LV8712T / LV8713T

Bi-CMOS LSI

PWM Constant-Current Control Stepping Motor Driver

Overview

The LV8712T and LV8713T are microstepping motor drivers with built-in translator for easy operation. The LV8712T supports full-step, half-step, quarter-step, and 1/8-step resolution. The LV8713T supports full-step, half-step, 1/16-step, and 1/32-step resolution. These ICs are optimal for driving stepping motor of scanner and small printer.

Features

- Single-channel PWM constant-current control stepping motor driver incorporated.
- Microstepping is configurable to the following modes:
  Full-step, half-step, quarter-step, or 1/8-step. (LV8712T)
  Full-step, half-step, 1/16-step, or 1/32-step. (LV8713T)
- CLK-IN input facilitates the control of microstepping.
- Power-supply voltage of motor : VM max = 18V
- Output current : I_O max = 0.8A
- Output ON resistance : R_{ON} = 1.1Ω (upper and lower total, typical, Ta = 25°C)
- Thermal shutdown circuit and low voltage detecting circuit incorporated.

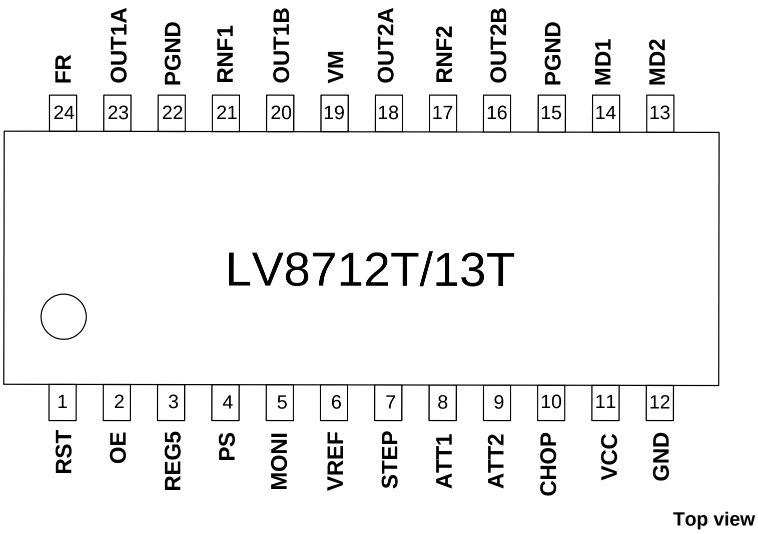
Typical Applications

- POS Printer
- Scanner
- Thermal Printer Unit
- Security camera
- Air-conditioner

Selection Guide

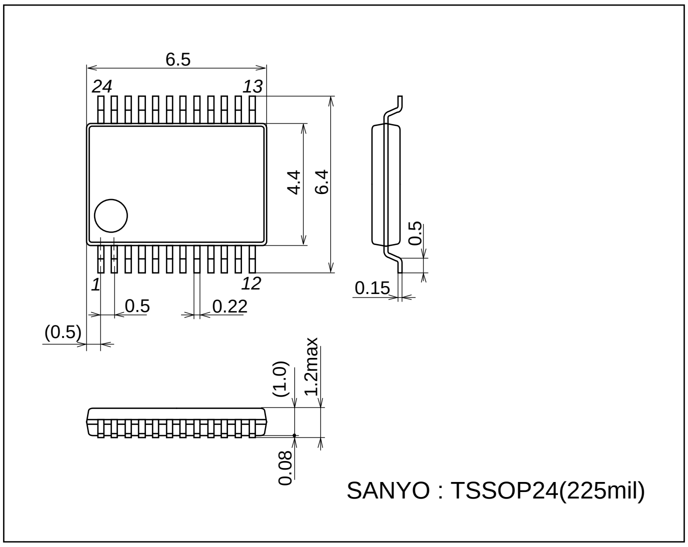
Part Number	Microstepping mode
LV8712T	Full-,half-,quarter-,1/8-step
LV8713T	Full-,half-,1/16-,1/32-step

Pin Assignment

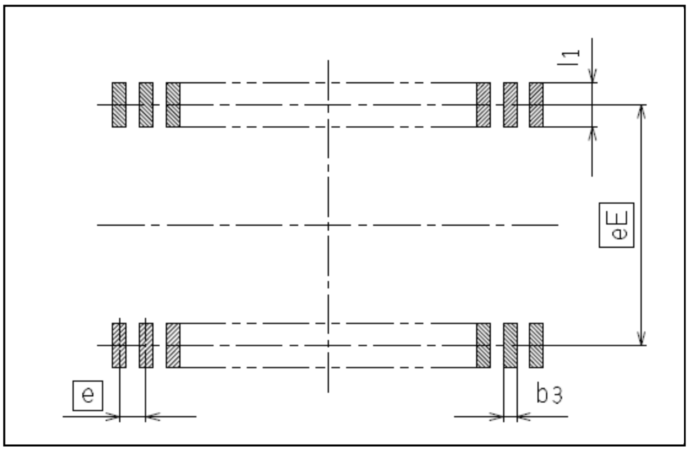


Package Dimension

unit: mm (typ)
3260A



Mounting Pad Sketch

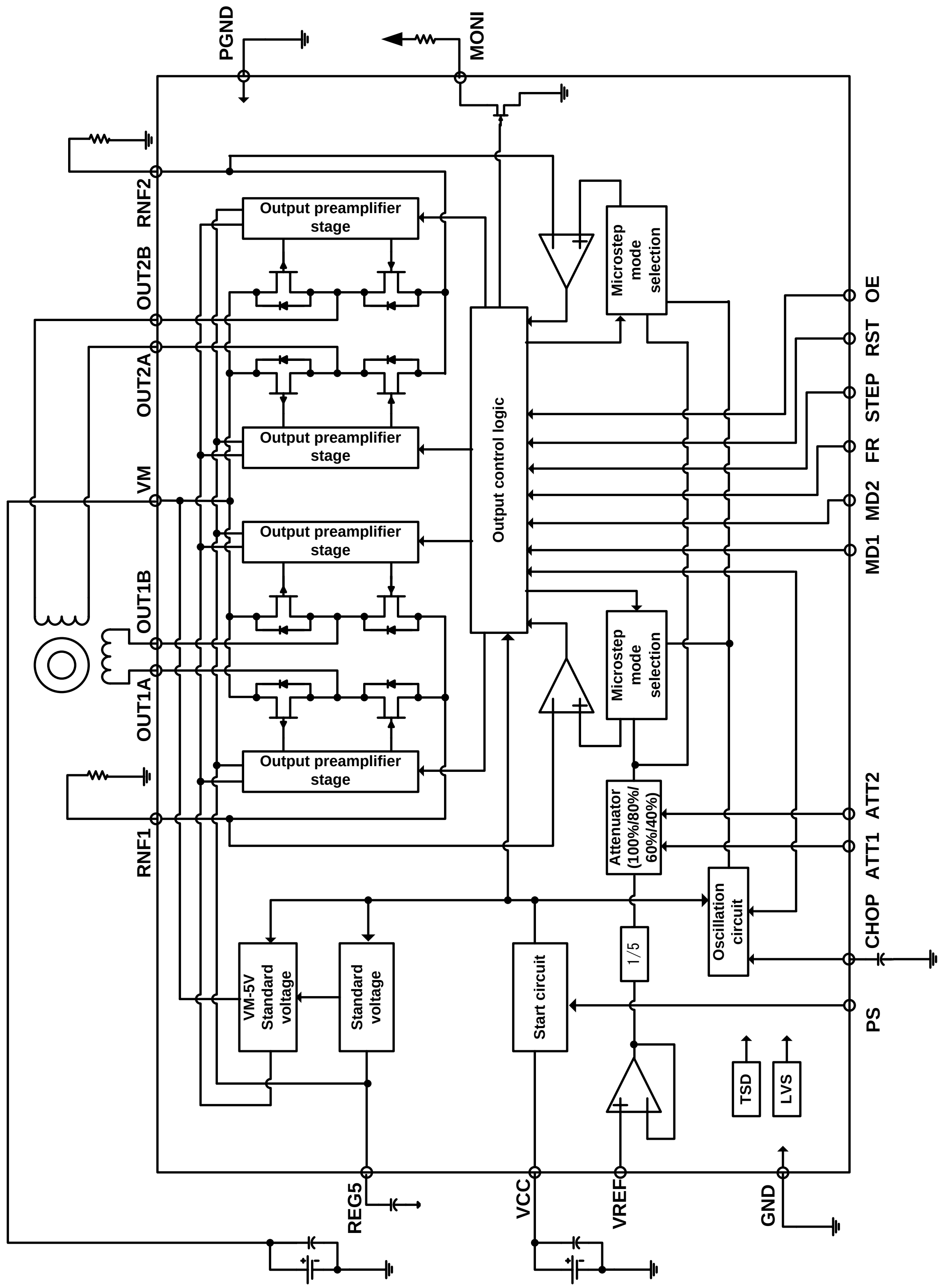


(Unit:mm)

Reference symbol	TSSOP24 (225mil)
eE	5.80
e	0.50
b3	0.32
l1	1.00

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

Block Diagram



Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Motor supply voltage	VM max		18	V
Logic supply voltage	V_{CC} max		6	V
Output peak current	I_O peak	Each 1ch, tw ≤ 10ms, duty 20%	1.0	A
Output continuousness current	I_O max	Each 1ch	800	mA
Logic input voltage	V_{IN}		-0.3 to V_{CC} + 0.3	V
Allowable power dissipation	Pd max	*	1.35	W
Operating temperature	Topr		-20 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

* Specified circuit board: 57.0mm×57.0mm×1.7mm, glass epoxy 2-layer board.

Allowable Operating Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Motor supply voltage range	VM		4 to 16	V
Logic supply voltage range	V_{CC}		2.7 to 5.5	V
Logic input voltage	V_{IN}		-0.3 to V_{CC}+0.3	V
VREF input voltage range	VREF		0 to V_{CC}-1.8	V

Electrical Characteristics at Ta = 25°C, VM = 12V, V_{CC} = 3.3V, VREF = 1.0V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain	IMstn	PS = “L”, no load			1	μA
	I_{CC}stn	PS = “L”, no load			1	μA
Operating mode current drain	IM	PS = “H”, no load	0.3	0.5	0.7	mA
	I_{CC}	PS = “H”, no load	0.9	1.3	1.7	mA
Thermal shutdown temperature	TSD	Design guarantee		180		°C
Thermal hysteresis width	ΔTSD	Design guarantee		40		°C
V_{CC} low voltage cutting voltage	VthV_{CC}		2.1	2.4	2.7	V
Low voltage hysteresis voltage	VthHIS		100	130	160	mV
REG5 output voltage	Vreg5	I_O = -1mA	4.5	5	5.5	V
Output on resistance	RonU	I_O = -800mA, Source-side on resistance		0.78	1.0	Ω
	RonD	I_O = 800mA, Sink-side on resistance		0.32	0.43	Ω
Output leakage current	$I_O$leak	V_O = 15V			10	μA
Diode forward voltage	VD	ID = -800mA		1.0	1.2	V
Logic pin input current	I_{IN}L	V_{IN} = 0.8V	4	8	12	μA
	I_{IN}H	V_{IN} = 3.3V	22	33	45	μA
Logic high-level input voltage	V_{IN}H		2.0			V
Logic low-level input voltage	V_{IN}L				0.8	V
VREF input current	I_{REF}	VREF = 1.0V	-0.5			μA
Current setting comparator threshold voltage (current attenuation rate switching)	Vtatt00	ATT1 = L, ATT2 = L	0.191	0.200	0.209	V
	Vtatt01	ATT1 = H, ATT2 = L	0.152	0.160	0.168	V
	Vtatt10	ATT1 = L, ATT2 = H	0.112	0.120	0.128	V
	Vtatt11	ATT1 = H, ATT2 = H	0.072	0.080	0.088	V
Chopping frequency	Fchop	Cchop = 220pF	36	45	54	kHz
CHOP pin threshold voltage	V_{CHOP}H		0.6	0.7	0.8	V
	V_{CHOP}L		0.17	0.2	0.23	V
CHOP pin charge/discharge current	Ichop		7	10	13	μA
MONI pin saturation voltage	Vsatmon	Imoni = 1mA		250	400	mV

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Parameter		Symbol	Conditions	Ratings min	Ratings typ	Ratings max	Unit
Current setting comparator threshold voltage (current step switching)	8W1-2-phase drive (1/32-step at LV8713T)	Vtdac0_2W	Step 0 (When initialized: channel 1 comparator level)	0.191	0.200	0.209	V
		Vtdac1_8W	Step 1 (Initial state+1)	0.191	0.200	0.209	V
		Vtdac2_8W	Step 2 (Initial state+2)	0.191	0.200	0.209	V
		Vtdac3_8W	Step 3 (Initial state+3)	0.189	0.198	0.207	V
		Vtdac4_8W	Step 4 (Initial state+4)	0.187	0.196	0.205	V
		Vtdac5_8W	Step 5 (Initial state+5)	0.185	0.194	0.203	V
		Vtdac6_8W	Step 6 (Initial state+6)	0.183	0.192	0.201	V
		Vtdac7_8W	Step 7 (Initial state+7)	0.179	0.188	0.197	V
		Vtdac8_8W	Step 8 (Initial state+8)	0.175	0.184	0.193	V
		Vtdac9_8W	Step 9 (Initial state+9)	0.171	0.180	0.189	V
		Vtdac10_8W	Step 10 (Initial state+10)	0.167	0.176	0.185	V
		Vtdac11_8W	Step 11 (Initial state+11)	0.163	0.172	0.181	V
		Vtdac12_8W	Step 12 (Initial state+12)	0.158	0.166	0.174	V
		Vtdac13_8W	Step 13 (Initial state+13)	0.152	0.160	0.168	V
		Vtdac14_8W	Step 14 (Initial state+14)	0.146	0.154	0.162	V
		Vtdac15_8W	Step 15 (Initial state+15)	0.140	0.148	0.156	V
		Vtdac16_8W	Step 16 (Initial state+16)	0.132	0.140	0.148	V
		Vtdac17_8W	Step 17 (Initial state+17)	0.126	0.134	0.142	V
		Vtdac18_8W	Step 18 (Initial state+18)	0.118	0.126	0.134	V
		Vtdac19_8W	Step 19 (Initial state+19)	0.112	0.120	0.128	V
		Vtdac20_8W	Step 20 (Initial state+20)	0.102	0.110	0.118	V
		Vtdac21_8W	Step 21 (Initial state+21)	0.094	0.102	0.110	V
		Vtdac22_8W	Step 22 (Initial state+22)	0.086	0.094	0.102	V
		Vtdac23_8W	Step 23 (Initial state+23)	0.078	0.086	0.094	V
		Vtdac24_8W	Step 24 (Initial state+24)	0.068	0.076	0.084	V
		Vtdac25_8W	Step 25 (Initial state+25)	0.060	0.068	0.076	V
		Vtdac26_8W	Step 26 (Initial state+26)	0.050	0.058	0.066	V
		Vtdac27_8W	Step 27 (Initial state+27)	0.040	0.048	0.056	V
		Vtdac28_8W	Step 28 (Initial state+28)	0.032	0.040	0.048	V
		Vtdac29_8W	Step 29 (Initial state+29)	0.022	0.030	0.038	V
		Vtdac30_8W	Step 30 (Initial state+30)	0.012	0.020	0.028	V
		Vtdac31_8W	Step 31 (Initial state+31)	0.002	0.010	0.018	V
	4W1-2-phase drive (1/16-step at LV8713T)	Vtdac0_4W	Step 0 (When initialized: channel 1 comparator level)	0.191	0.200	0.209	V
		Vtdac2_4W	Step 2 (Initial state+1)	0.191	0.200	0.209	V
		Vtdac4_4W	Step 4 (Initial state+2)	0.187	0.196	0.205	V
		Vtdac6_4W	Step 6 (Initial state+3)	0.183	0.192	0.201	V
		Vtdac8_4W	Step 8 (Initial state+4)	0.175	0.184	0.193	V
		Vtdac10_4W	Step 10 (Initial state+5)	0.167	0.176	0.185	V
		Vtdac12_4W	Step 12 (Initial state+6)	0.158	0.166	0.174	V
		Vtdac14_4W	Step 14 (Initial state+7)	0.146	0.154	0.162	V
		Vtdac16_4W	Step 16 (Initial state+8)	0.132	0.140	0.148	V
		Vtdac18_4W	Step 18 (Initial state+9)	0.118	0.126	0.134	V
		Vtdac20_4W	Step 20 (Initial state+10)	0.102	0.110	0.118	V
		Vtdac22_4W	Step 22 (Initial state+11)	0.086	0.094	0.102	V
		Vtdac24_4W	Step 24 (Initial state+12)	0.068	0.076	0.084	V
		Vtdac26_4W	Step 26 (Initial state+13)	0.050	0.058	0.066	V
		Vtdac28_4W	Step 28 (Initial state+14)	0.032	0.040	0.048	V
		Vtdac30_4W	Step 30 (Initial state+15)	0.012	0.020	0.028	V

