when the temperature exceed the junction temperature of $T_{jmax}=150^{\circ}\text{C}$.

TSD = 180°C (typ)

ΔTSD = 40°C (typ)

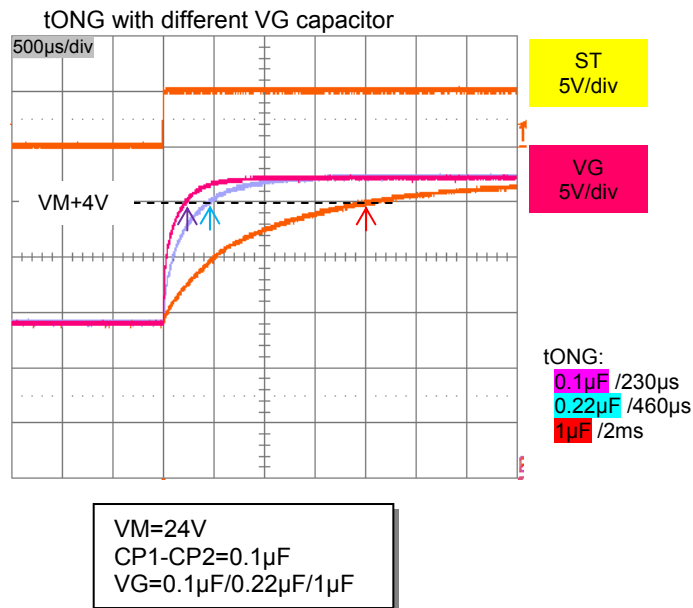
Charge Pump Circuit

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



VG Pin Voltage Schematic View

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

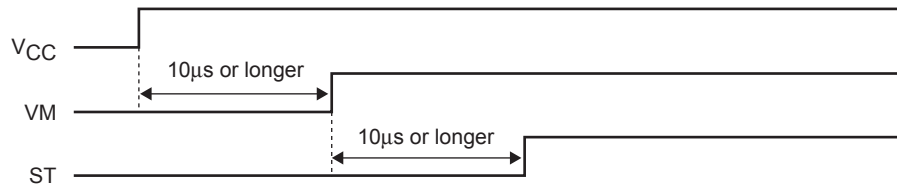


LV8741V Application Note

Recommended Power-on Sequence

Provide a wait time of 10 μ s or more after the V_{CC} power supply rises before supplying the motor power supply.

