Ordering number : ENA1998

LV8727

ON Semiconductor®

http://onsemi.com

Bi-CMOS LSI

PWM Current Control Stepping Motor Driver

Overview

The LV8727 is a PWM current-controlled micro step bipolar stepping motor driver. This driver can do eight ways of micro step resolution of Half, 1/8, 1/16, 1/32, 1/64, 1/128, 1/10, 1/20 Step, and can drive simply by the step input.

Features

- Single-channel PWM current control stepping motor driver.
- Output on-resistance (upper side : 0.25Ω ; lower side : 0.15Ω ; total of upper and lower : 0.4Ω ; Ta = 25°C, I_O = 4.0A)
- Half, 1/8, 1/16, 1/32, 1/64, 1/128, 1/10, 1/20 Step are selectable.
- Advance the excitation step with the only step signal input.
- BiCDMOS process IC.
- I_O max=4.0A
- Input pull down resistance
- Available forward reverse control.
- Thermal shutdown circuit.
- With reset pin and enable pin.

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_M max		50	V
Output current	I_O max		4	A
Output peak current	I_O peak	tw≤10ms, duty 20%	4.6	A
Logic input voltage	V_{IN} max		6	V
VREF input voltage	VREF max		6	V
MO / DOWN pin input voltage	V_{MO} /V_{DOWN} max		6	V
Allowable power dissipation	Pd max	Indipendent IC	2.45	W
Operating temperature	Topr		-30 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

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.

Recommendation Operating Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range	V_M		9 to 45	V
Logic input voltage	V_{IN}		0 to 5	V
VREF input voltage range	VREF		0 to 3	V

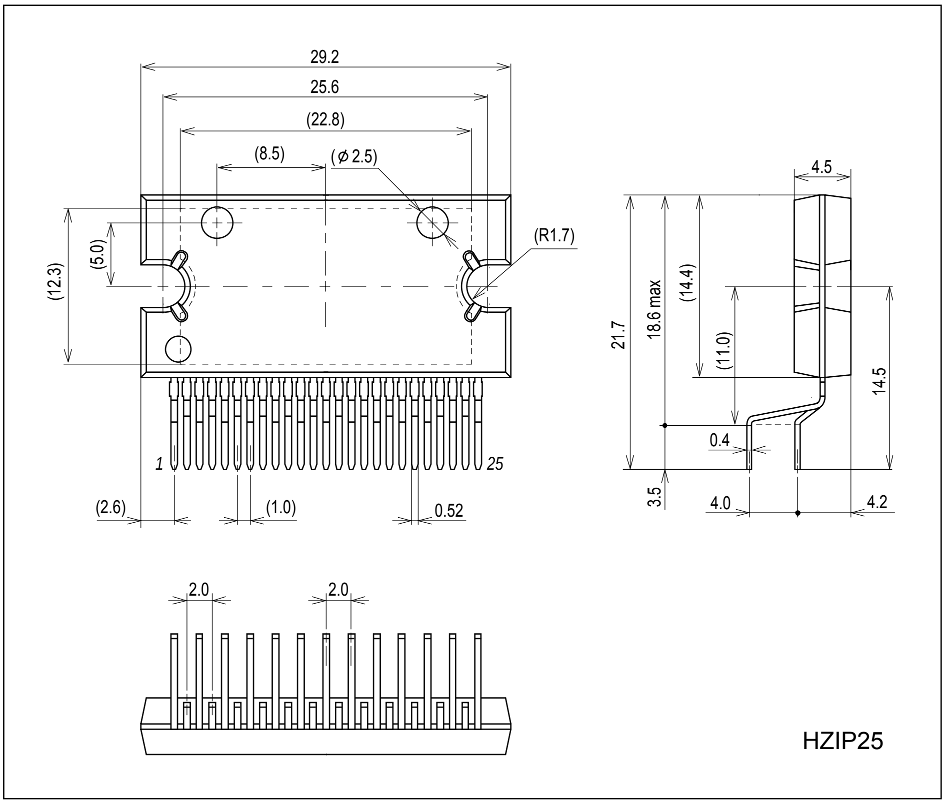
Electrical Characteristics at Ta = 25°C, V_M = 24V, VREF = 1.5V