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Parameter		Symbol	Conditions	Ratings			Unit
				min	typ	max	
Current setting comparator threshold voltage (current step switching)	2W1-2-phase drive (1/8-step at LV8712T)	Vtdac0_2W	Step 0 (When initialized: channel 1 comparator level)	0.191	0.2	0.209	V
		Vtdac4_2W	Step 4 (Initial state+1)	0.187	0.196	0.205	V
		Vtdac8_2W	Step 8 (Initial state+2)	0.175	0.184	0.193	V
		Vtdac12_2W	Step 12 (Initial state+3)	0.158	0.166	0.174	V
		Vtdac16_2W	Step 16 (Initial state+4)	0.132	0.140	0.148	V
		Vtdac20_2W	Step 20 (Initial state+5)	0.102	0.110	0.118	V
		Vtdac24_2W	Step 24 (Initial state+6)	0.068	0.076	0.084	V
		Vtdac28_2W	Step 28 (Initial state+7)	0.032	0.040	0.048	V
	W1-2-phase drive (quarter-step at LV8712T)	Vtdac0_W	Step 0 (When initialized: channel 1 comparator level)	0.191	0.200	0.209	V
		Vtdac8_W	Step 8 (Initial state+1)	0.175	0.184	0.193	V
		Vtdac16_W	Step 16 (Initial state+2)	0.132	0.140	0.148	V
		Vtdac24_W	Step 24 (Initial state+3)	0.068	0.076	0.084	V
	1-2 phase drive (half-step at LV8712T/13T)	Vtdac0_H	Step 0 (When initialized: channel 1 comparator level)	0.191	0.200	0.209	V
		Vtdac16_H	Step 16 (Initial state+1)	0.132	0.140	0.148	V
	2 phase drive (full-step at LV8712T/13T)	Vtdac16_F	Step 16' (When initialized: channel 1 comparator level)	0.191	0.200	0.209	V

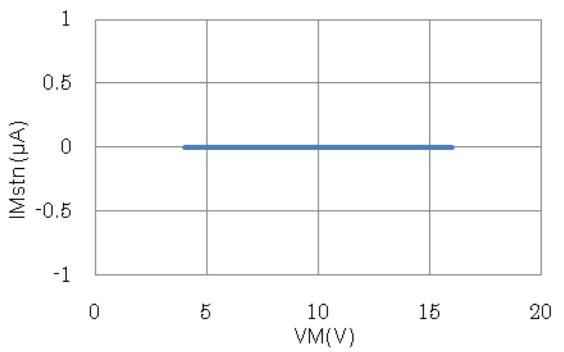


Figure 1 Standby mode current drain (IMstn) vs VM Voltage

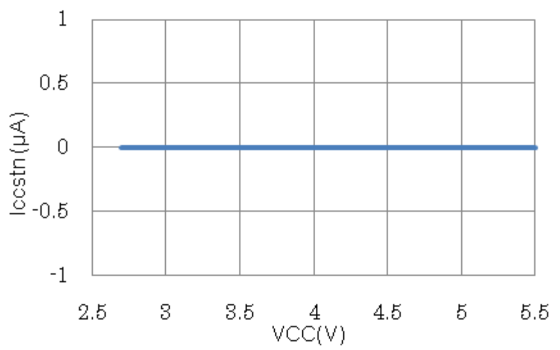


Figure 2 Standby mode current drain (Iccstn) vs Vcc Voltage

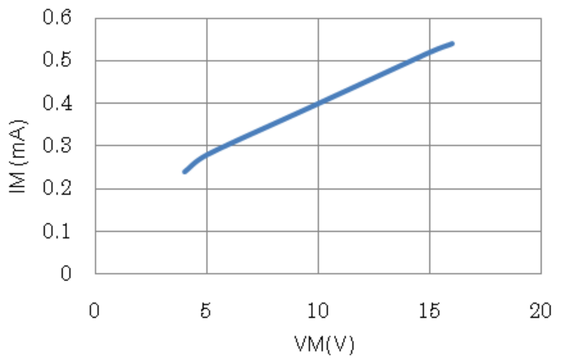


Figure 3 Operating mode current drain (IM) vs VM Voltage

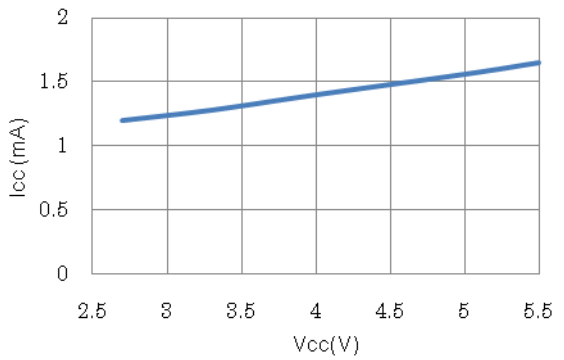


Figure 4 Operating mode current drain (Icc) vs Vcc Voltage

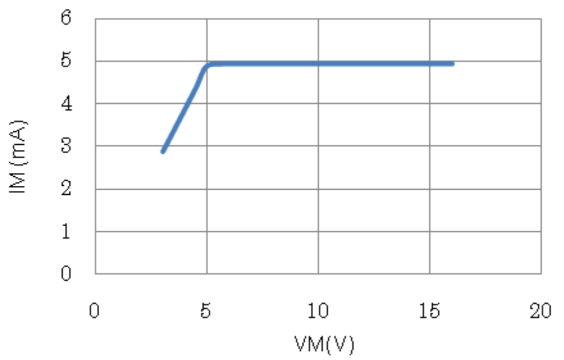


Figure 5 REG5 output voltage vs VM Voltage

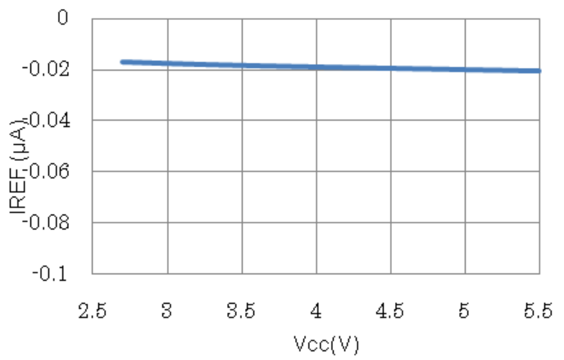


Figure 6 VREF input current vs Vcc Voltage

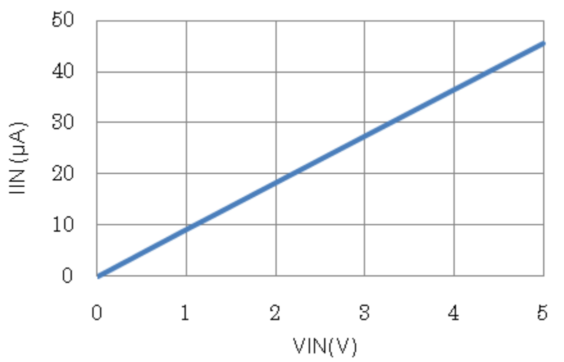


Figure 7 Logic pin input current vs VIN Voltage

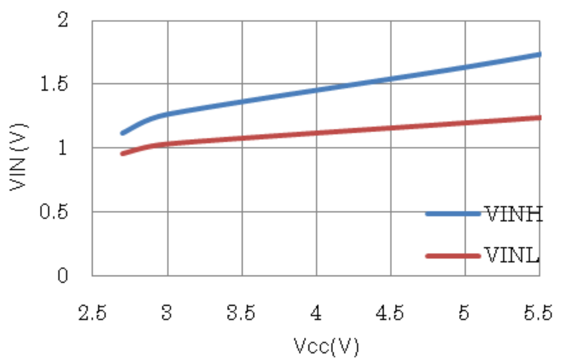


Figure 8 Logic high/low-level input voltage vs Vcc Voltage

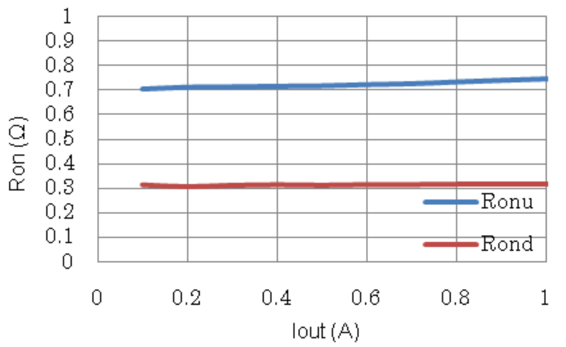


Figure 9 Output on Resistance vs Output Current(VM=12V)

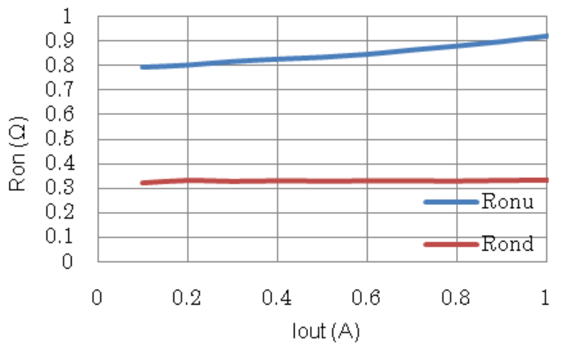


Figure 10 Output on Resistance vs Output Current(VM=4V)