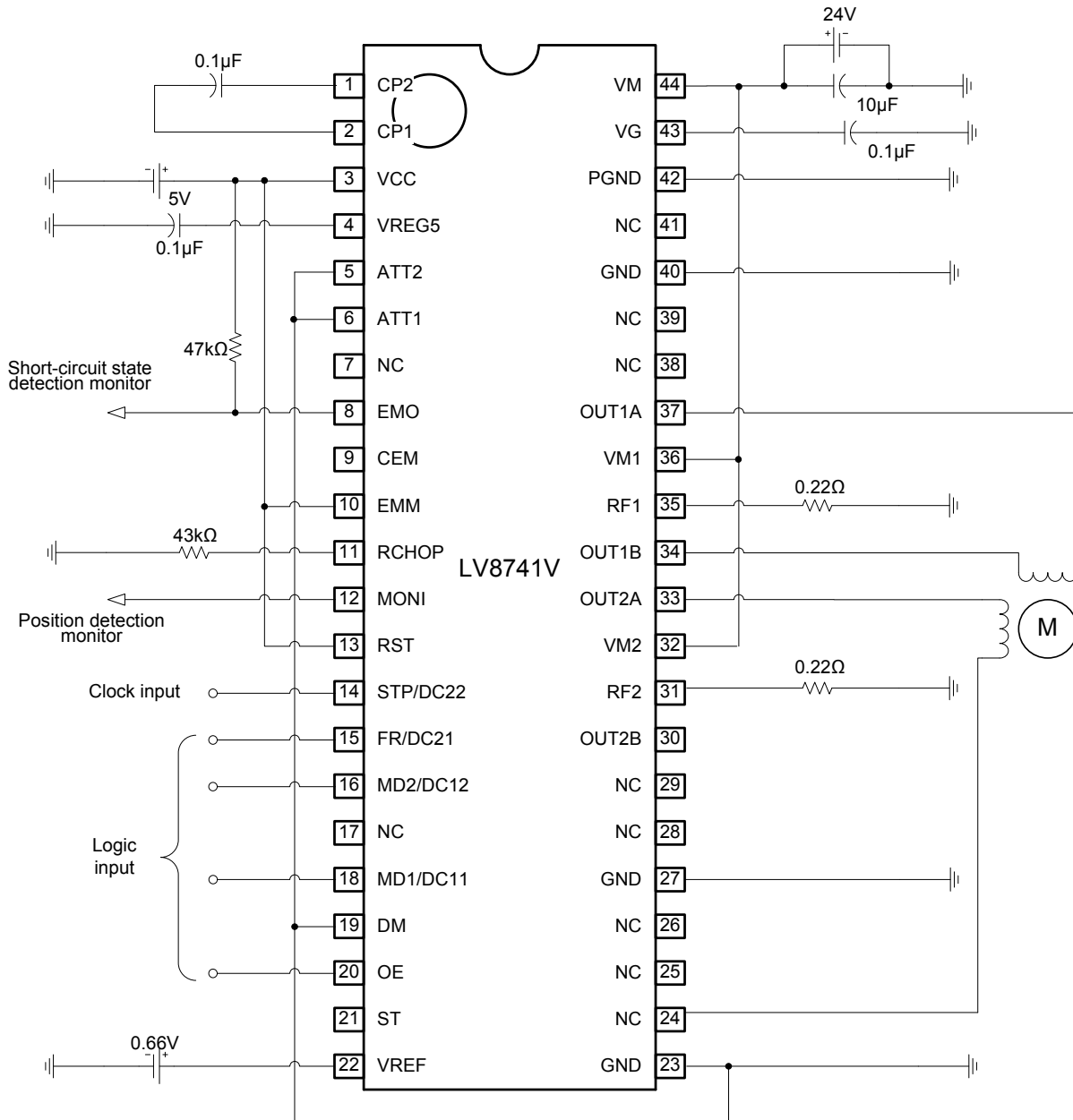
Provide a wait time of 10 μ s or more after the motor power supply rises before setting the ST pin High.



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

Application Circuits

- Stepping motor driver application circuit example



Each constant setting type in the example of the above-mentioned circuit is as follows.
When setting current ratio = 100%, VREF = 0.66V, the following output current flows:

$$I_{OUT} = VREF/3/RF \text{ resistance}$$

$$= 0.66V/3 \times 100\%/0.22\Omega = 1.0A$$

Chopping frequency setting.