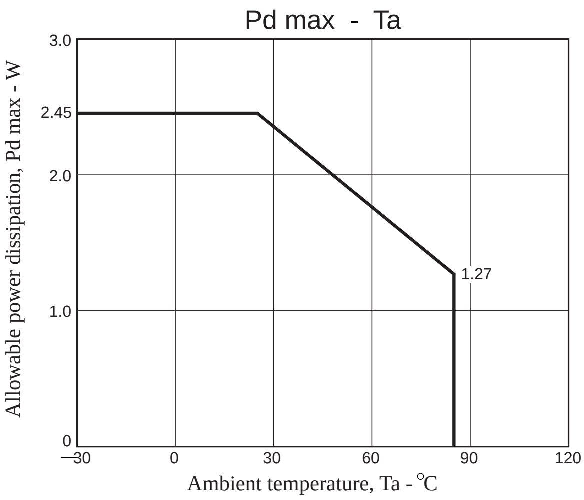
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain	I_Mst	ST = “L”		70	100	μA
Current drain	IM	ST = “H”, OE = “H”, no load		3.5	4.9	mA
Thermal shutdown temperature	TSD	Design guarantee	150	180	200	°C
Thermal hysteresis width	ΔTSD	Design guarantee		40		°C
Logic pin input current	I_{IN}L	V_{IN} = 0.8V	3	8	15	μA
	I_{IN}H	V_{IN} = 5V	30	50	70	μA
Logic high-level input voltage	V_{IN}H		2.0			V
Logic low-level input voltage	V_{IN}L				0.8	V
FDT pin high-level voltage	Vfdth		3.5			V
FDT pin middle-level voltage	Vfdtm		1.1		3.1	V
FDT pin low-level voltage	Vfdtl				0.8	V
Chopping frequency	Fch	Cosc1 = 100pF	70	100	130	kHz
OSC1 pin charge/discharge current	Iosc1		7	10	13	μA
Chopping oscillation circuit threshold voltage	Vtup1		0.8	1	1.2	V
	Vtdown1		0.3	0.5	0.7	V
VREF pin input voltage	Iref	VREF = 1.5V	-0.5			μA
DOWN output residual voltagr	V_O1DOWN	Idown = 1mA		50	200	mV
MO pin residual voltage	V_O1MO	Imo = 1mA		50	200	mV
Hold current switching frequency	Fdown	Cosc2 = 1500pF	1.12	1.6	2.08	Hz
OSC2 pin charge/discharge current	Iosc2		7	10	13	μA
Hold current switching frequency threshold voltage	Vtup2		0.8	1	1.2	V
	Vtdown2		0.3	0.5	0.7	V
Output on-resistance	Ronu	I_O = 4.0A, high-side ON resistance		0.25	0.325	Ω
	Rond	I_O = 4.0A, low-side ON resistance		0.15	0.195	Ω
Output leakage current	$I_O$leak	V_M = 50V			50	μA
Diode forward voltage	VD	I_D = -4.0A		1	1.3	V
Current setting reference voltage	VRF	VREF = 1.5V, Current ratio 100%	0.485	0.5	0.515	V

Package Dimensions

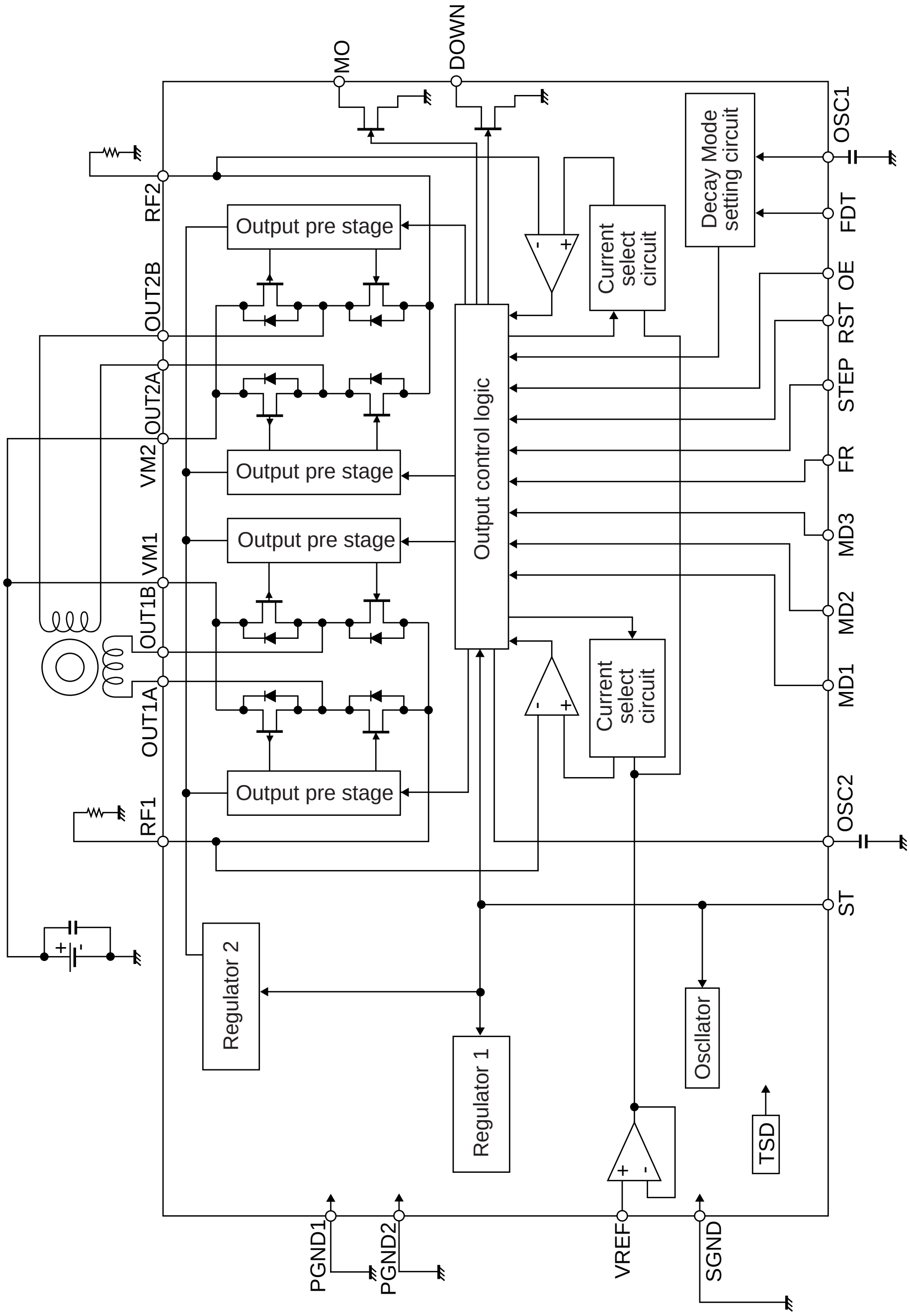
unit : mm (typ)