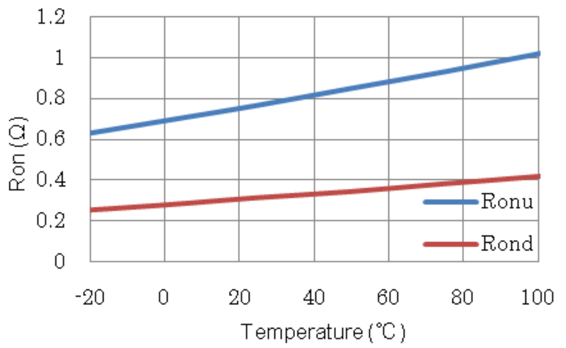


Figure 11 Output on Resistance (VM=12V,Io=0.8A) vs Temperature

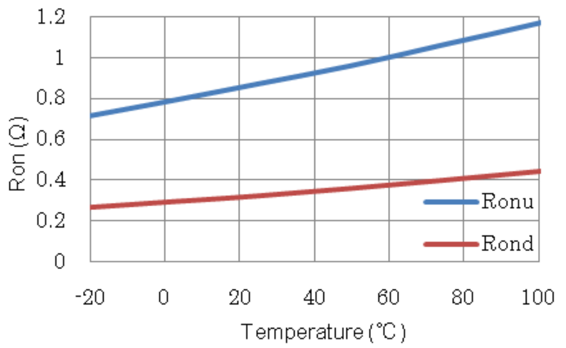


Figure 12 Output on Resistance (VM=4V,Io=0.8A) vs Temperature

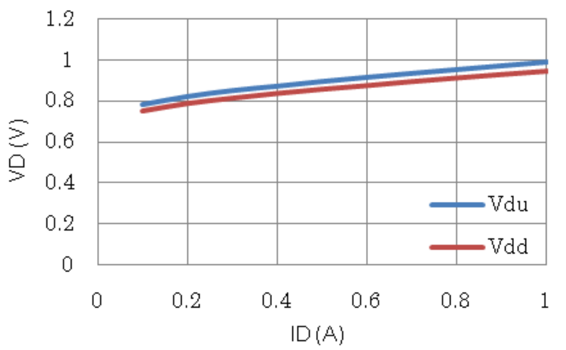


Figure 13 Diode forward voltage vs Diode Current

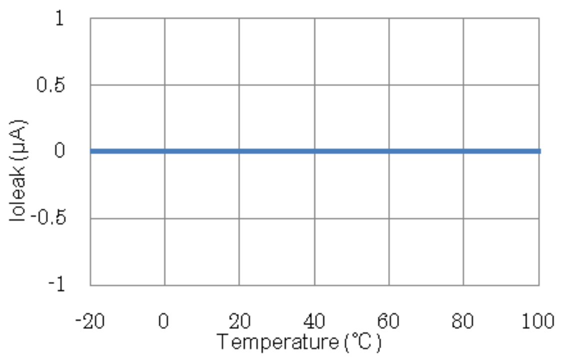


Figure 14 Output leakage voltage vs Temperature

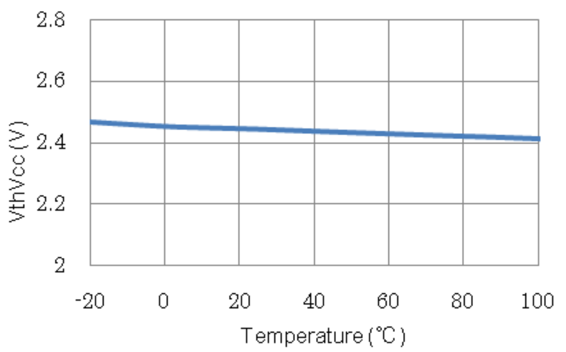


Figure 15 Vcc low-voltage cutoff voltage vs Temperature

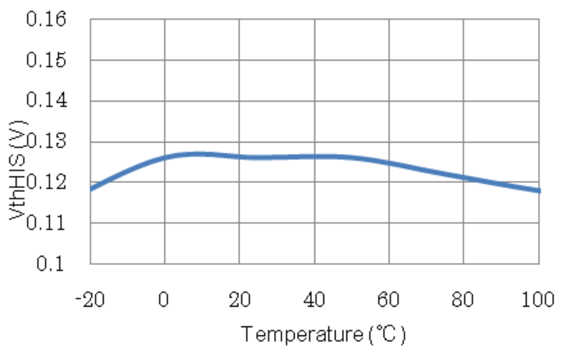


Figure 16 Low-voltage hysteresis voltage vs Temperature

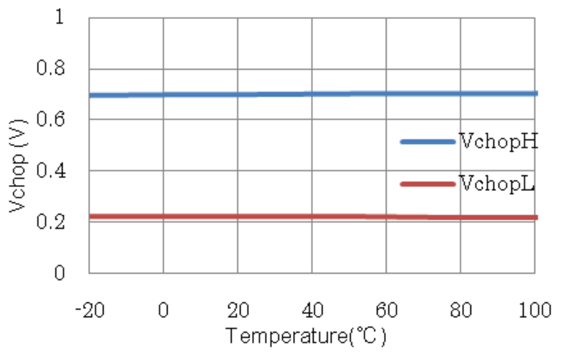


Figure 17 CHOP pin threshold voltage vs Temperature

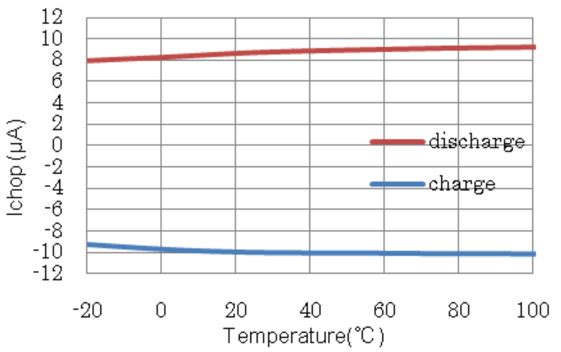


Figure 18 CHOP pin charge/discharge current vs Temperature

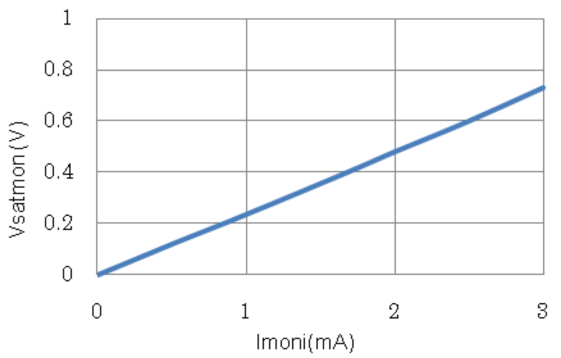
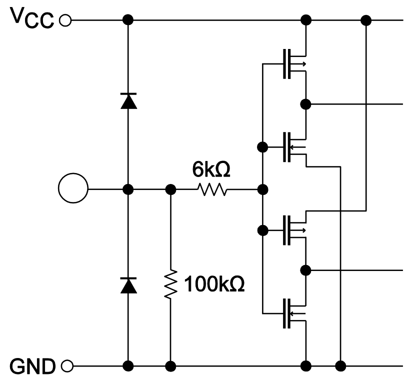
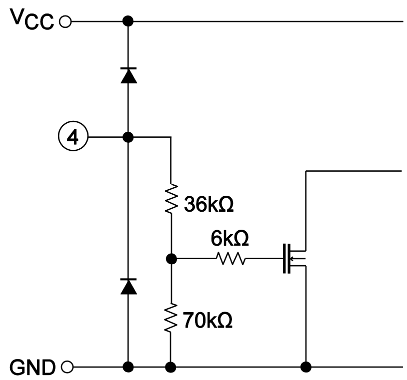
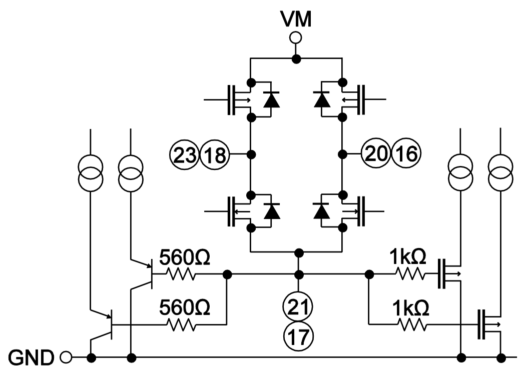
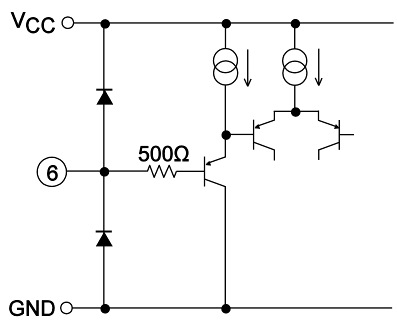


Figure 19 MONI pin saturation voltage vs Output current

Pin Functions

Pin No.	Pin Name	Pin Function	Equivalent Circuit
1 2 7 8 9 13 14 24	RST OE STEP ATT1 ATT2 MD2 MD1 FR	Excitation reset signal input pin. Output enable signal input pin. STEP signal input pin. Motor holding current switching pin. Motor holding current switching pin. Excitation mode switching pin 2. Excitation mode switching pin 1. CW / CCW switching signal input pin.	
4	PS	Power save signal input pin.	
16 17 18 20 21 23	OUT2B RNF2 OUT2A OUT1B RNF1 OUT1A	Channel 2 OUTB output pin. Channel 2 current-sense resistor connection pin. Channel 2 OUTA output pin. Channel 1 OUTB output pin. Channel 1 current-sense resistor connection pin. Channel 1 OUTA output pin	
6	VREF	Constant current control reference voltage input pin.	

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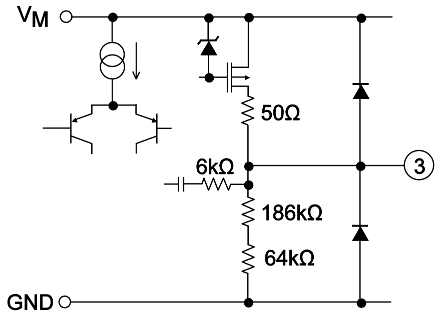
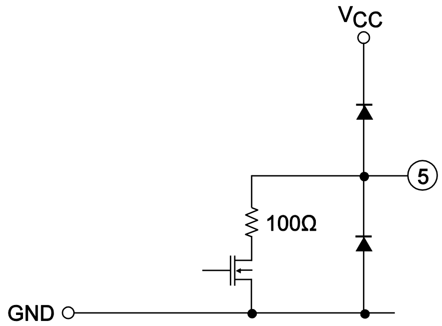
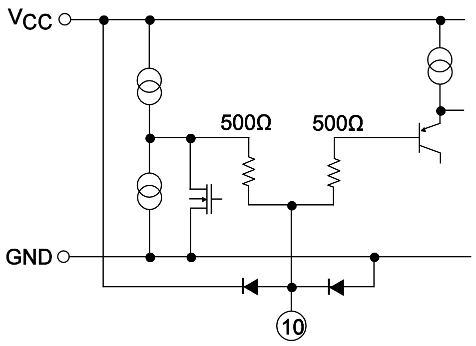
Pin No.	Pin Name	Pin Function	Equivalent Circuit
3	REG5	Internal power supply capacitor connection pin.	
5	MONI	Position detection monitor pin.	
10	CHOP	Chopping frequency setting capacitor connection pin.	

Operation description

Stepping motor control

1. Power save function

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

PS	Mode	Internal regulator
Low or Open	Standby mode	Standby
High	Operating mode	Operating

2. The recommended order of power supply

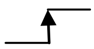
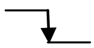
It is recommendable that the power supplies are turned on in the following order.

VCC power supply → VM power supply → PS pin = High

For turning off the power supplies, the order should be reversed.

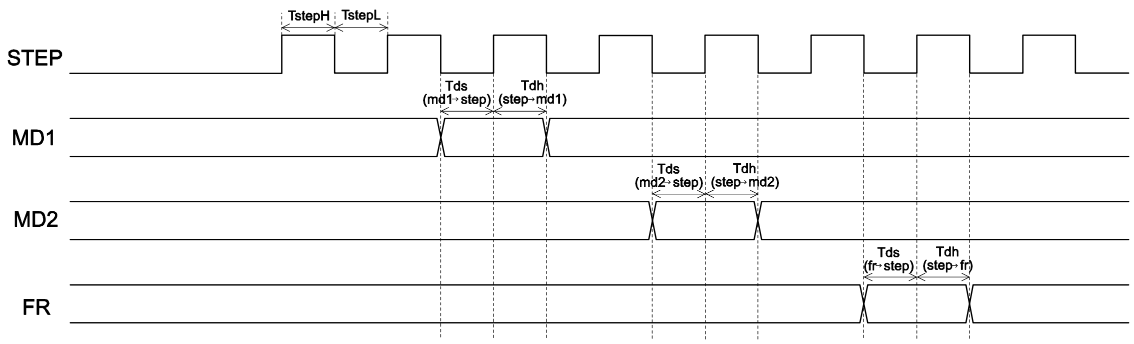
However, the above-mentioned order is presented only as a recommendation, and noncompliance is not going to be the cause of over-current or IC destruction.

3. STEP pin function

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

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

4. Input timing



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

Figure 20. Input timing chart

5. Microstepping mode setting function (initial position)

<LV8712T>

MD1	MD2	Microstepping Resolution	Excitation mode	Initial position	
				Channel 1	Channel 2
Low	Low	Full Step	2 Phase	100%	-100%
High	Low	Half Step	1-2 Phase	100%	0%
Low	High	Quarter Step	W1-2 Phase	100%	0%
High	High	1/8 Step	2W1-2 Phase	100%	0%

<LV8713T>

MD1	MD2	Microstepping Resolution	Excitation mode	Initial position	
				Channel 1	Channel 2
Low	Low	Full Step	2 Phase	100%	-100%
High	Low	Half Step	1-2 Phase	100%	0%
Low	High	1/16 Step	4W1-2 Phase	100%	0%
High	High	1/32 Step	8W1-2 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.

6. Initial Position monitoring function

MONI pin monitors the initial position which is open drain.
When the excitation is in the initial position, the MONI output is turned on.
(Refer to " (13) Examples of current waveforms in the respective excitation modes.")

7. Reset function

RST	Operating mode
High	Normal operation
Low	Reset state

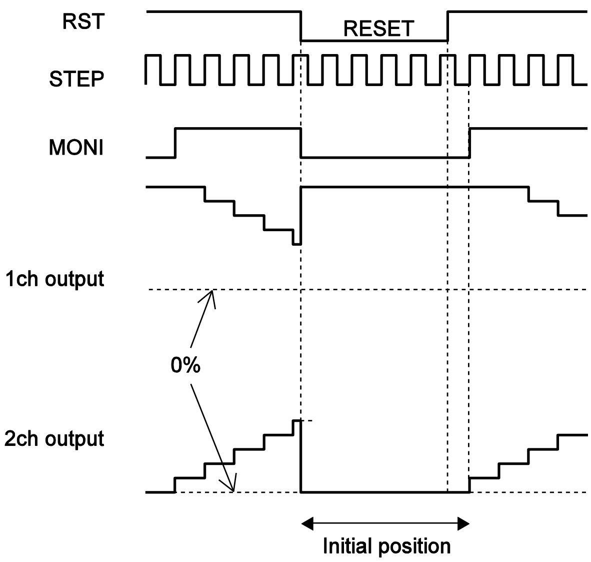


Figure 21. Reset function timing chart

When the RST pin is Low, the excitation position of the output is forcibly set to the initial position, and the MONI output is turned on. When RST turns High, the excitation position is advanced by the next STEP input.

8. Output enable function

OE	Operating mode
Low	Output ON
High	Output OFF

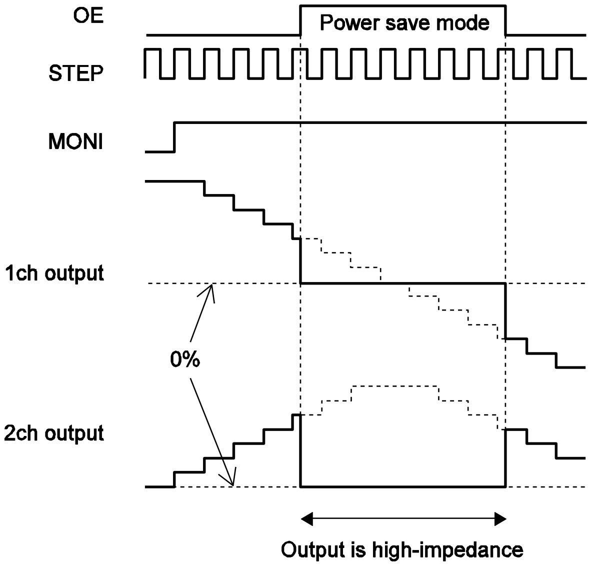


Figure 22. Output enable function timing chart

When the OE pin is High, the output turns OFF by force and turns to high impedance. However, since the internal logic circuits are under operation, the excitation position proceeds when the STEP signal is input. Therefore, when OE turns Low again, the output level follows the excitation position led by the STEP input.

9. Forward/reverse switching function

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

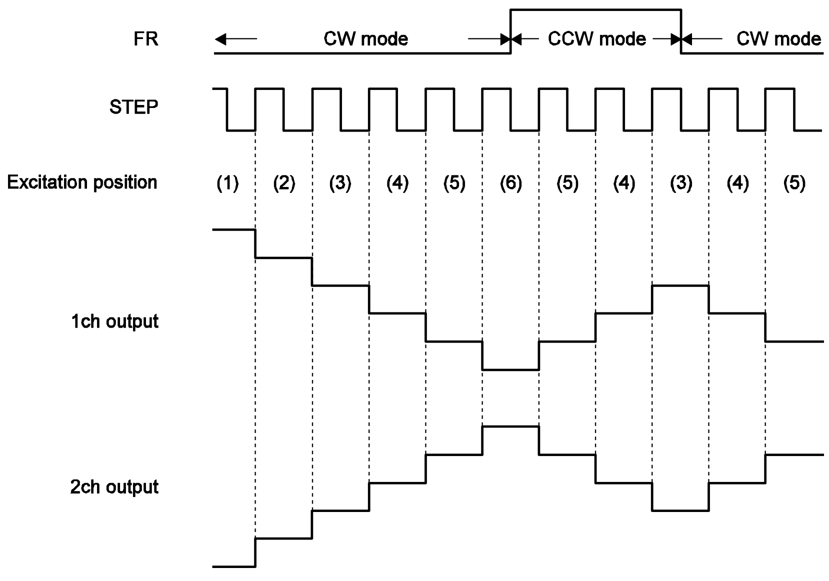


Figure 23. Forward/Reverse switching function timing chart

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.

10. Constant current control setting

The setting of STM driver's constant current control is determined by the following based on the VREF voltage and the resistor connected between RNF and GND.

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

* The above formula gives setting value where the output current is100% in each excitation mode.

If VREF is open or the setting is out of the recommendation operating range, output current will increase and you cannot set constant current under normal condition. Hence, make sure that VREF is set in accordance with the specification.
However, if current control is not performed (if the IC is used by saturation drive or used without current limit at DCM) make sure that the setting is as follows: VREF=5V or VREF=VREG5

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

The voltage input to the VREF pin can be switched to four-step settings depending on the statuses of the two inputs, ATT1 and ATT2. This is effective for reducing power consumption when motor holding current is supplied.