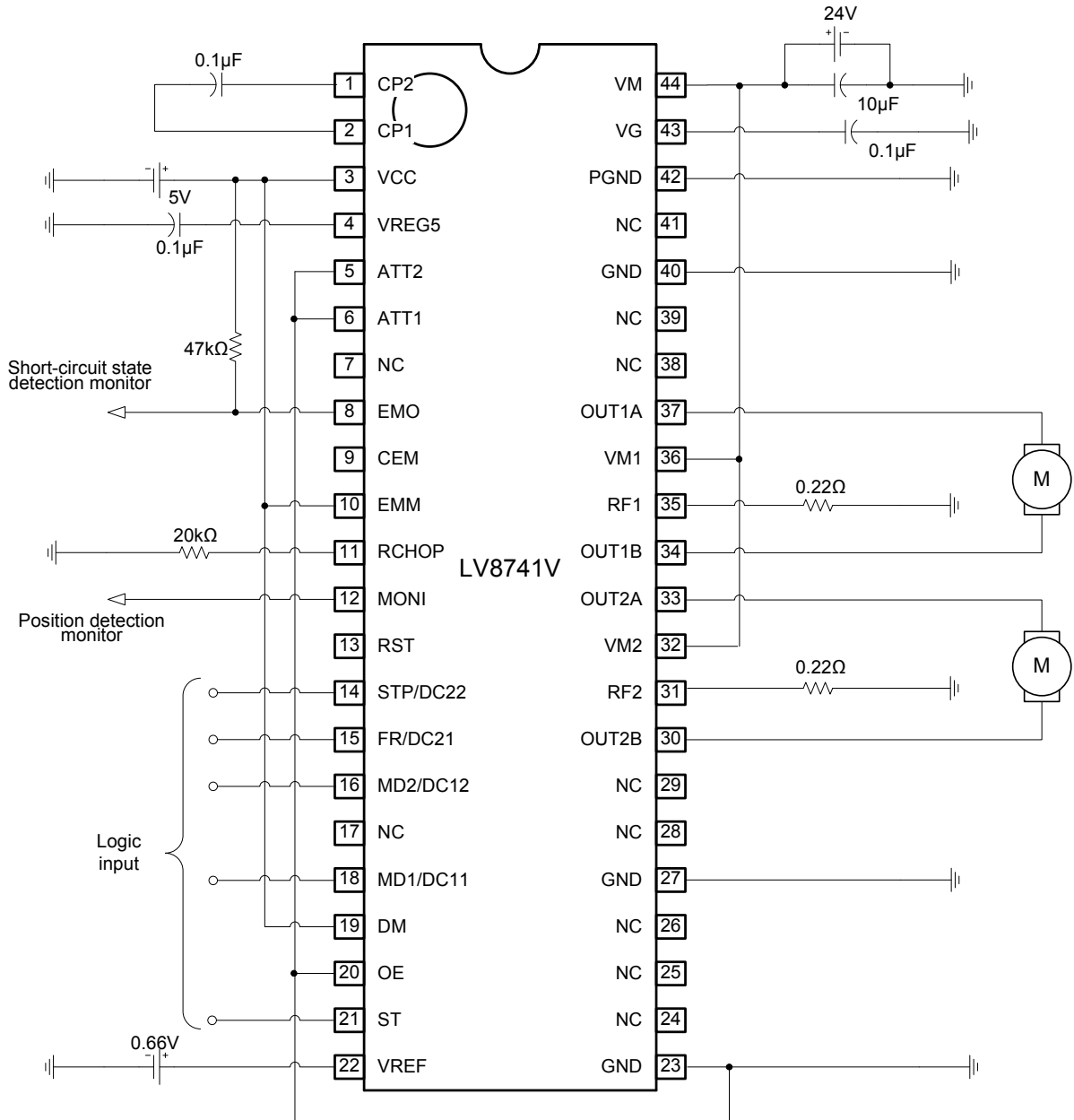
37kHz (RCHOP=43kΩ)

Latch-type output short-circuit protection function (EMM = High)

Reset function fixed to normal operation (RST = High)

LV8741V Application Note

• DC motor driver application circuit example



Each constant setting type in the example of the above-mentioned circuit is as follows.
When setting current LIMIT = 100%, VREF = 0.66V, the following output current flows:

$$\begin{aligned} I_{\text{limit}} &= V_{\text{REF}}/5/\text{RF resistance} \\ &= 0.66\text{V}/3 \times 100\%/0.22\Omega = 1.0\text{A} \end{aligned}$$

Chopping frequency setting.