3236A

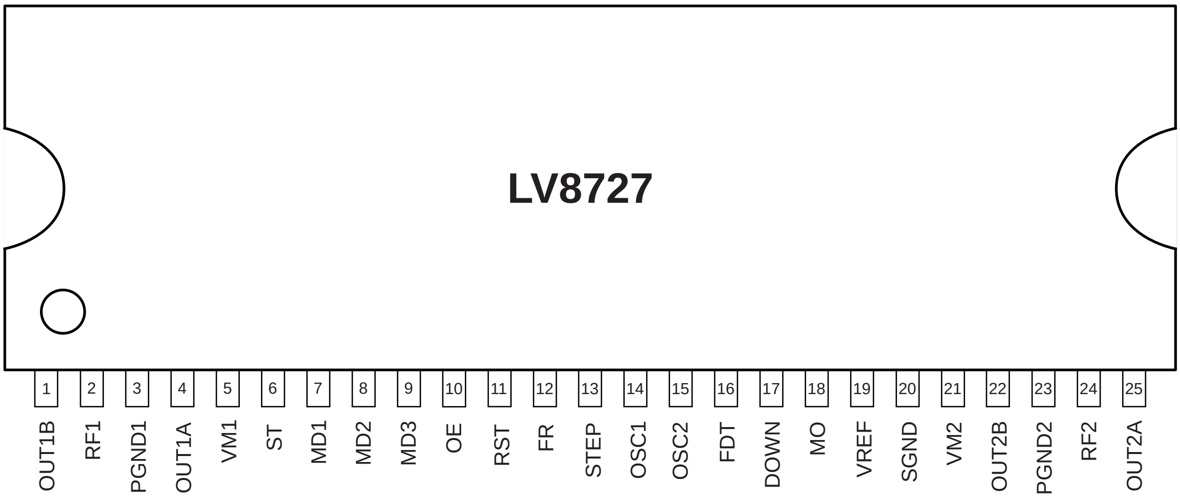




Block Diagram

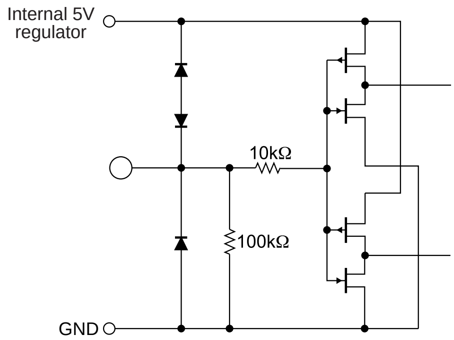
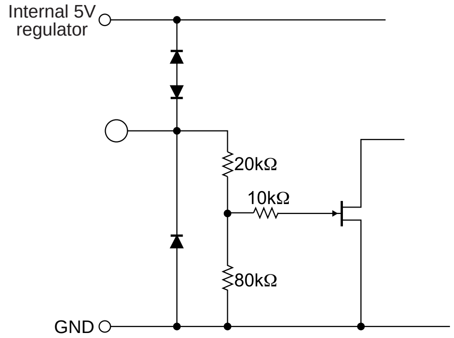
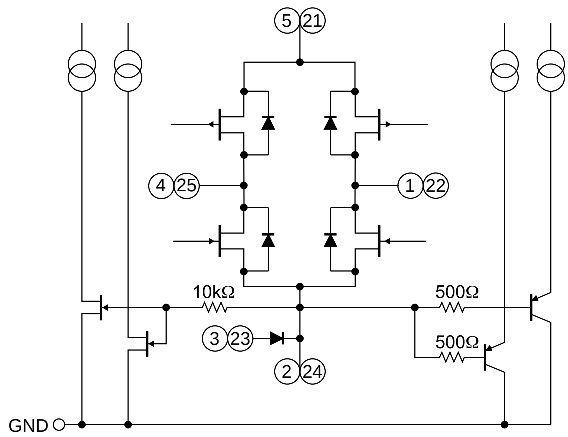


Pin Assignment



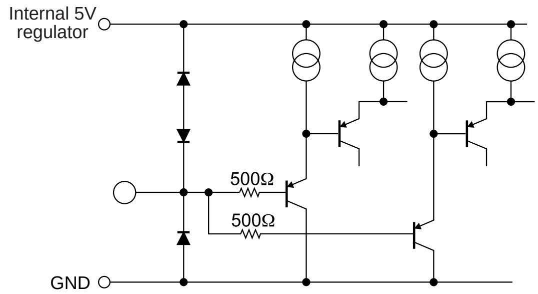
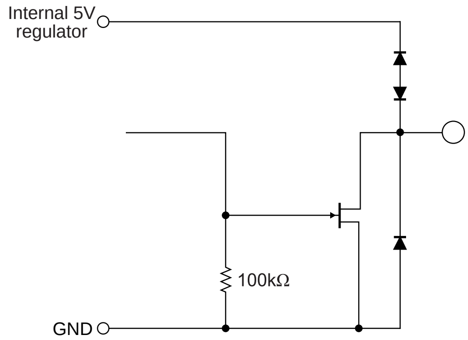
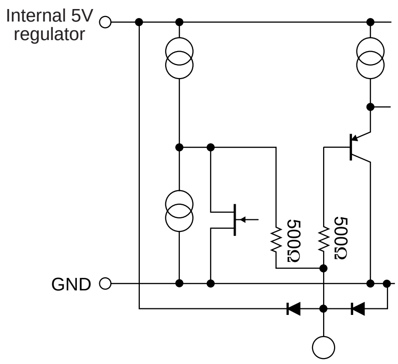
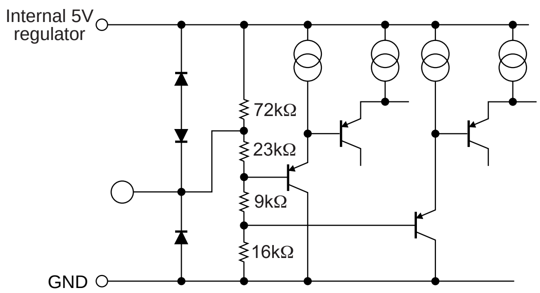
Top view

Pin Functions

Pin No.	Pin Name	Pin Functtion	Equivalent Circuit
7 8 9 10 11 12 13	MD1 MD2 MD3 OE RST FR STEP	Excitation mode switching pin Excitation mode switching pin Excitation mode switching pin Output enable signal input pin Reset signal input pin Forward / Reverse signal input pin Clock pulse signal input pin	
6	ST	Chip enable input pin.	
1 2 3 4 5 21 22 23 24 25	OUT1B RF1 PGND1 OUT1A V_M1 V_M2 OUT2B PGND2 RF2 OUT2A	Channel 1 OUTB output pin. Channel 1 current-sense resistor connection pin. Channel 1 power GND Channel 1 OUTA output pin. Channel 1 motor supply connect pin Channel 2 motor supply connect pin Channel 2 OUTB output pin. Channel 2 power GND Channel 2 current-sense resistor connection pin. Channel 2 OUTA output pin.	

Continued on next page.

Continued from preceding page.