Attenuation function for VREF input voltage

ATT1	ATT2	Current setting reference voltage attenuation ratio
Low	Low	100%
High	Low	80%
Low	High	60%
High	High	40%

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

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

Example: At VREF of 1.0V and a reference voltage setting is 100% [(ATT1, ATT2) = (L, L)] and an RNF resistance of 0.5Ω, the output current is set as follows.

$$I_{OUT} = 1.0V/5 \times 100\%/0.5\Omega = 400mA$$

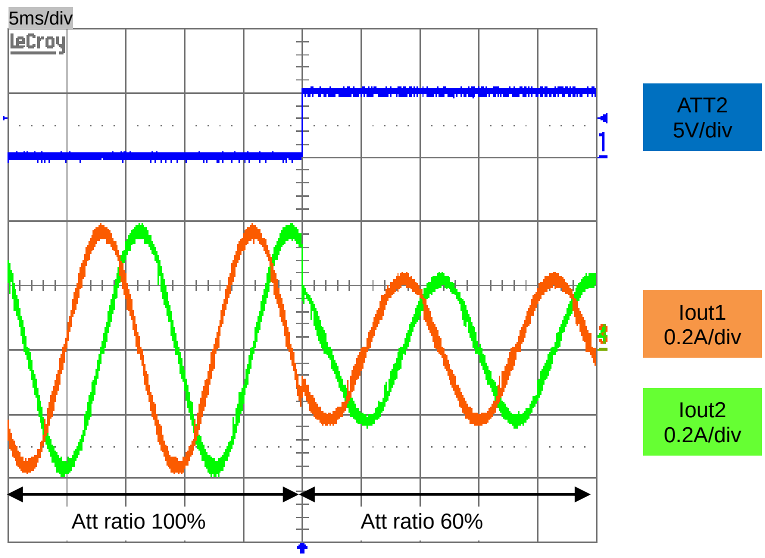
If (ATT1, ATT2) is set to (H, H) in this state, IOUT is obtained as follows:

$$I_{OUT} = 400mA \times 40\% = 160mA$$

In this way, the output current is attenuated when the motor holding current is supplied for power saving.

Figure 24. Constant current control (Attenuation function) waveform

[LV8713T]
Vcc=5V, VM=12V
VREF=1V, RNF=0.51Ω
PS=High, RST=High, ATT1=Low
MD1=MD2=High, fSTEP=10 kHz



11. 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.

Tchop ≈Cchop × Vtchop × 2 / Ichop (s)
Vtchop: Width of threshold voltage (VchopH-VchopL), typ 0.5V
Ichop: Charge/discharge current, typ 10μA

Fchop ≈1 / Tchop (Hz)

For instance, when Cchop is 220pF, the chopping frequency will be as follows:
Fchop =1/Tchop= 10μA/ (220pF × 0.5V × 2) = 45 kHz

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

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

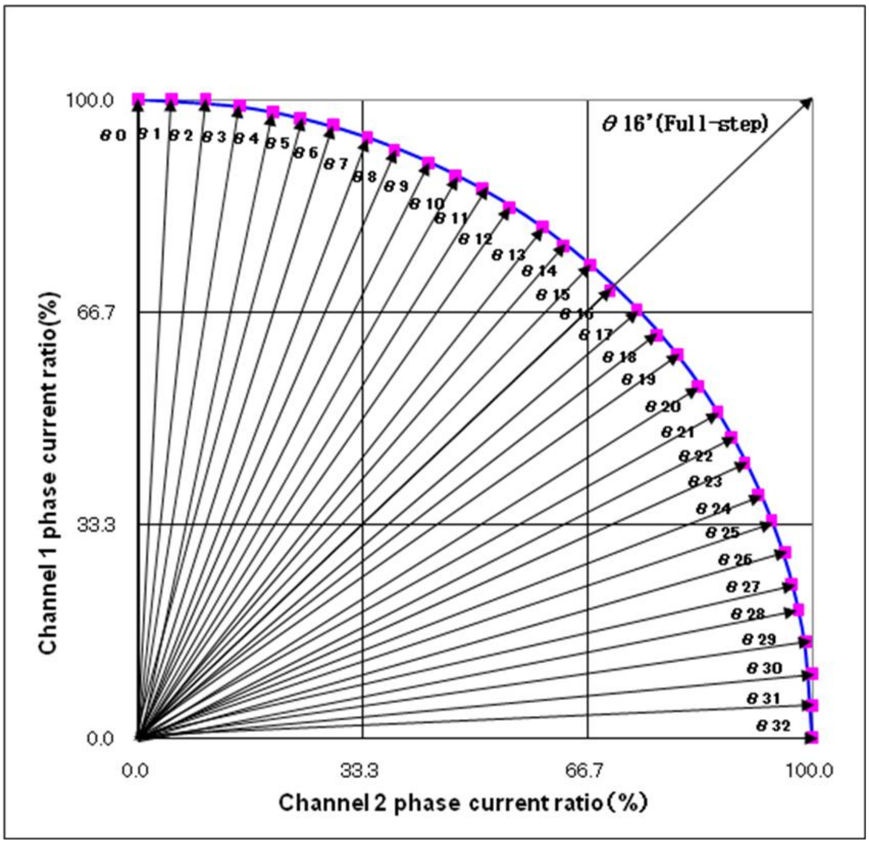


Figure 25.Output current vector

Setting current ration in each Microstepping mode

STEP	LV8713T selectable				LV8712T selectable				LV8712T/LV8713T selectable			
	1/32 Step		1/16 Step		1/8 Step		Quarter Step		Half Step		Full Step	
	Ch- 1 (%)	Ch- 2 (%)	Ch- 1 (%)	Ch- 2 (%)	Ch- 1 (%)	Ch- 2 (%)	Ch- 1 (%)	Ch- 2 (%)	Ch- 1 (%)	Ch- 2 (%)	Ch- 1 (%)	Ch- 2 (%)
θ0	100	0	100	0	100	0	100	0	100	0		
θ1	100	5										
θ2	100	10	100	10								
θ3	99	15										
θ4	98	20	98	20	98	20						
θ5	97	24										
θ6	96	29	96	29								
θ7	94	34										
θ8	92	38	92	38	92	38	92	38				
θ9	90	43										
θ10	88	47	88	47								
θ11	86	51										
θ12	83	55	83	55	83	55						
θ13	80	60										
θ14	77	63	77	63								
θ15	74	67										
θ16	70	70	70	70	70	70	70	70	70	70	100	100
θ17	67	74										
θ18	63	77	63	77								
θ19	60	80										
θ20	55	83	55	83	55	83						
θ21	51	86										
θ22	47	88	47	88								
θ23	43	90										
θ24	38	92	38	92	38	92	38	92				
θ25	34	94										
θ26	29	96	29	96								
θ27	24	97										
θ28	20	98	20	98	20	98						
θ29	15	99										
θ30	10	100	10	100								
θ31	5	100										
θ32	0	100	0	100	0	100	0	100	0	100		

13. Typical current waveform in each excitation mode

Figure 26. Full-Step resolution (FR="Low")

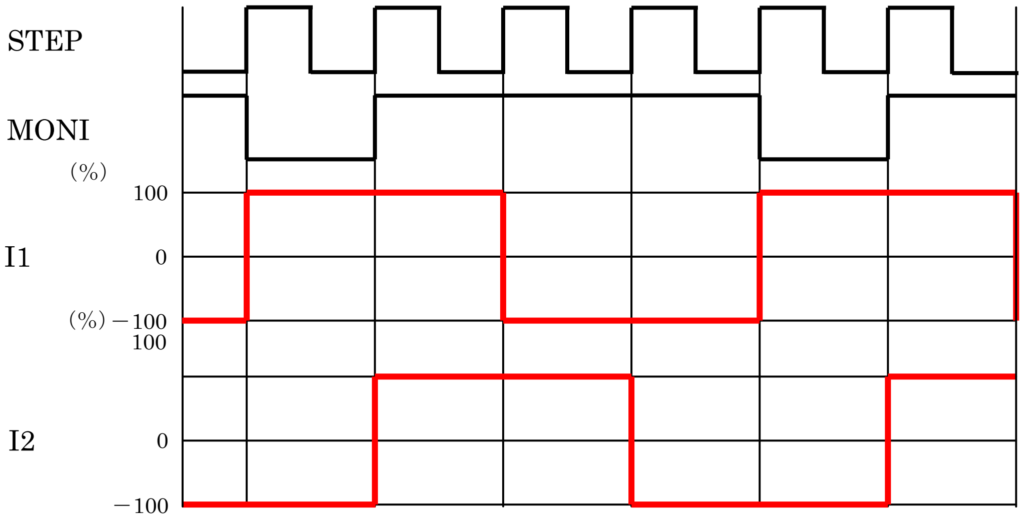


Figure 27. Half-Step resolution (FR="Low")

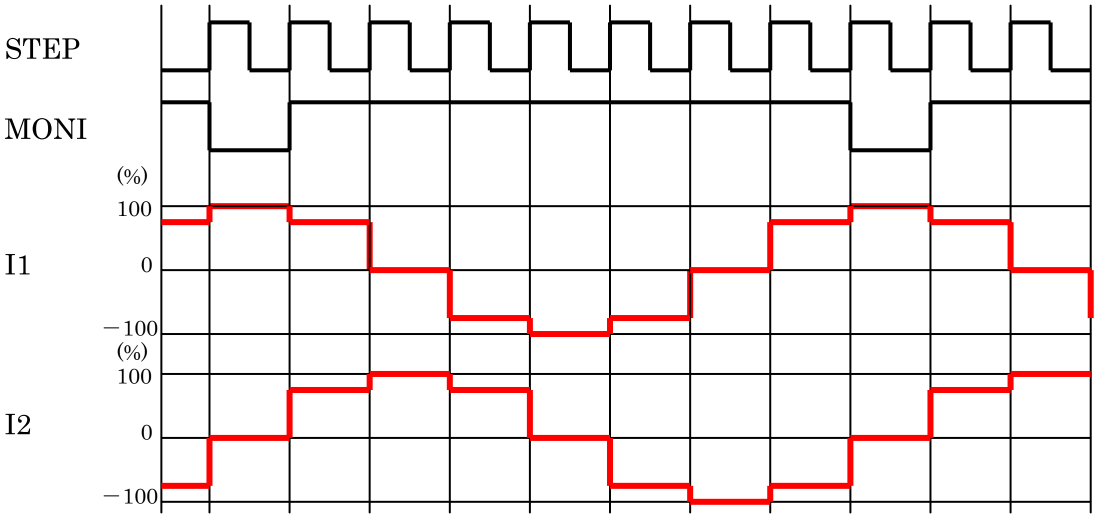


Figure 28. Quarter-Step resolution (FR="Low") (LV8712T)

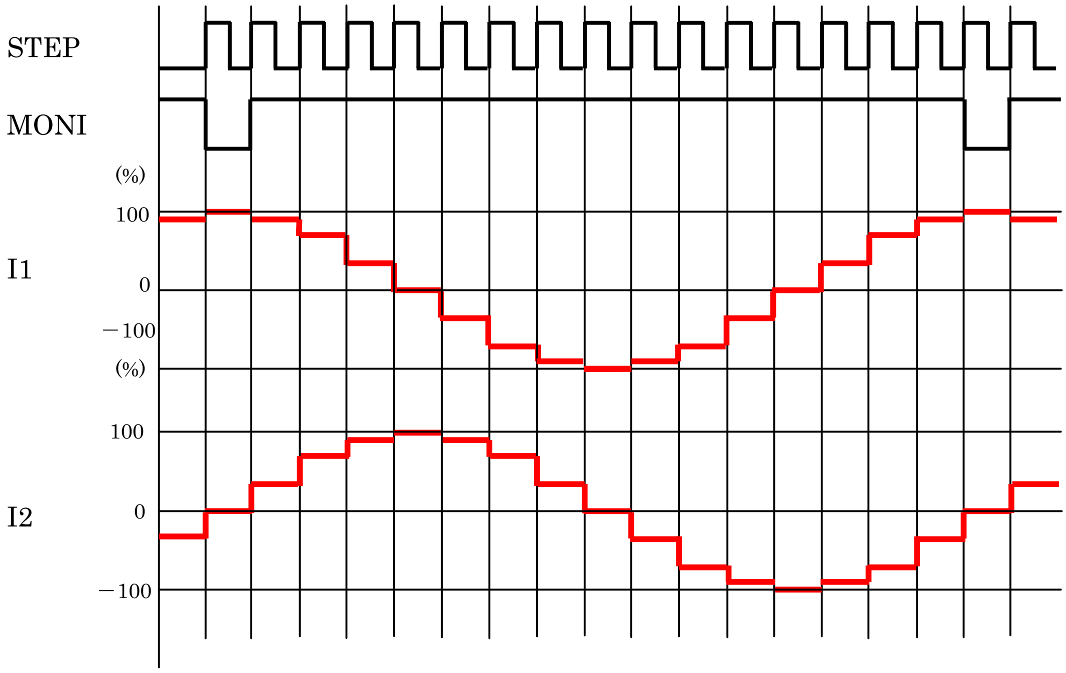


Figure 29. 1/8-Step resolution (FR="Low") (LV8712T)

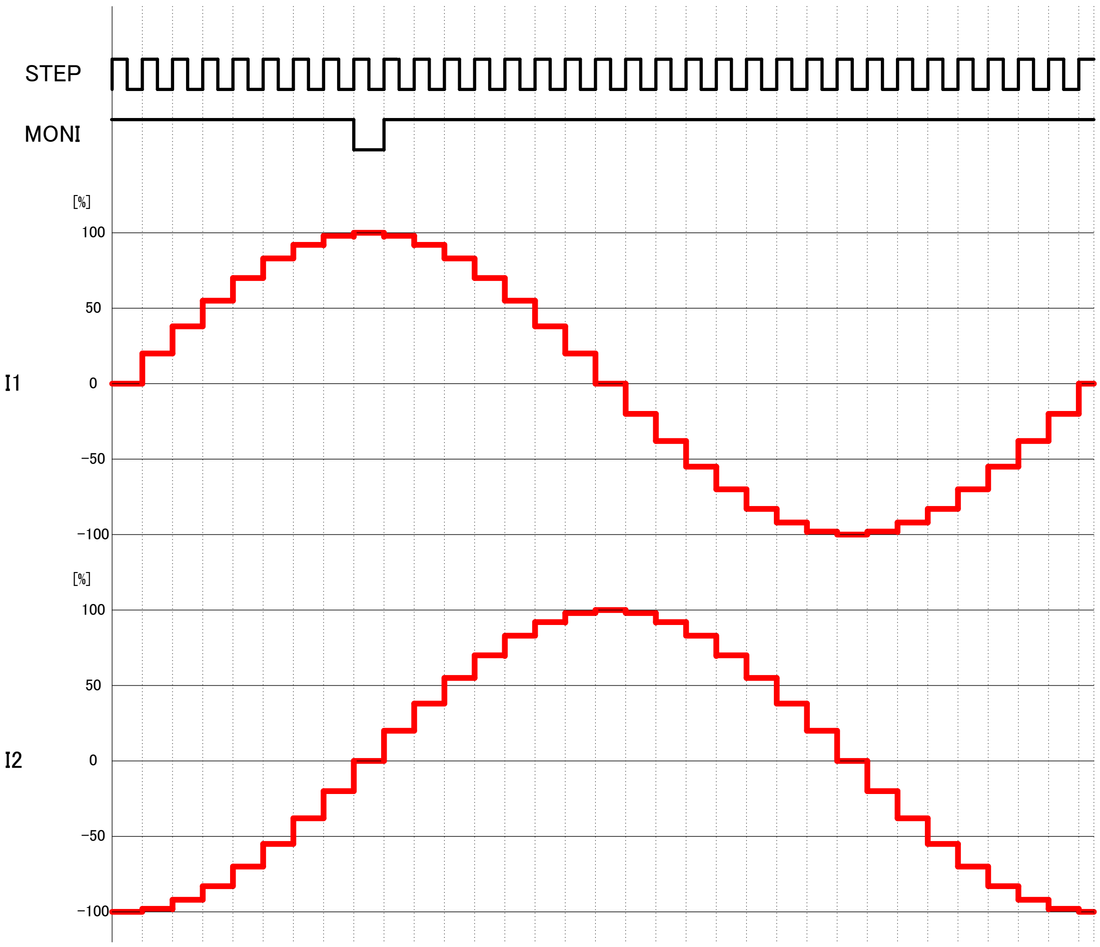


Figure 30. 1/16-Step resolution (FR="Low") (LV8713T)