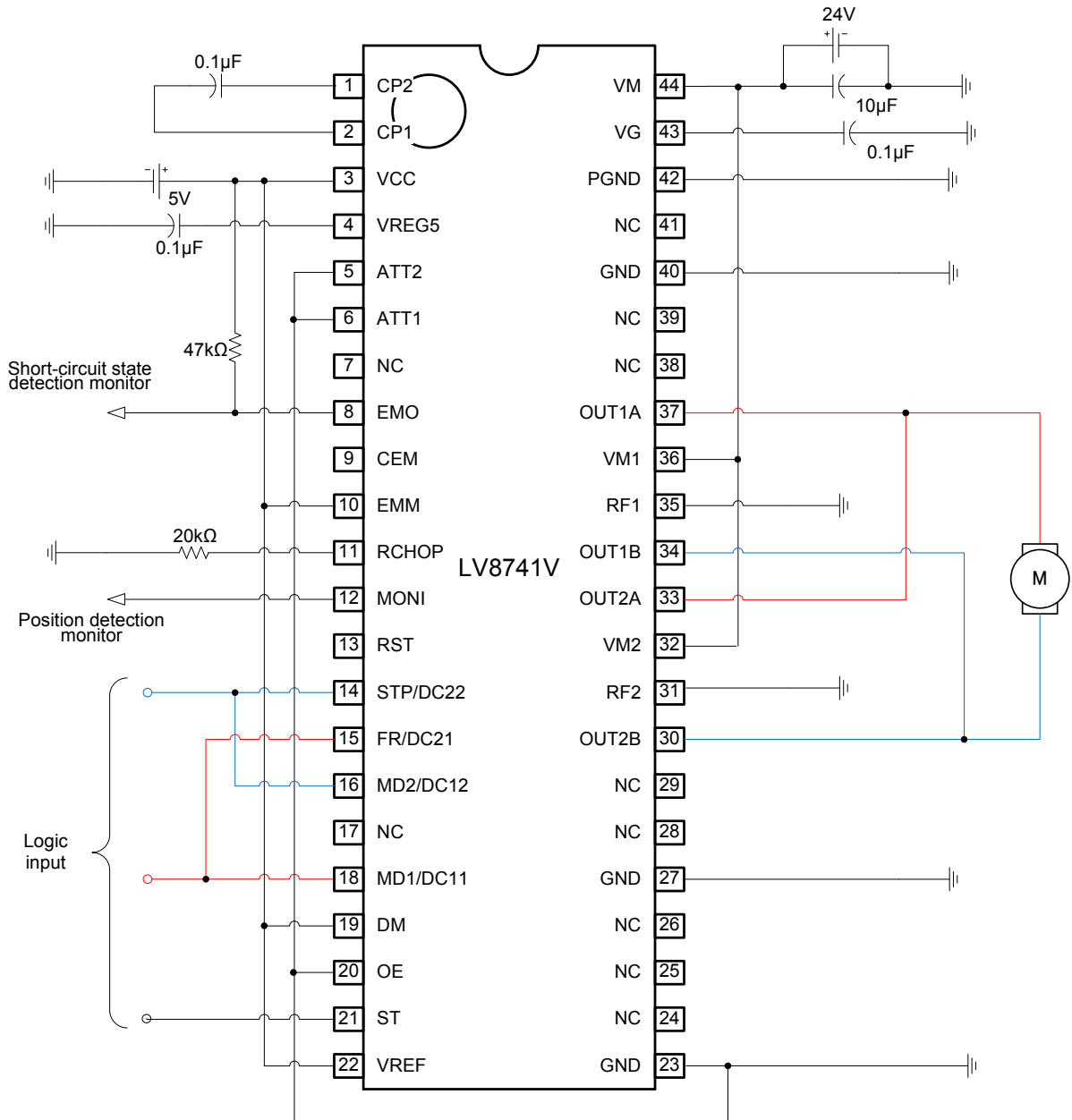
62.5kHz (RCHOP=20kΩ)

Latch-type output short-circuit protection function (EMM = High)

LV8741V Application Note

- DC motor driver parallel connection application circuit example

By connecting OUT1A and OUT2A as well as OUT2A and OUT2B, you can double the current capability. However, you cannot use current limit function. (RF=GND)



Each constant setting type in the example of the above-mentioned circuit is as follows.

Chopping frequency setting.

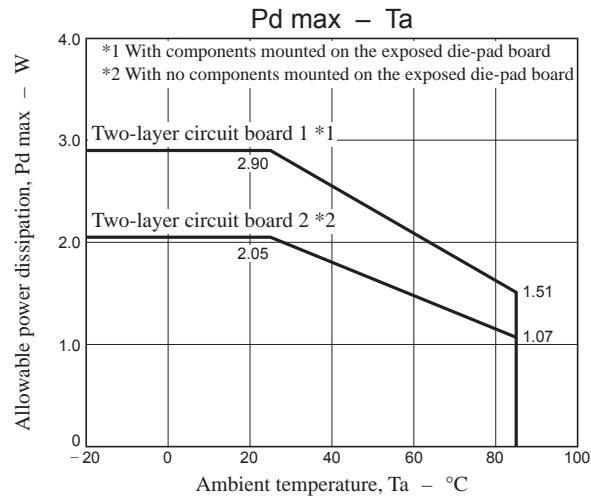
62.5kHz (RCHOP=20kΩ)

Latch-type output short-circuit protection function (EMM = High)

Current Ability (Iomax)