Pin No.	Pin Name	Pin Functtion	Equivalent Circuit
19	VREF	Constant-current control reference voltage input pin.	
17 18	DOWN MO	Holding current output pin. Position detecting monitor pin.	
14 15	OSC1 OSC2	Chopping frequency setting capacitor connection pin. Holding current detection time setting capacitor connection pin.	
16	FDT	Decay mode select voltage input	

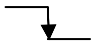
Reference describing operation

(1) Stand-by function

When ST pin is at low levels, the IC enters stand-by mode, all logic is reset and output is turned OFF.
When ST pin is at high levels, the stand-by mode is released.

(2) STEP pin function

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

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

(3) Excitation setting method

Set the excitation setting as shown in the following table by setting MD1 pin, MD2 pin and MD3 pin.

Input			Mode	Initial position	
MD3	MD2	MD1	(Excitation)	1ch current	2ch current
Low	Low	Low	Half	100%	0%
Low	Low	High	1/8	100%	0%
Low	High	Low	1/16	100%	0%
Low	High	High	1/32	100%	0%
High	Low	Low	1/64	100%	0%
High	Low	High	1/128	100%	0%
High	High	Low	1/10	100%	0%
High	High	High	1/20	100%	0%

The initial position is also the default state at start-up and excitation position at counter-reset in each Micro step resolution.

(4) MO output pin

MO output pin serves as open-drain connection.
If MO pin will be in the state of an initial position, it is turned on, and it outputs a Low level.

Excitation position	MO
Initial position	Low
Other initial position	OPEN

(5) Output current setting

Output current is set shown below by the VREF pin (applied voltage) and a resistance value between RF1(2) pin and GND.

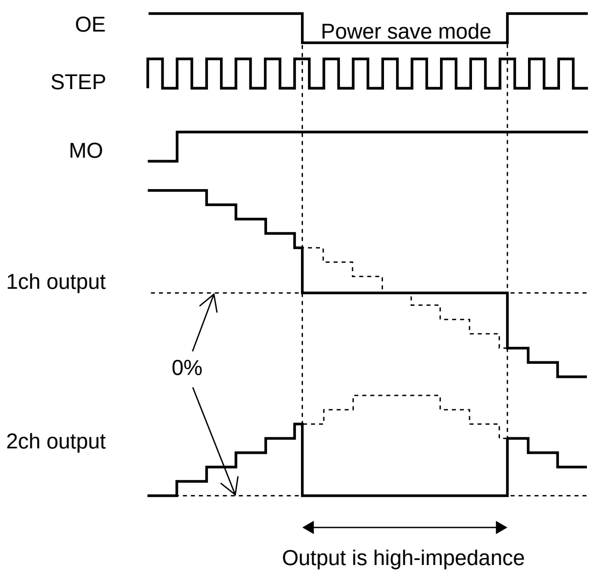
I_{OUT} = (VREF / 3) / RF1 (2) resistance
* The setting value above is a 100% output current in each excitation mode.

(Example) When VREF = 0.9V and RF1 (2) resistance is 0.1Ω, the setting is shown below.
I_{OUT} = (0.9V / 3) / 0.1Ω = 3A

(6) Output enable function

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

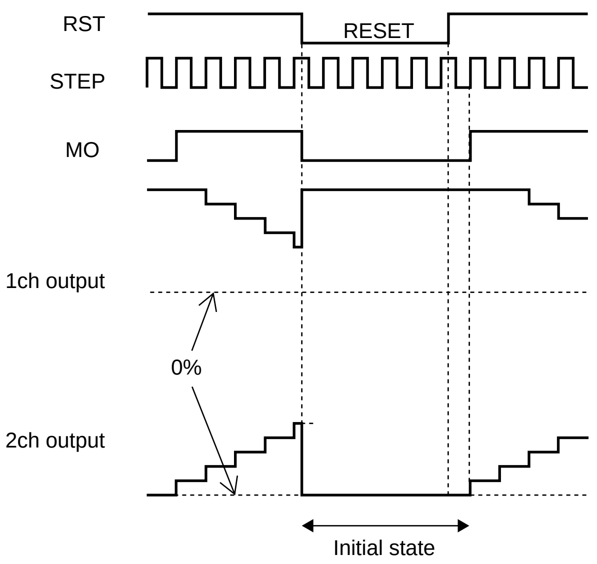
OE	Operation mode
L	Output: OFF
H	Output: ON