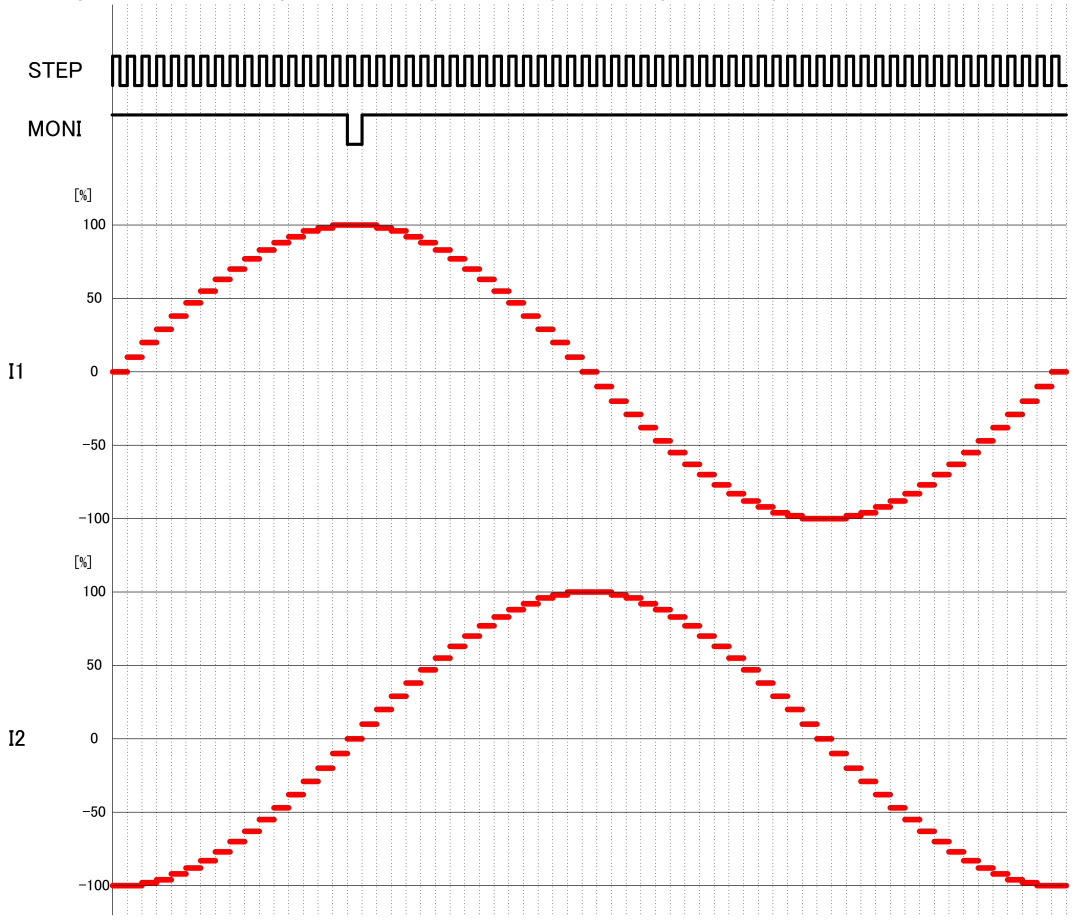
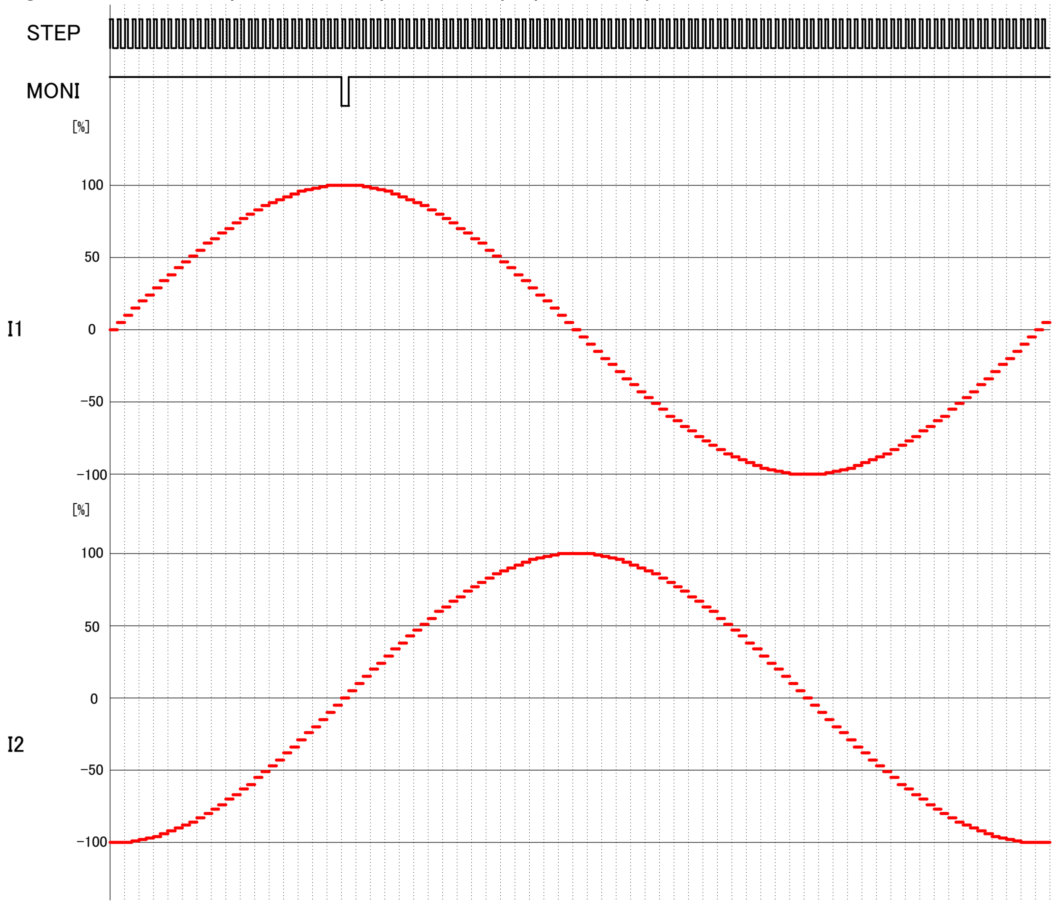
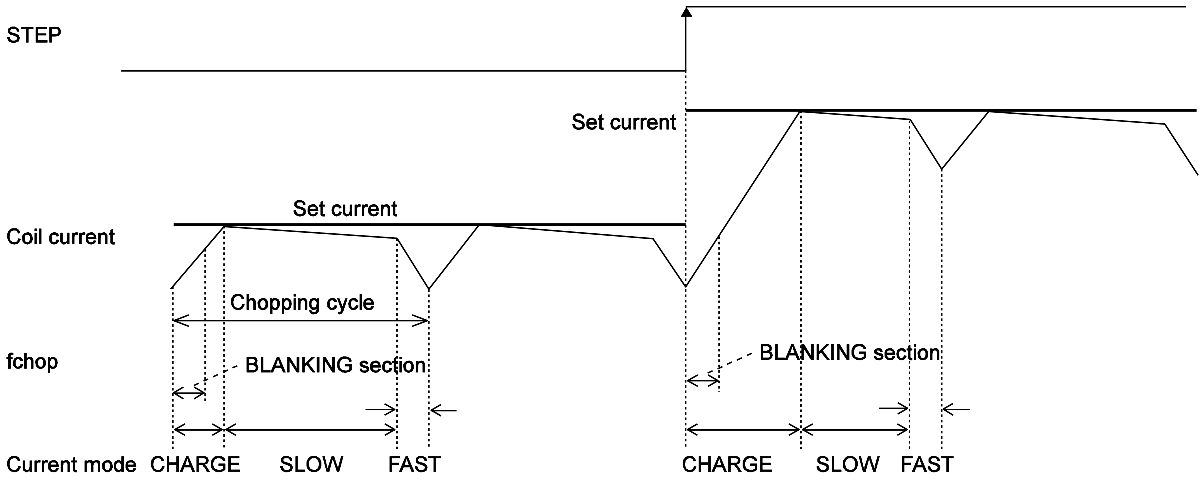


Figure 31. 1/32-Step resolution (FR="Low") (LV8713T)



14. Constant Current control (Chopping operation)

(Sine wave increasing direction)



(Sine wave decreasing direction)

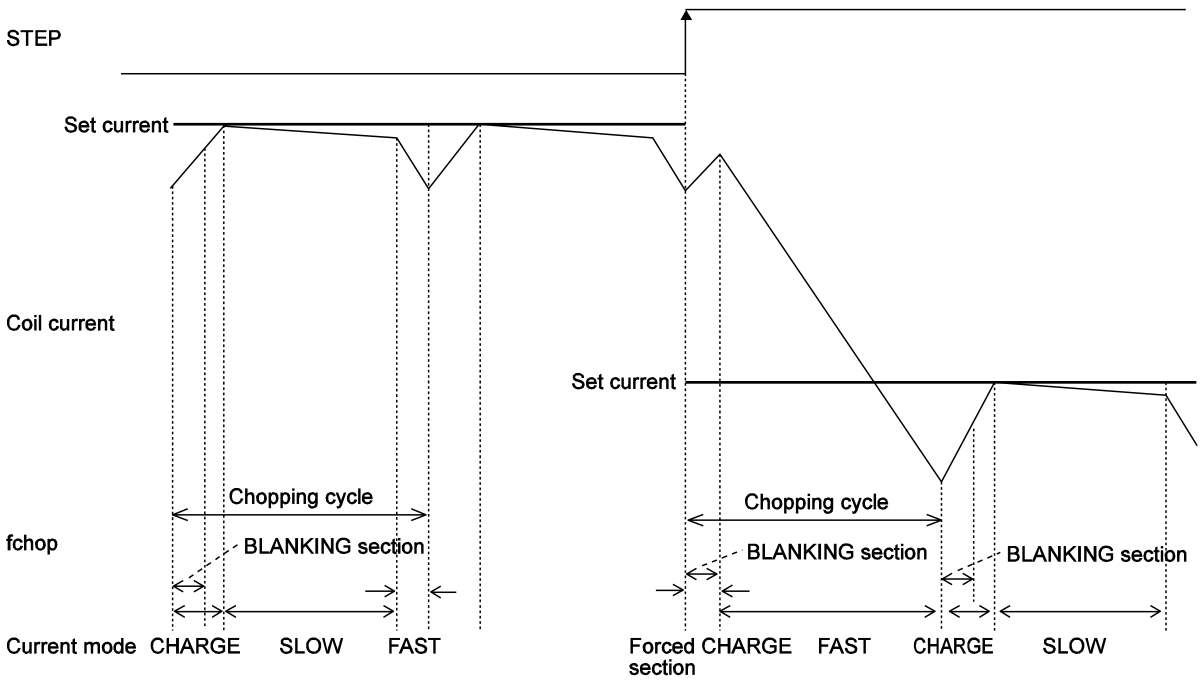


Figure 32. Constant current control timing chart

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

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

Above operations are repeated. Normally, the SLOW (+FAST) DECAY mode continues in the 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

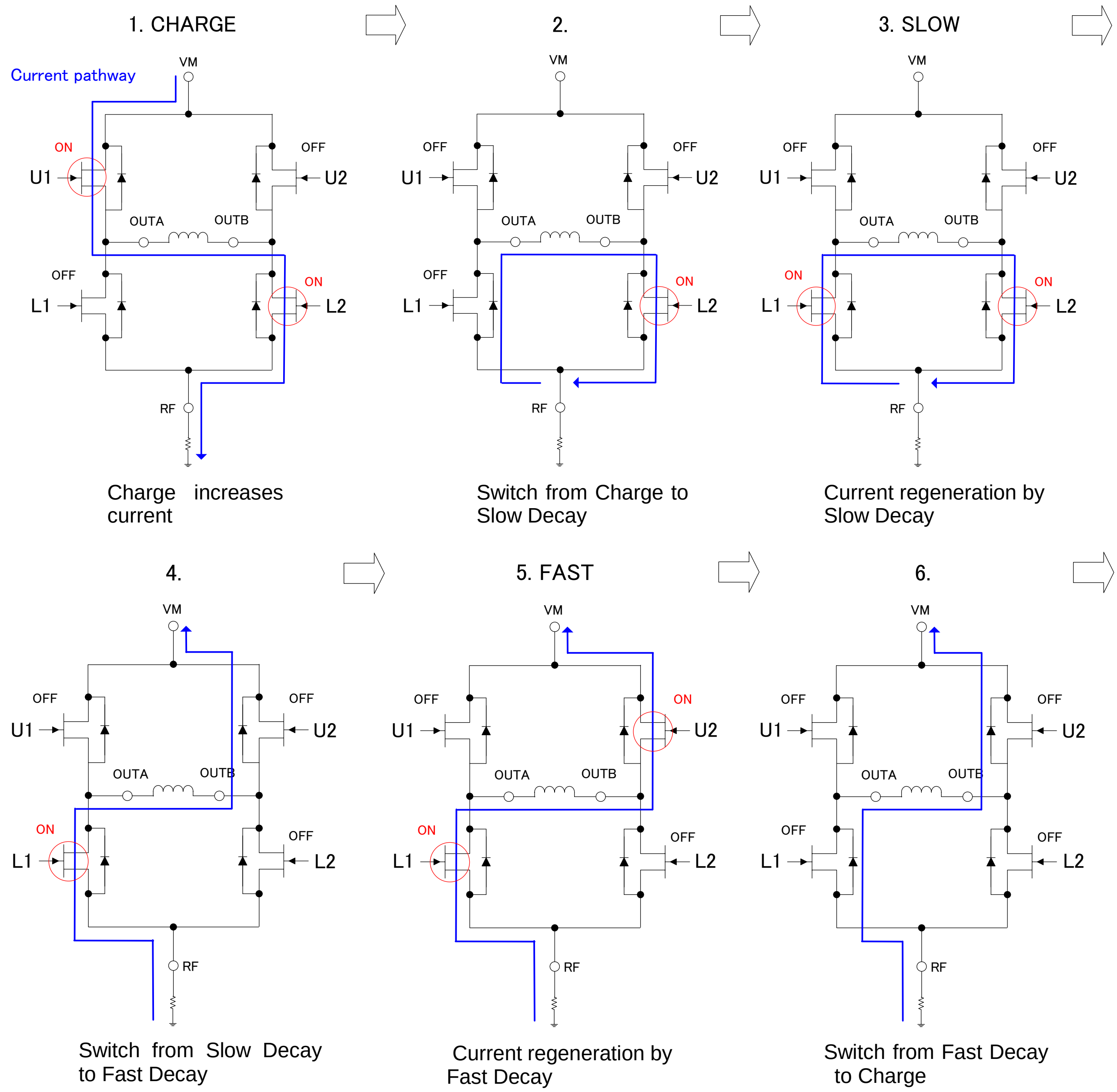


Figure 33 . Output transistor operation sequence

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

Output FET control function

OUTA→OUTB (CHARGE)