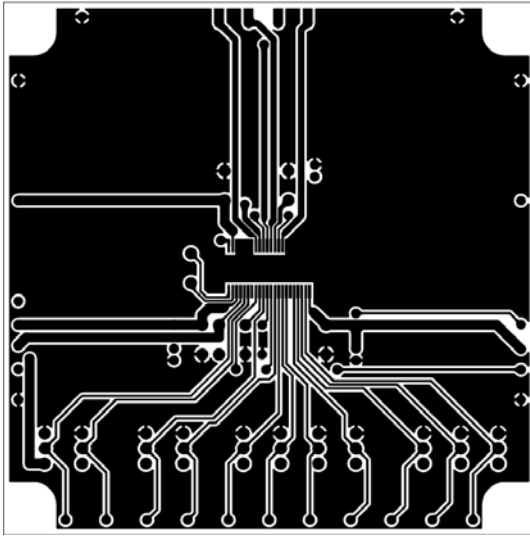
OUT1	OUT2	OUT1/2(Parallel Connect)
1.5A	1.5A	3A

LV8741V Application Note

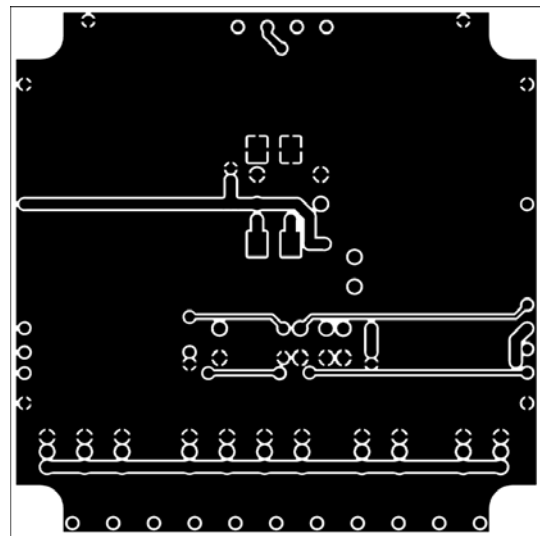


Substrate Specifications (Substrate recommended for operation of LV8741V)

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



L1 : Copper wiring pattern diagram



L2 : Copper wiring pattern diagram

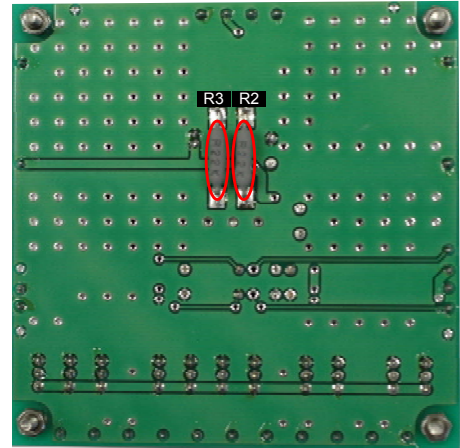
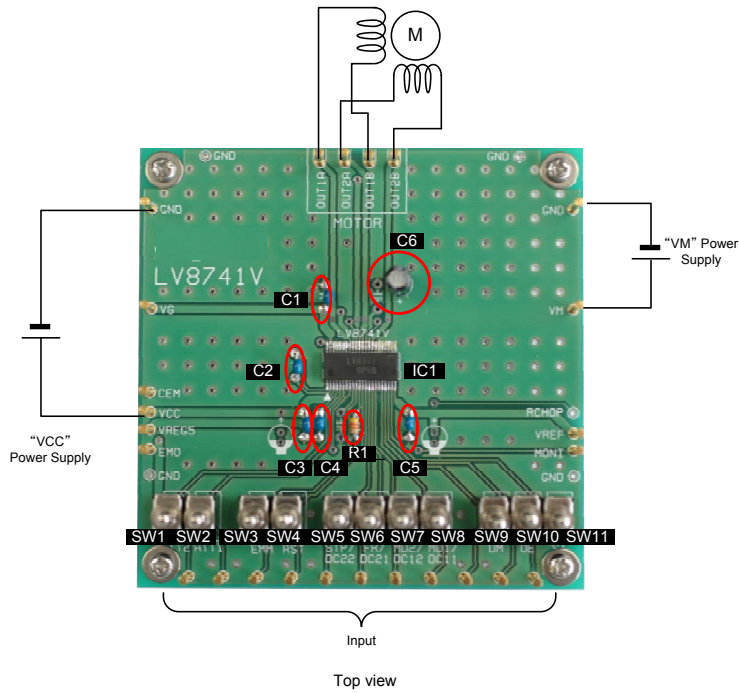
Cautions