(7) Reset function

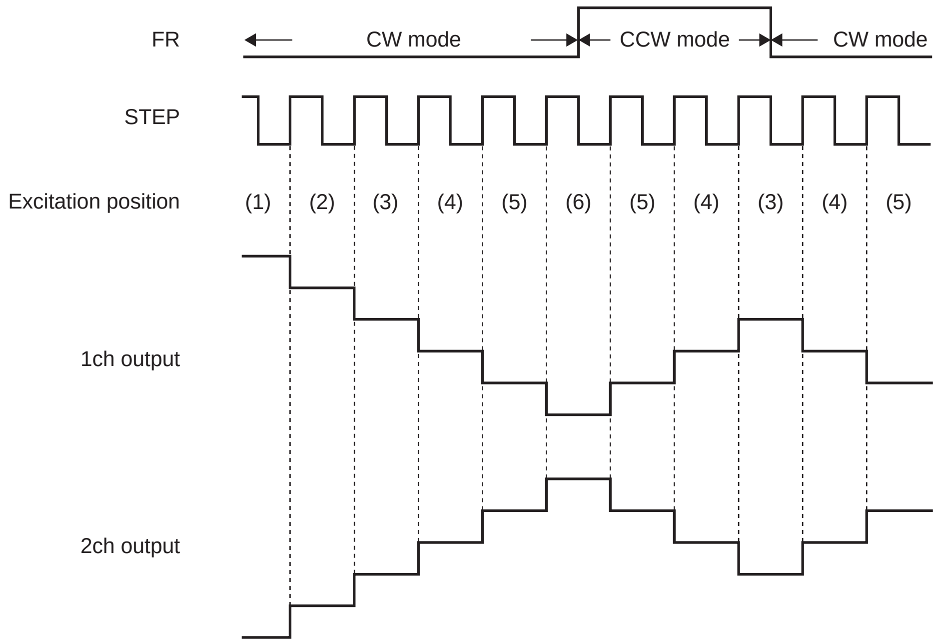
When the RST pin is set Low, the output goes to initial mode and excitation position is fixed in the initial position for STEP pin and FR pin input. MO pin outputs at low levels at the initial position. (Open drain connection)

RST	Operation mode
H	Normal operation
L	Reset state



(8) Forward / reverse switching function

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



The internal D/A converter proceeds by a bit on the rising edge of the step signal input to the STEP pin. In addition, CW and CCW mode are switched by FR pin setting.
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.

(9) DECAY mode setting

Current DECAY method is selectable as shown below by applied voltage to the FDT pin.

FDT voltage	DECAY method
3.5V to	SLOW DECAY
1.1V to 3.1V or OPEN	MIXED DECAY
To 0.8V	FAST DECAY

(10) Chopping frequency setting function

Chopping frequency is set as shown below by a capacitor between OSC1 pin and GND.

$$Fcp = 1 / (Cosc1 / 10 \times 10^{-6}) \text{ (Hz)}$$

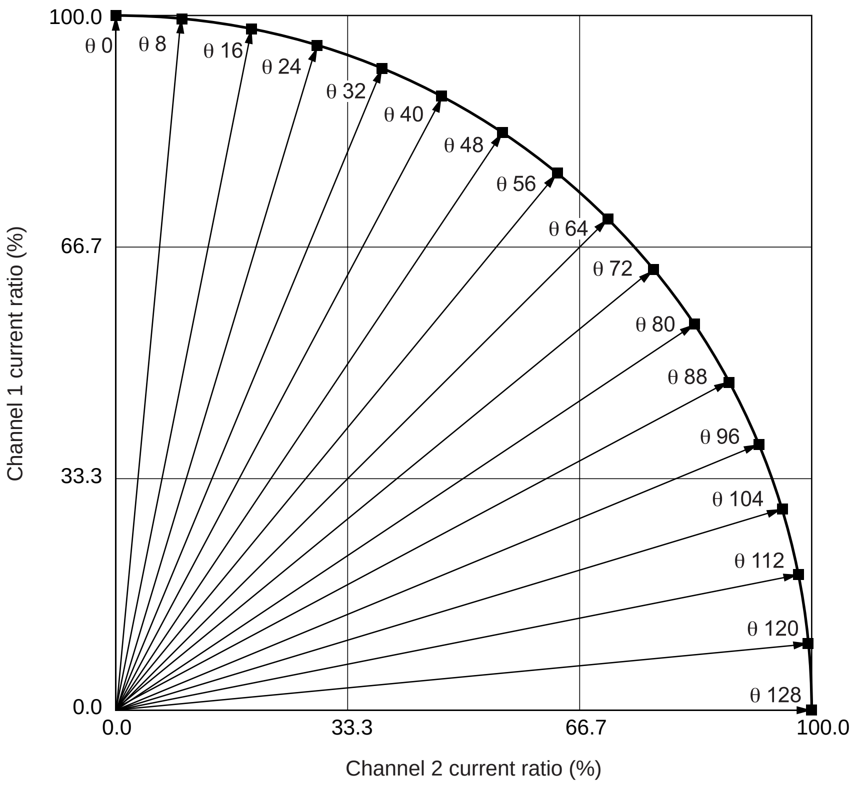
(Example) When Cosc1 = 180pF, the chopping frequency is shown below.