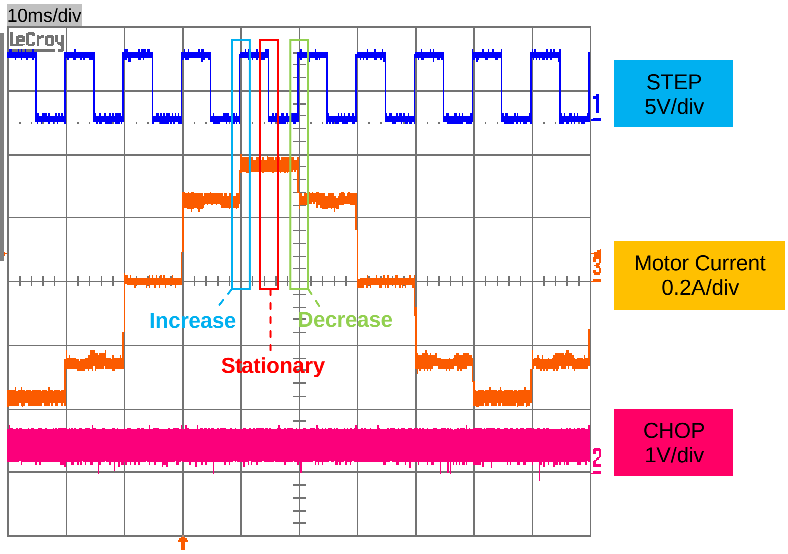
Output Tr	CHARGE	SLOW	FAST
U1	ON	OFF	OFF
U2	OFF	OFF	ON
L1	OFF	ON	ON
L2	ON	ON	OFF

OUTB→OUTA (CHARGE)

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

Figure 34.Constant current control waveform [LV8713T]

Vcc=5V, VM=12V
VREF=1V, RNF=0.51Ω, Cchop=220pF
PS=High, RST=High, ATT1=ATT2=Low
MD1=High, MD2=Low, fSTEP=100Hz



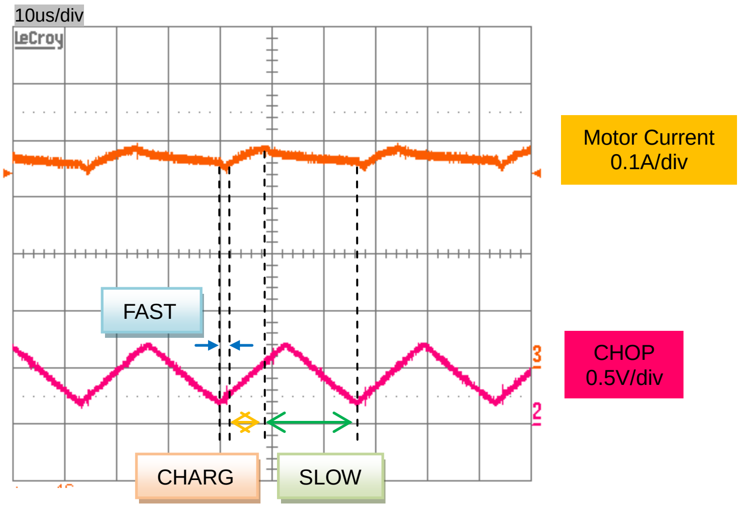
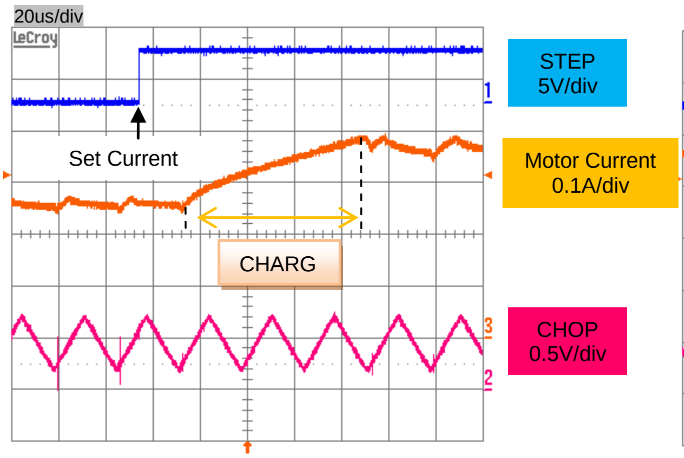


Figure 35. Constant current control waveform (Stationary state)

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



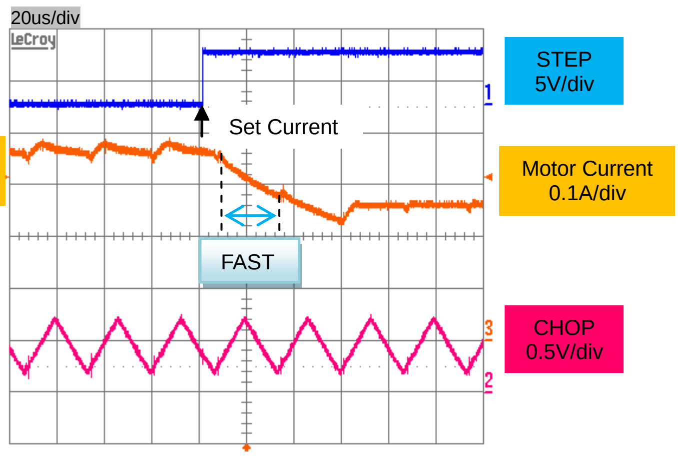


Figure 36. Constant current control waveform (Increasing direction)

Figure 37. Constant current control waveform (Decreasing direction)

16. Blanking time

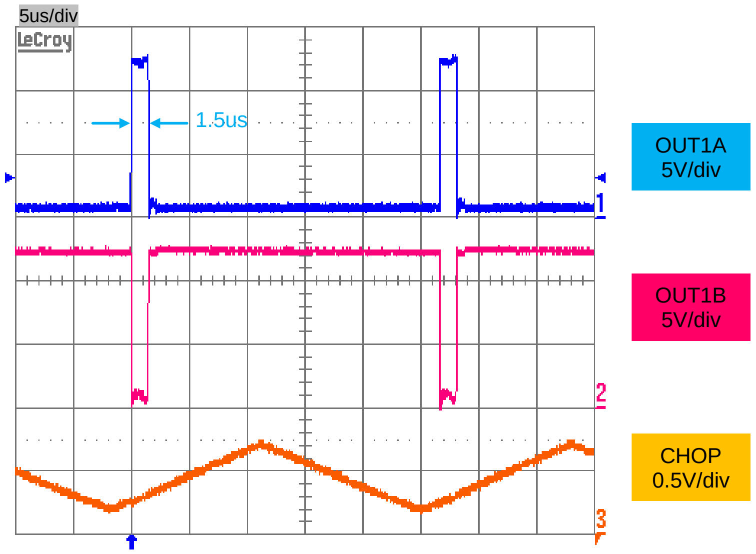
If, when exercising PWM constant-current chopping control over the motor current, the mode is switched from decay to charge, the recovery current of the parasitic diode may flow to the current sensing resistance, causing noise to be carried on the current sensing resistance pin, and this may result in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

The blanking time, tBLANK (μs), is approximately

tBLANK≈1μs

Figure 38.Blanking time waveform
[LV8713T]

Vcc=5V, VM=12V
VREF=5V, RNF=1V, CCHOP=220pF
PS=High,



From the above Fig. , the blanking time appears to be 1.5μs. However, since the mode shifts from charge (blanking time), OFF, to DECAY, the actual blanking time is obtained as follows:
Blanking time=1μs + OFF zone = 0.5μs

17. Microstepping mode switching operation

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

FR＝“Low”

Before the Microstepping mode changes		Position after the Microstepping mode is changed					
Microstepping mode	Step angle	1/32 Step	1/16 Step	1/8 Step	Quarter Step	Half Step	Full Step
1/32 Step Resolution	θ0-θ1		θ2	θ4	θ8	θ16	θ16’
	θ2-θ3		θ4	θ4	θ8	θ16	θ16’
	θ4-θ5		θ6	θ8	θ8	θ16	θ16’
	θ6-θ7		θ8	θ8	θ8	θ16	θ16’
	θ8-θ9		θ10	θ12	θ16	θ16	θ16’
	θ10-θ11		θ12	θ12	θ16	θ16	θ16’
	θ12-θ13		θ14	θ16	θ16	θ16	θ16’
	θ14-θ15		θ16	θ16	θ16	θ16	θ16’
	θ16-θ17		θ18	θ20	θ24	θ32	θ16’
	θ18-θ19		θ20	θ20	θ24	θ32	θ16’
	θ20-θ21		θ22	θ24	θ24	θ32	θ16’
	θ22-θ23		θ24	θ24	θ24	θ32	θ16’
	θ24-θ25		θ26	θ28	θ32	θ32	θ16’
	θ26-θ27		θ28	θ28	θ32	θ32	θ16’
	θ28-θ29		θ30	θ32	θ32	θ32	θ16’
	θ30-θ31		θ32	θ32	θ32	θ32	θ16’
	θ32		-θ30	-θ28	-θ24	-θ16	-θ16’
1/16 Step Resolution	θ0	θ1		θ4	θ8	θ16	θ16’
	θ2	θ3		θ4	θ8	θ16	θ16’
	θ4	θ5		θ8	θ8	θ16	θ16’
	θ6	θ7		θ8	θ8	θ16	θ16’
	θ8	θ9		θ12	θ16	θ16	θ16’
	θ10	θ11		θ12	θ16	θ16	θ16’
	θ12	θ13		θ16	θ16	θ16	θ16’
	θ14	θ15		θ16	θ16	θ16	θ16’
	θ16	θ17		θ20	θ24	θ32	θ16’
	θ18	θ19		θ20	θ24	θ32	θ16’
	θ20	θ21		θ24	θ24	θ32	θ16’
	θ22	θ23		θ24	θ24	θ32	θ16’
	θ24	θ25		θ28	θ32	θ32	θ16’
	θ26	θ27		θ28	θ32	θ32	θ16’
	θ28	θ29		θ32	θ32	θ32	θ16’
	θ30	θ31		θ32	θ32	θ32	θ16’
	θ32	-θ31		-θ28	-θ24	-θ16	-θ16’
1/8 Step Resolution	θ0	θ1	θ2		θ8	θ16	θ16’
	θ4	θ5	θ6		θ8	θ16	θ16’
	θ8	θ9	θ10		θ16	θ16	θ16’
	θ12	θ13	θ14		θ16	θ16	θ16’
	θ16	θ17	θ18		θ24	θ32	θ16’
	θ20	θ21	θ22		θ24	θ32	θ16’
	θ24	θ25	θ26		θ32	θ32	θ16’
	θ28	θ29	θ30		θ32	θ32	θ16’
	θ32	-θ31	-θ30		-θ24	-θ16	-θ16’
Quarter Step Resolution	θ0	θ1	θ2	θ4		θ16	θ16’
	θ8	θ9	θ10	θ12		θ16	θ16’
	θ16	θ17	θ18	θ20		θ32	θ16’
	θ24	θ25	θ26	θ28		θ32	θ16’
	θ32	-θ31	-θ30	-θ28		-θ16	-θ16’
Half Step Resolution	θ0	θ1	θ2	θ4	θ8		θ16’
	θ16	θ17	θ18	θ20	θ24		θ16’
	θ32	-θ31	-θ30	-θ28	-θ24		-θ16’
Full Step Resolution	θ16’	θ17	θ18	θ20	θ24	θ32	

*As for θ0 to θ32, please refer to the step position of current ratio setting.

If you switch Microstepping mode while the motor is driving, the mode setting will be reflected from the next STEP and the motor advances to the position shown in the following.

(a) Microstepping (1/32-,1/16-,1/8-,Quarter-.Half-step) → Microstepping (1/32-,1/16-,1/8-,Quarter-.Half-step)

When a microstepping switches to the next microstepping, the excitation position is switched to the next corresponding step angle of the next microstepping mode.

e.g.) When the rotation direction is forward at 1/16-step (θ6) and if you switch to 1/8 step, the step angle is set to θ8 at the next step.
When the rotation direction is forward at 1/16-step (θ20) and if you switch to 1/8 step, the step angle is set to θ24 at the next step.

(b) Microstepping (1/32-,1/16-,1/8-,Quarter-.Half-step) → Full-step

When a microstepping switches to the full-step, the excitation position is switched to full-step angle of the present quadrant. Caution is required when switching from θ16 or higher step angle of microstepping position to full-step.

e.g.) When the rotation direction is forward at 1/8 step (θ8) and if you switch to full-step, the step angle is set to θ16' at the next step.
When the rotation direction is forward at 1/8 step (θ16) and if you switch to full-step, the step angle is set to θ16' at the next step. (the electric angle is the same but the absolute value changes)
When the rotation direction is forward at 1/8 step (θ24) (the electric angle returns and the absolute value changes)

(c) Full-step → Microstepping (1/32-,1/16-,1/8-,Quarter-.Half-step)

When full step switches to microstepping, the excitation position is switched to the next corresponding step angle.

e.g.) When the rotation direction is forward at Full step (θ16') and if you switch to 1/8 step, the step angle is set to θ20 at the next step.