- 1) The data for the case with the Exposed Die-Pad substrate mounted shows the values when 95% or more of the Exposed Die-Pad is wet.
- 2) For the set design, employ the derating design with sufficient margin.
Stresses to be derated include the voltage, current, junction temperature, power loss, and mechanical stresses such as vibration, impact, and tension.
Accordingly, the design must ensure these stresses to be as low or small as possible.
The guideline for ordinary derating is shown below :
 - (1)Maximum value 80% or less for the voltage rating
 - (2)Maximum value 80% or less for the current rating
 - (3)Maximum value 80% or less for the temperature rating
- 3) After the set design, be sure to verify the design with the actual product.
Confirm the solder joint state and verify also the reliability of solder joint for the Exposed Die-Pad, etc.
Any void or deterioration, if observed in the solder joint of these parts, causes deteriorated thermal conduction, possibly resulting in thermal destruction of IC.

LV8741V Application Note

Evaluation board

LV8741V (90.0mm×90.0mm×1.7mm, glass epoxy 2-layer board, with backside mounting)

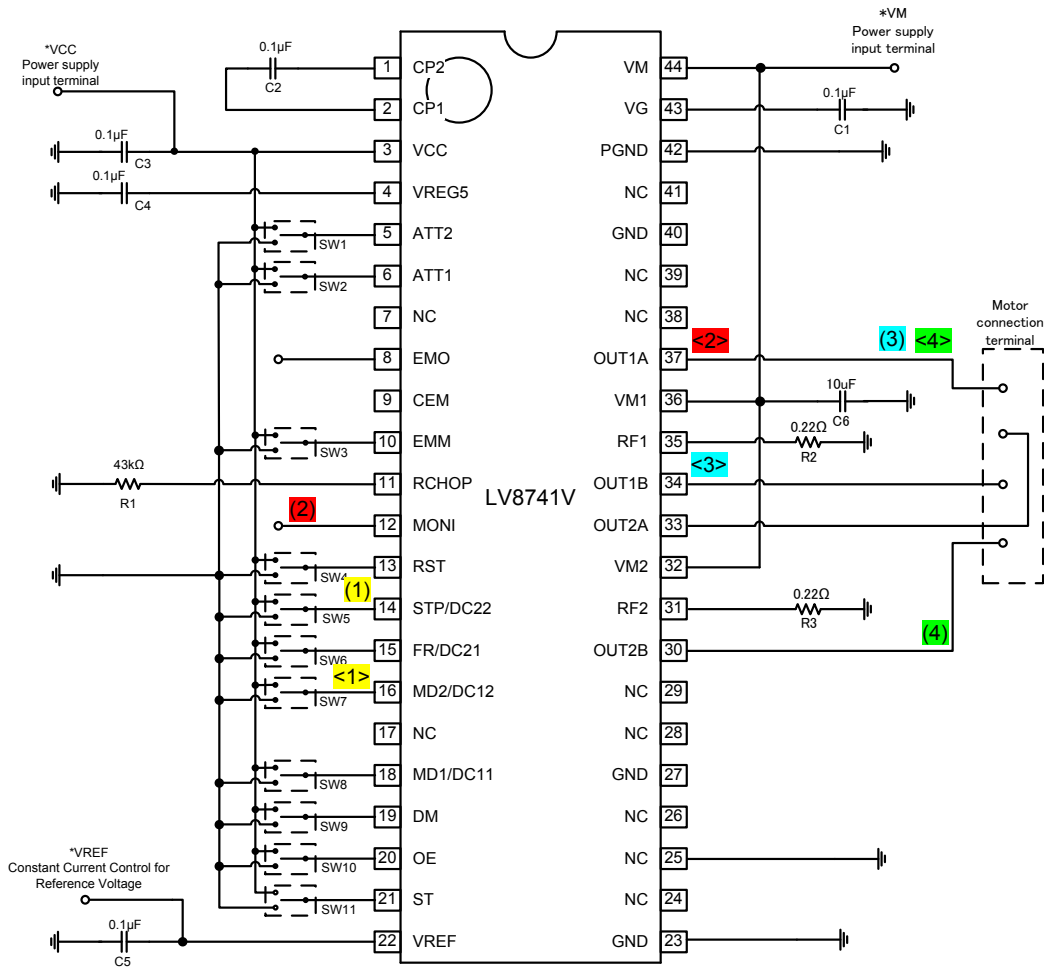


Bill of Materials for LV8741V Evaluation Board

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
C1	1	Capacitor for Charge pump	0.1μF, 100V	±10%		TDK-EPC	FK28X7R1H104K	Yes	Yes
C2	1	Capacitor for Charge pump	0.1μF, 100V	±10%		TDK-EPC	FK28X7R1H104K	Yes	Yes
C3	1	VCC Bypass Capacitor	0.1μF, 100V	±10%		TDK-EPC	FK28X7R1H104K	Yes	Yes