$$Fcp = 1 / (180 \times 10^{-12} / 10 \times 10^{-6}) = 55.6\text{(kHz)}$$

(11) Output current in each micro step resolution

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

Half, 1/8, 1/16, 1/32, 1/64, 1/128 Step



Current setting ratio in each micro step resolution

STEP	1/128 (%)		1/64 (%)		1/32 (%)		1/16 (%)		1/8 (%)		Half (%)	
	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch
θ0	100	0	100	0	100	0	100	0	100	0	100	0
θ1	100	1										
θ2	100	2	100	2								
θ3	100	4										
θ4	100	5	100	5	100	5						
θ5	100	6										
θ6	100	7	100	7								
θ7	100	9										
θ8	100	10	100	10	100	10	100	10				
θ9	99	11										
θ10	99	12	99	12								
θ11	99	13										
θ12	99	15	99	15	99	15						
θ13	99	16										
θ14	99	17	99	17								
θ15	98	18										
θ16	98	20	98	20	98	20	98	20	98	20		
θ17	98	21										
θ18	98	22	98	22								
θ19	97	23										
θ20	97	24	97	24	97	24						
θ21	97	25										
θ22	96	27	96	27								
θ23	96	28										
θ24	96	29	96	29	96	29	96	29				
θ25	95	30										

Continued on next page.

Continued from preceding page.

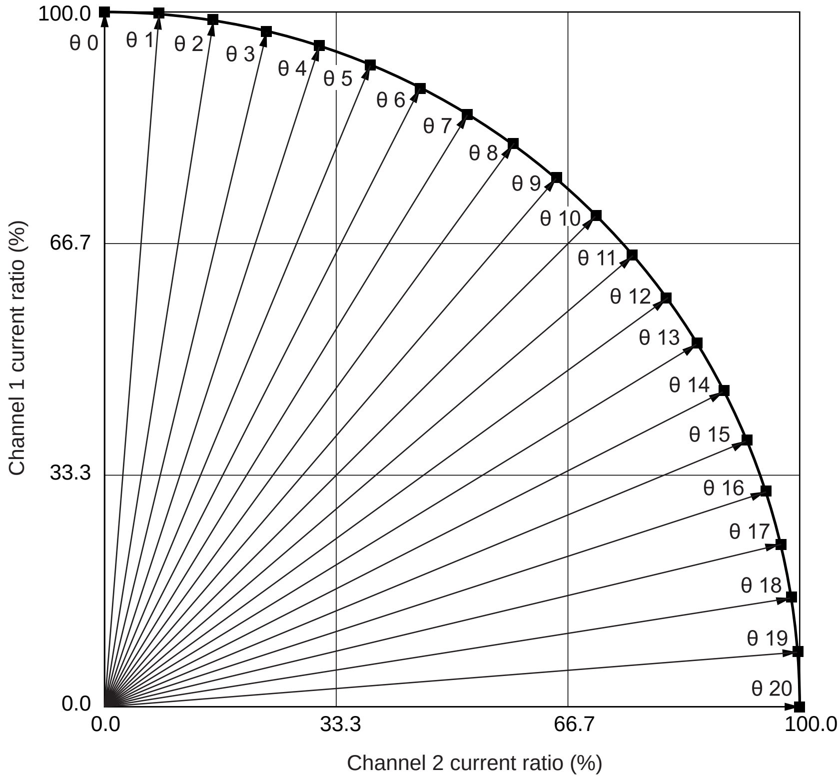
STEP	1/128 (%)		1/64 (%)		1/32 (%)		1/16 (%)		1/8 (%)		Halfe (%)	
	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch
θ026	95	31	95	31								
θ027	95	33										
θ028	94	34	94	34	94	34						
θ029	94	35										
θ030	93	36	93	36								
θ031	93	37										
θ032	92	38	92	38	92	38	92	38	92	38		
θ033	92	39										
θ034	91	41	91	41								
θ035	91	42										
θ036	90	43	90	43	90	43						
θ037	90	44										
θ038	89	45	89	45								
θ039	89	46										
θ040	88	47	88	47	88	47	88	47				
θ041	88	48										
θ042	87	49	87	49								
θ043	86	50										
θ044	86	51	86	51	86	51						
θ045	85	52										
θ046	84	53	84	53								
θ047	84	55										
θ048	83	56	83	56	83	56	83	56	83	56		
θ049	82	57										
θ050	82	58	82	58								
θ051	81	59										
θ052	80	60	80	60	80	60						
θ053	80	61										
θ054	79	62	79	62								
θ055	78	62										
θ056	77	63	77	63	77	63	77	63				
θ057	77	64										
θ058	76	65	76	65								
θ059	75	66										
θ060	74	67	74	67	74	67						
θ061	73	68										
θ062	72	69	72	69								
θ063	72	70										
θ064	71	71	71	71	71	71	71	71	71	71	71	71
θ065	70	72										
θ066	69	72	69	72								
θ067	68	73										
θ068	67	74	67	74	67	74						
θ069	66	75										
θ070	65	76	65	76								
θ071	64	77										
θ072	63	77	63	77	63	77	63	77				
θ073	62	78										
θ074	62	79	62	79								
θ075	61	80										
θ076	60	80	60	80	60	80						
θ077	59	81										
θ078	58	82	58	82								
θ079	57	82										
θ080	56	83	56	83	56	83	56	83	56	83		
θ081	55	84										
θ082	53	84	53	84								
θ083	52	85										
θ084	51	86	51	86	51	86						
θ085	50	86										
θ086	49	87	49	87								
θ087	48	88										
θ088	47	88	47	88	47	88	47	88				
θ089	46	89										
θ090	45	89	45	89								