Microstep mode switching operation
[LV8712T]
Vcc=5V, VM=12V
VREF=1V,RNF=0.51Ω
PS=High, RST=High, fSTEP=100Hz

Figure 39
Microstepping (1/8step) → Microstepping (quarter step)
MD2=High

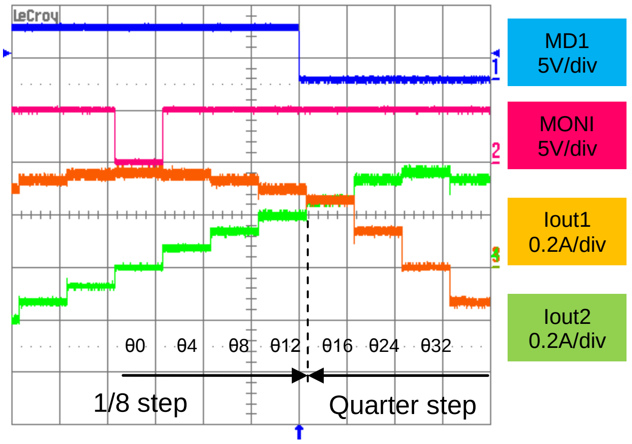


Figure 40.
Microstepping (Half-step) → Microstepping (1/8 step)
MD1=High

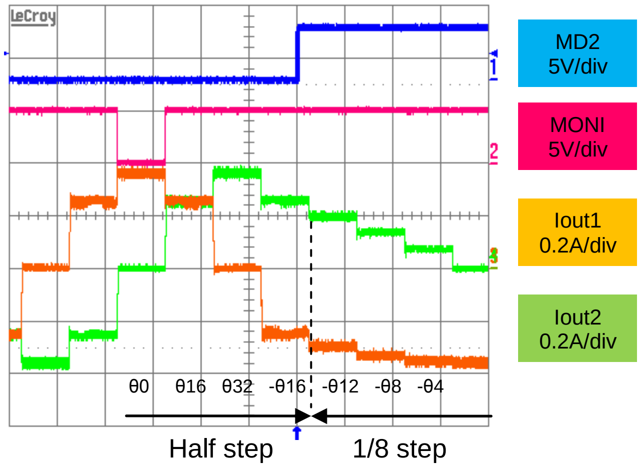


Figure 41
Microstepping (quarter step) → Full step
MD1=Low

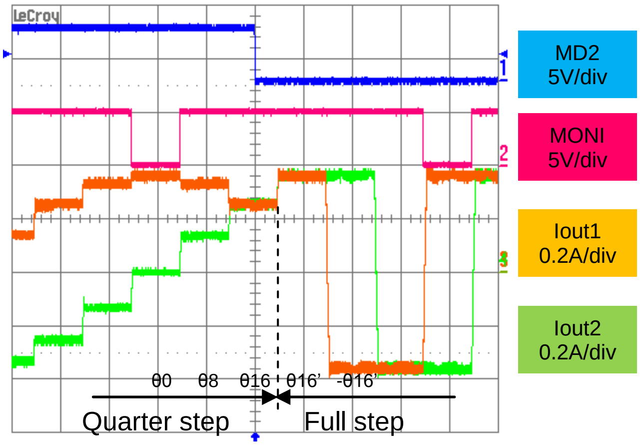
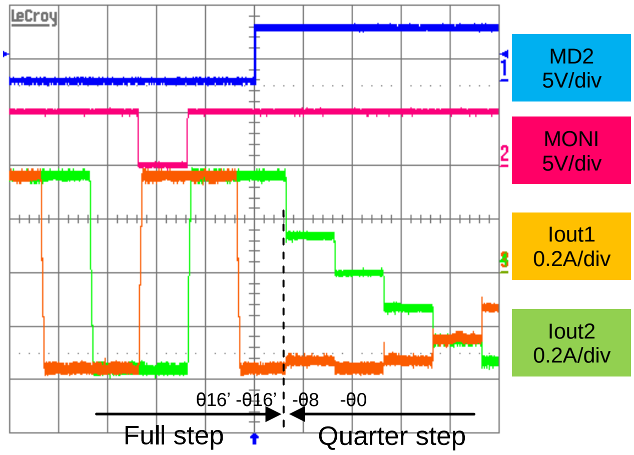


Figure 42.
Full step → Microstepping (quarter step)
MD1=Low

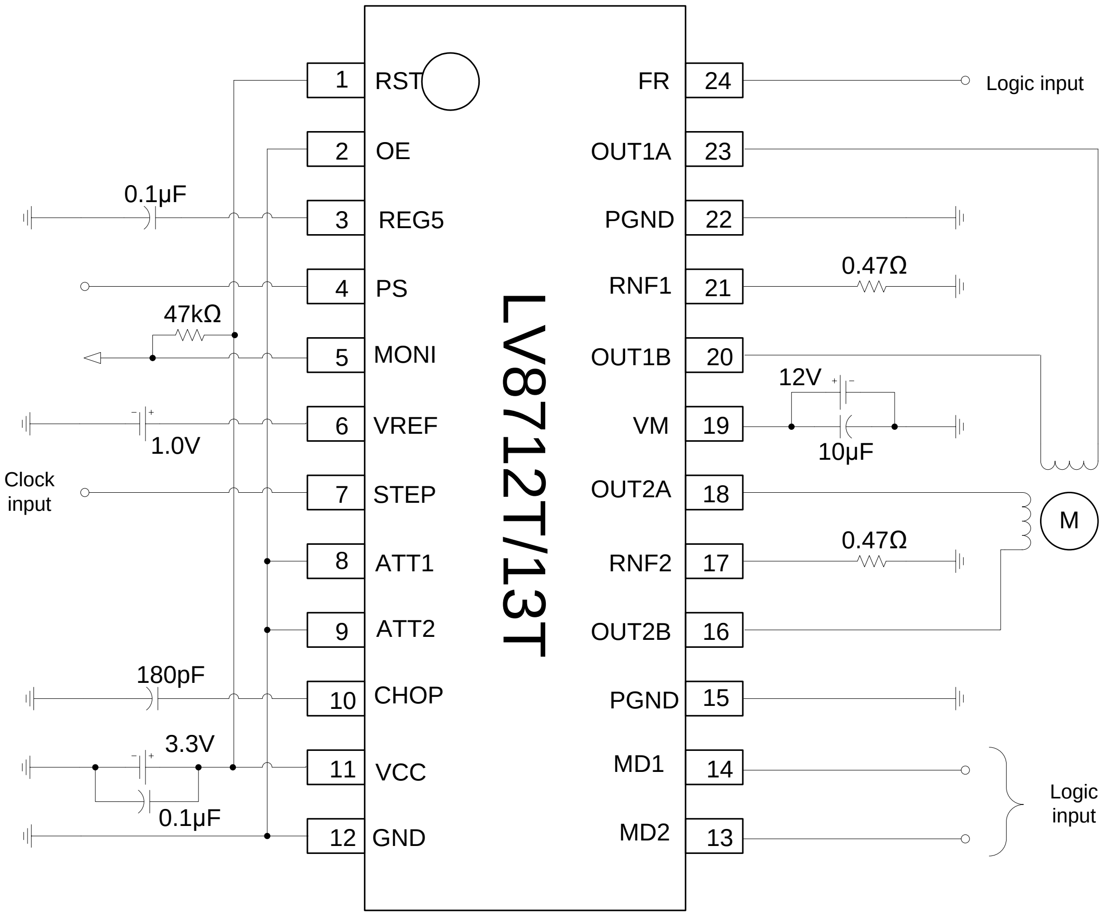


Thermal shutdown function

The thermal shutdown circuit is incorporated and the output is turned off when junction temperature Tj 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 Tjmax=150°C.

TSD = 180°C (typ)
ΔTSD = 40°C (typ)

Application Circuit Example



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

Constant current (100%) setting

When VREF = 1.0V

I_{OUT} = VREF/5/RNF resistance

= 1.0V/5/0.47Ω = 0.426A

Chopping frequency setting

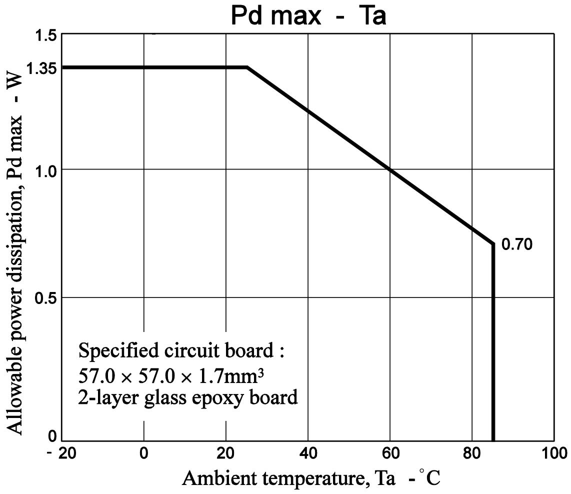
Fchop = Ichop/ (Cchop × Vtchop × 2)

= 10μA/ (180pF × 0.5V × 2) = 55 kHz

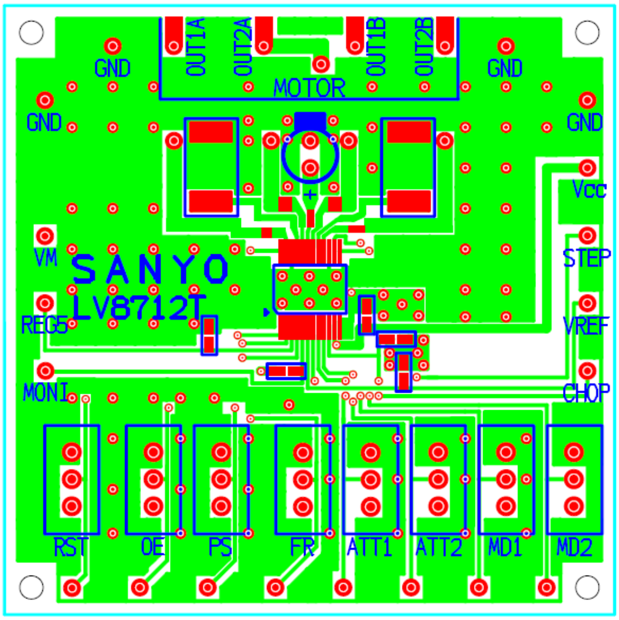
Allowable power dissipation

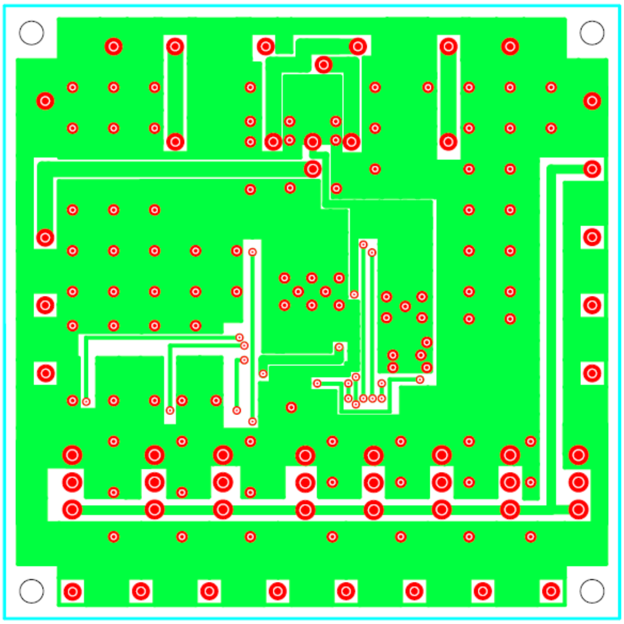
Evaluation board

Size: 57mm x 57mm x 1.7mm, glass epoxy 2-layer board



Evaluation board Design Diagram





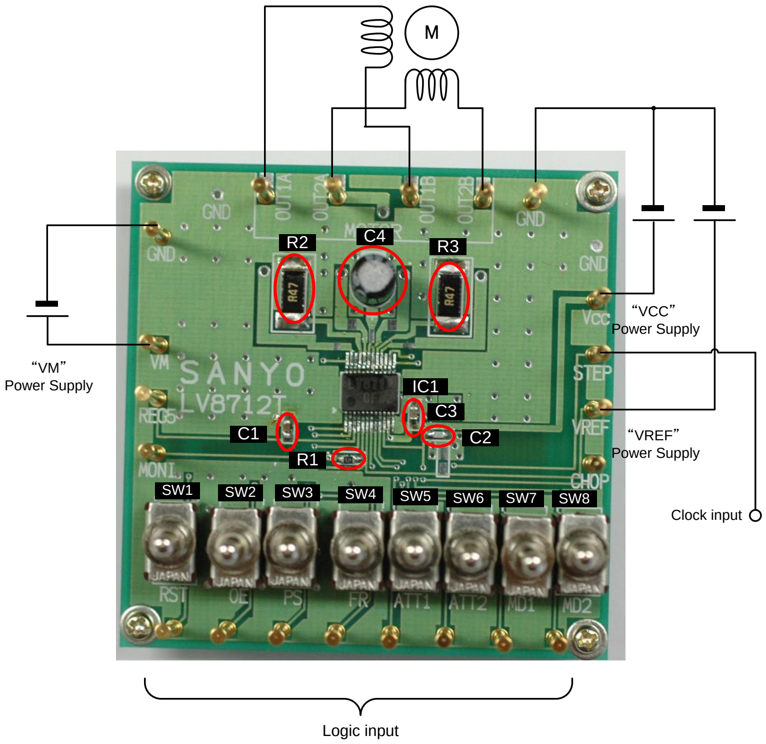
TOP View

Evaluation board

1. Completed PCB with Devices

The evaluation board of LV8712T and LV8713T is common.