C4	1	VREG5 stabilization Capacitor	0.1μF, 100V	±10%		TDK-EPC	FK28X7R1H104K	Yes	Yes
C5	1	VREF stabilization Capacitor	0.1μF, 100V	±10%		TDK-EPC	FK28X7R1H104K	Yes	Yes
C6	1	VM Bypass Capacitor	10μF, 50V	±20%		SUN Electronic Industries	50ME10HC	Yes	Yes
R1	1	Resistor to set chopping frequency	43kΩ, 1/10W	±5%		akane ohm	RD16S433J	Yes	Yes
R2	1	Channel 1 output current detective Resistor	0.22Ω, 1W	±5%		JAPAN RESISTOR MFG	KNP2WR22J/R0	Yes	Yes
R3	1	Channel 2 output current detective Resistor	0.22Ω, 1W	±5%		JAPAN RESISTOR MFG	KNP2WR22J/R0	Yes	Yes
IC1	1	Motor Driver			SSOP44K (275mil)	ON Semiconductor	LV8741V	No	Yes
SW1-SW11	11	Switch				MIYAMA	MS-621C-A01	Yes	Yes
TP1-TP25	25	Test Point				MAC8	ST-1-3	Yes	Yes

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Evaluation board circuit

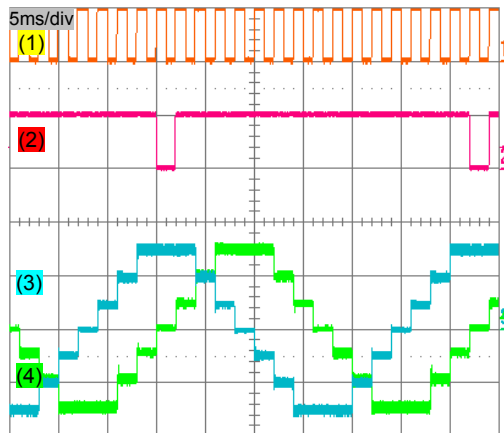


【Stepping Motor】

VCC=5V, VM=24V, VREF=0.53V
 ST=H, DM=L
 ATT1=ATT2=L,
 FR/DC21=L
 MD1/DC11=MD2/DC12=H
 STP/DC22=500Hz(Duty50%)

【DC Motor(OUT1A-OUT1B)】

VCC=5V, VM=24V, VREF=0.9V
 ST=H, DM=H
 ATT1=ATT2=L,
 FR/DC21=STP/DC22=L
 MD1/DC11=H
 MD2/DC12=100kHz(Duty50%)

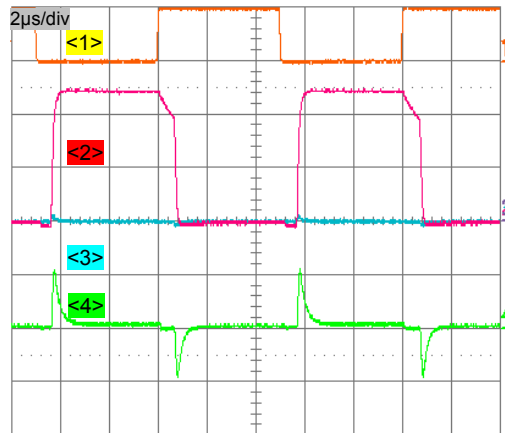


STP
5V/div

MONI
5V/div

Iout1
0.5A/div

Iout2
0.5A/div



DC12
5V/div

OUT1A
10V/div

OUT1B
10V/div

Iout1
1A/div

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Evaluation Board Manual

[Supply Voltage] VCC (2.7 to 5.5V): Logic Supply for LSI
 VM (9 to 35V): Power Supply for LSI
 VREF (0 to 3V): Const. Current Control for Reference Voltage

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

[Operation Guide]

For stepping motor control

1. **Initial Condition Setting:** Set "Open" the toggle switch STP/D22, and "Open or Low" the other switches
2. **Motor Connection:** Connect the Motors between OUT1A and OUT1B, between OUT2A and OUT2B.
3. **Power Supply:** Supply DC voltage to VCC, VM, and VREF.
4. **Ready for Operation from Standby State:** Turn "High" the ST terminal toggle switch. After the tONG time passes, turn "High" the OE terminal toggle switch. Channel 1 and 2 are into full-step initial position (100%, -100%).
5. **Motor Operation:** Turn "High" the RST terminal toggle switch. Input the clock signal into the terminal STP/DC22.
6. **Other Setting**
 - i. ATT1, ATT2: Motor current attenuation.
 - ii. EMM: Short circuit protection mode change.
 - iii. RST: Initial Mode.
 - iv. FR/DC21: Motor rotation direction (CW / CCW) setting.
 - v. MD1/DC11, MD2/DC12: Excitation mode.
 - vi. OE: Output Enable.

For DC motor control

1. **Initial Condition Setting:** Set "Open" the toggle switch DM, and "Open or Low" the other switches
2. **Motor Connection:** Connect the Motor(s) between OUT1A and OUT1B, between OUT2A and OUT2B.
3. **Power Supply:** Supply DC voltage to VCC, VM, and VREF.
4. **Ready for Operation from Standby State:** Turn "High" the ST and DM terminal toggle switch.
5. **Motor Operation:** After the tONG time passes since turn "High" the ST, Set MD1/DC11, MD2/DC12 and STP/DC22 terminals according to the purpose.
6. **Other Setting**
 - i. ATT1, ATT2: Motor current attenuation.
 - ii. EMM: Short circuit protection mode change.
 - iii. RST: Not performed
 - iv. OE: Output enable.

[Setting for External Component Value]

1. Constant Current (100%)

At VREF=0.66V

$$I_{out} = VREF [V] / 3 / RF [\Omega]$$
$$= 0.66 [V] / 3 / 0.22 [\Omega]$$
$$= 1 [A]$$
2. Chopping frequency setting.

37kHz (RCHOP=43kΩ)

LV8741V Application Note

Notes in design:

●Power supply connection terminal [VCC, VM, VM1, VM2]

- ✓ VCC is the power supply connection terminal for logic.
- ✓ VM, VM1, and VM2 are the power supply connection terminal for motor power.
- ✓ Make sure to short-circuit VM, VM1 and VM2.
- ✓ 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, Exposed Die-Pad]

- ✓ 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.
- ✓ The exposed die-pad is connected to the board frame of the IC. Therefore, do not connect it other than GND. Independent layout is preferable. If such layout is not feasible, please connect it to signal GND. Or if the area of GND and PGND is larger, you may connect the exposed die pad to the GND.
(The independent connection of exposed die pad to PGND is not recommended.)

●Internal power supply regulator terminal [VREG5]

- ✓ VREG5 is the power supply for output Tr and charge pump circuit (typ 5V).
- ✓ When VCC and VM supply are powered and ST is "H", VREG5 operates.
- ✓ Please connect capacitor for stabilize VREG5. The recommendation value is 0.1uF.
- ✓ Since the voltage of VREG5 fluctuates, do not use it as reference voltage that requires accuracy.

●Input terminal

- ✓ The logic input pin incorporates pull-down resistor (100kΩ).
- ✓ 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.
- ✓ Set input pin to high after VCC supply is powered, because the diode is connected between the logic terminal and VCC power supply.

●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.

●NC terminal

- ✓ NC pin is not connected to the IC.
- ✓ If VM line and output line are wide enough in your layout, please use NC.

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