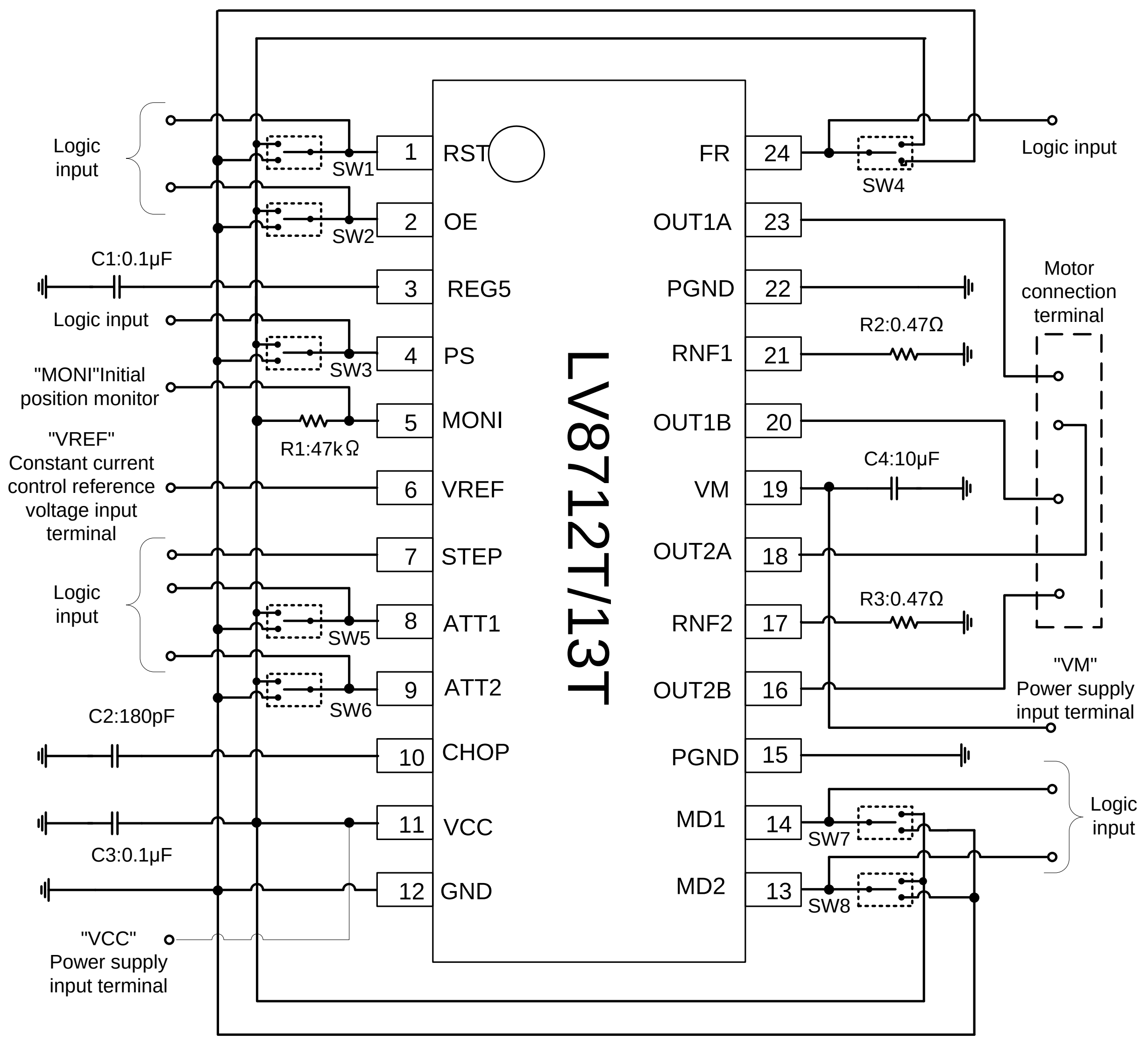
PCB size: 57mm×57mm×1.7mm, glass epoxy 2-layer board



2.Bill of Materials for LV8712T/13T Evaluation Board

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
C1	1	REG5 stabilization Capacitor	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C2	1	Capacitor to set chopping frequency	180pF, 50V	±5%		Murata	GRM1882C1H181JA01*	Yes	Yes
C3	1	VCC Bypass Capacitor	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C4	1	VM Bypass Capacitor	10μF, 50V	±20%		SUN Electronic Industries	50ME10HC	Yes	Yes
R1	1	Pull-up Resistor for for pin MONI	47kΩ, 1/10W	±5%		KOA	RK73B1JT**473J	Yes	Yes
R2	1	Channel 1 output current detective Resistor	0.47Ω, 1W	±5%		ROHM	MCR100JZHJLR47	Yes	Yes
R3	1	Channel 2 output current detective Resistor	0.47Ω, 1W	±5%		ROHM	MCR100JZHJLR47	Yes	Yes
IC1	1	Motor Driver			TSSOP24 (225mil)	SANYO semiconductor	LV8712T LV8713T	No	Yes
SW1-SW8	8	Switch				MIYAMA ELECTRIC	MS-621C-A01	Yes	Yes
TP1-TP21	21	Test Point				MAC8	ST-1-3	Yes	Yes

3.Evaluation board circuit



4.Evaluation Board Manual

[Supply Voltage]
VM (4 to 16V): Motor Power Supply
VCC (2.7 to 5.5V): Control Power Supply
VREF (0 to VCC-1.8V): 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]

1. **Initial Condition Setting:** Set “Open or Low” all 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 PS pin toggle switch. Channel 1 and 2 are into full-step excitement initial position (100%, -100%) .
5. **Motor Operation:** Turn “High” the RST pin toggle switch. Input the clock signal into the pin STEP.
6. **Other Setting** (See Application Note for detail)
   i. ATT1, ATT2: Motor current attenuation.
   ii. FR: Motor rotation direction (CW / CCW) setting.
   iii. MD1, MD2: Microstepping Resolution.
   iv. OE: Output Enable.

[Setting for External Component Value]

1. Constant Current (100%)

At VREF=1.0V

Iout =VREF [V] / 5 / RNF [ohm]
=1.0 [V] / 5 / 0.47 [ohm]
=0.426 [A]

2. Chopping Frequency

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

5. Evaluation Board waveform (Stepping motor drive)

LV8712T
VM=12V, VCC=5V,VREF=1.0V
PS=High,RST=High
ATT1=ATT2=FR=OE=Low

Figure 43.
Full-step (MD1=MD2=Low, fSTEP=500Hz)

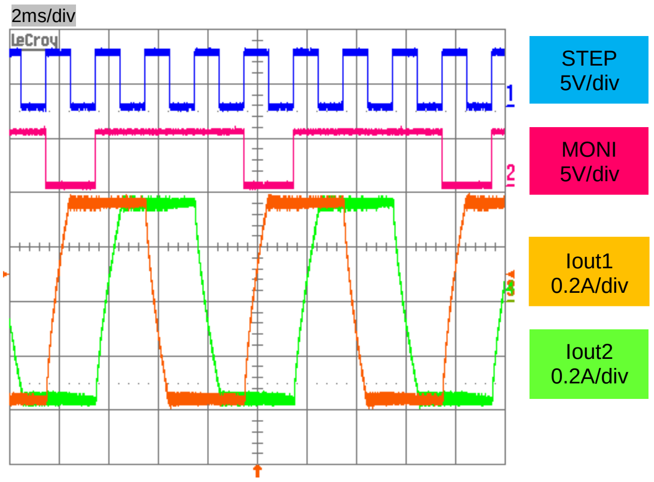


Figure 44.
Half-step (MD1=High, MD2=Low, fSTEP=1 kHz)

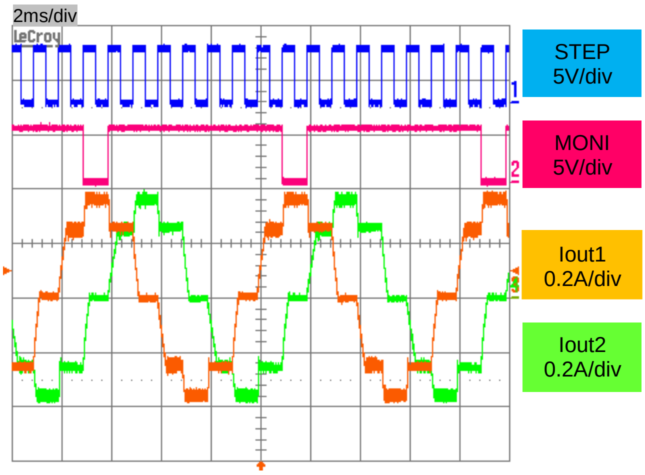


Figure 45.
Quarter-step (MD1=Low,MD2=High, fSTEP=2kHz)

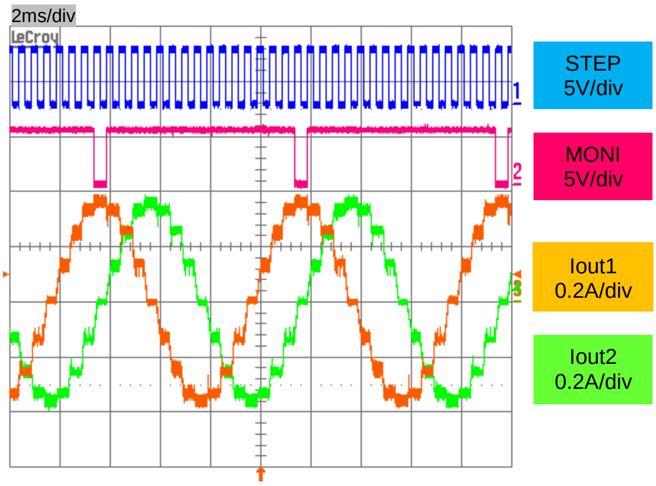
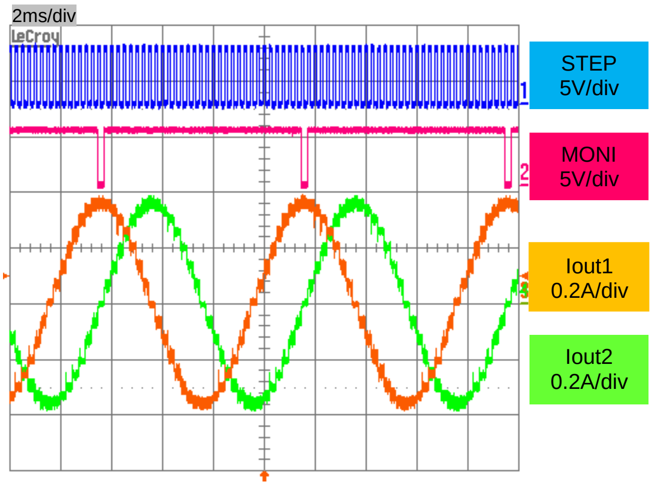


Figure 46.
1/8-step (MD1=MD2=High, fSTEP=4kHz)



LV8713T
VM=12V, VCC=5V, VREF=1.0V
PS=High, RST=High
ATT1=ATT2=FR=OE=Low

Figure 47.
Full-step (MD1=MD2=Low, fSTEP=500Hz)

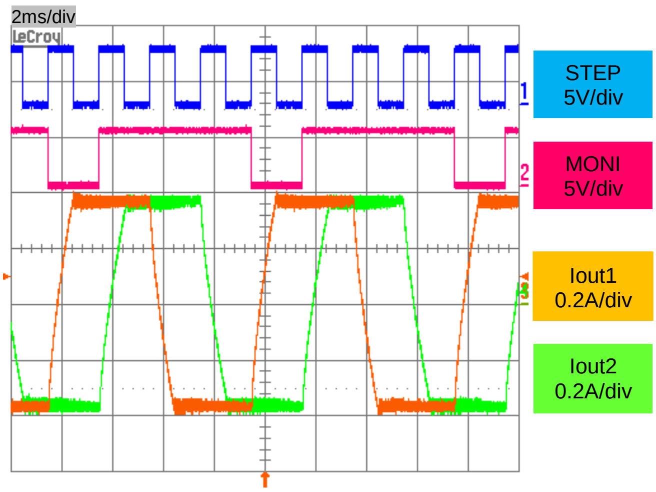


Figure 48
Half-step (MD1=High, MD2=Low, fSTEP=1 kHz)

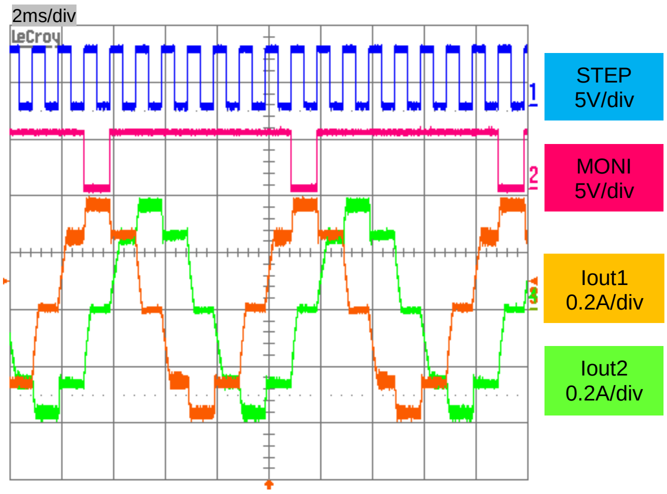


Figure 49.
1/16-step (MD1=Low,MD2=High, fSTEP=8kHz)

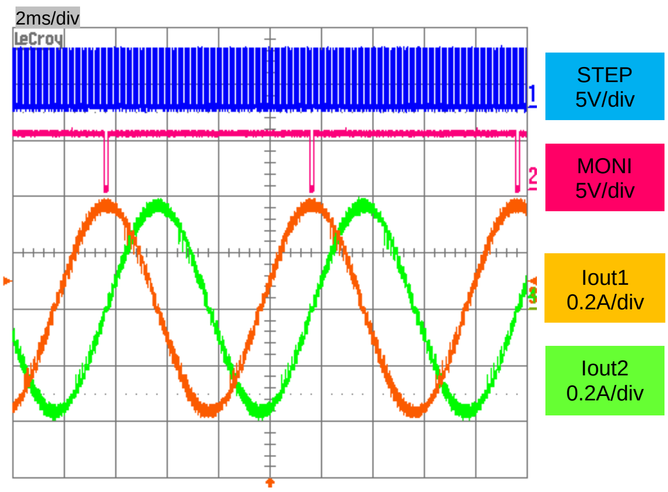
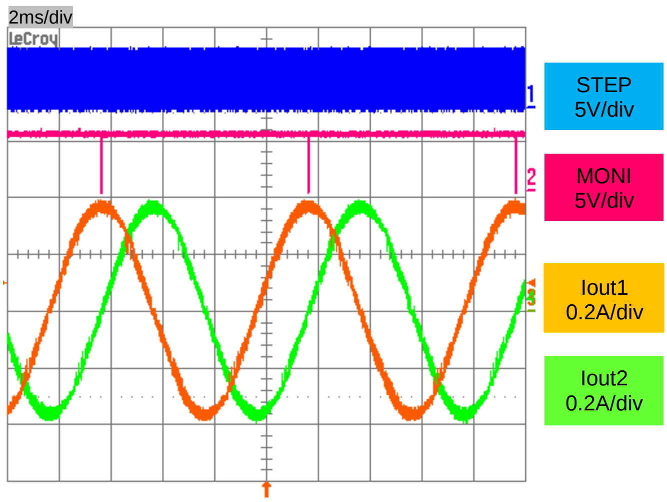


Figure 50.
1/32-step (MD1=MD2=High, fSTEP=16kHz)



Cautions for layout:

●Power supply connection pin【VM】

- ✓ VCC is a control power supply, and VM is a motor power supply.
- ✓ 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 VM supply voltage because this IC performs switching.
- ✓ The bypass capacitor of the VM 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 pin【GND, PGND, RNF-resistor GND line】

- ✓ High current flows into the PGND and GND side of RNF resistor; therefore, connect PGND and RNF – GND independently.
- ✓ On the other hand, since PGND and GND are connected through silicon board, if the line of PGND is too long, difference of electric potential occurs between PGND and GND which creates gradient to the GND electric potential within the IC board. This can be the cause of the IC malfunction. Hence make sure to connect PGND and RNF – GND independently so that the pins do not share the common impedance with GND. And GND, PGND, and RNF should be single-point grounded to the low impedance GND area near the IC. Also the capacitor between VM and GND should be connected adjacent to the IC.

●Internal power supply regulator pin【REG5】

- ✓ REG5 is a power supply to drive output FET (typ 5V).
- ✓ When VM supply is powered and PS is”High”, REG5 operates.
- ✓ Please connect capacitor for stabilize REG5. The recommendation value is 0.1uF.
- ✓ Since the voltage of REG5 fluctuates (±10%), do not use it as reference voltage that requires accuracy.

●Input pin

- ✓ 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.

●OUT pin【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 pin【RNF1, RNF2】

- ✓ To perform constant current control, please connect resistor to RNF pin.
- ✓ To perform saturation drive (without constant current control) , please connect RNF pin to GND.
- ✓ If RNF pin is open, you cannot set constant current under normal condition. Therefore, please connect it to resistor or GND.
- ✓ The motor current flows into RNF – GND line. Therefore, please connect it to common GND line and low impedance line.

This catalog provides information as of June, 2011. Specifications and information herein are subject to change without notice.