Continued on next page.

Continued from preceding page.

STEP	1/128 (%)		1/64 (%)		1/32 (%)		1/16 (%)		1/8 (%)		Half (%)	
	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch
θ91	44	90										
θ92	43	90	43	90	43	90						
θ93	42	91										
θ94	41	91	41	91								
θ95	39	92										
θ96	38	92	38	92	38	92	38	92	38	92		
θ97	37	93										
θ98	36	93	36	93								
θ99	35	94										
θ100	34	94	34	94	34	94						
θ101	33	95										
θ102	31	95	31	95								
θ103	30	95										
θ104	29	96	29	96	29	96	29	96				
θ105	28	96										
θ106	27	96	27	96								
θ107	25	97										
θ108	24	97	24	97	24	97						
θ109	23	97										
θ110	22	98	22	98								
θ111	21	98										
θ112	20	98	20	98	20	98	20	98	20	98		
θ113	18	98										
θ114	17	99	17	99								
θ115	16	99										
θ116	15	99	15	99	15	99						
θ117	13	99										
θ118	12	99	12	99								
θ119	11	99										
θ120	10	100	10	100	10	100	10	100				
θ121	9	100										
θ122	7	100	7	100								
θ123	6	100										
θ124	5	100	5	100	5	100						
θ125	4	100										
θ126	2	100	2	100								
θ127	1	100										
θ128	0	100	0	100	0	100	0	100	0	100	0	100

Output current vector locus (one step is normalized to 90 degrees)
1/10, 1/20 STEP

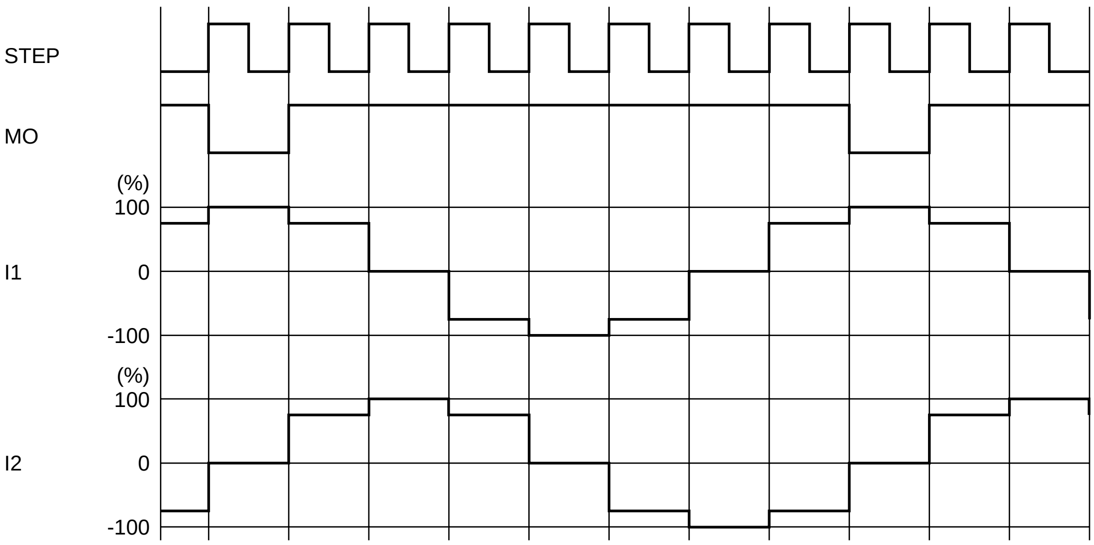


Current setting ratio in each micro step resolution
1/10, 1/20 STEP

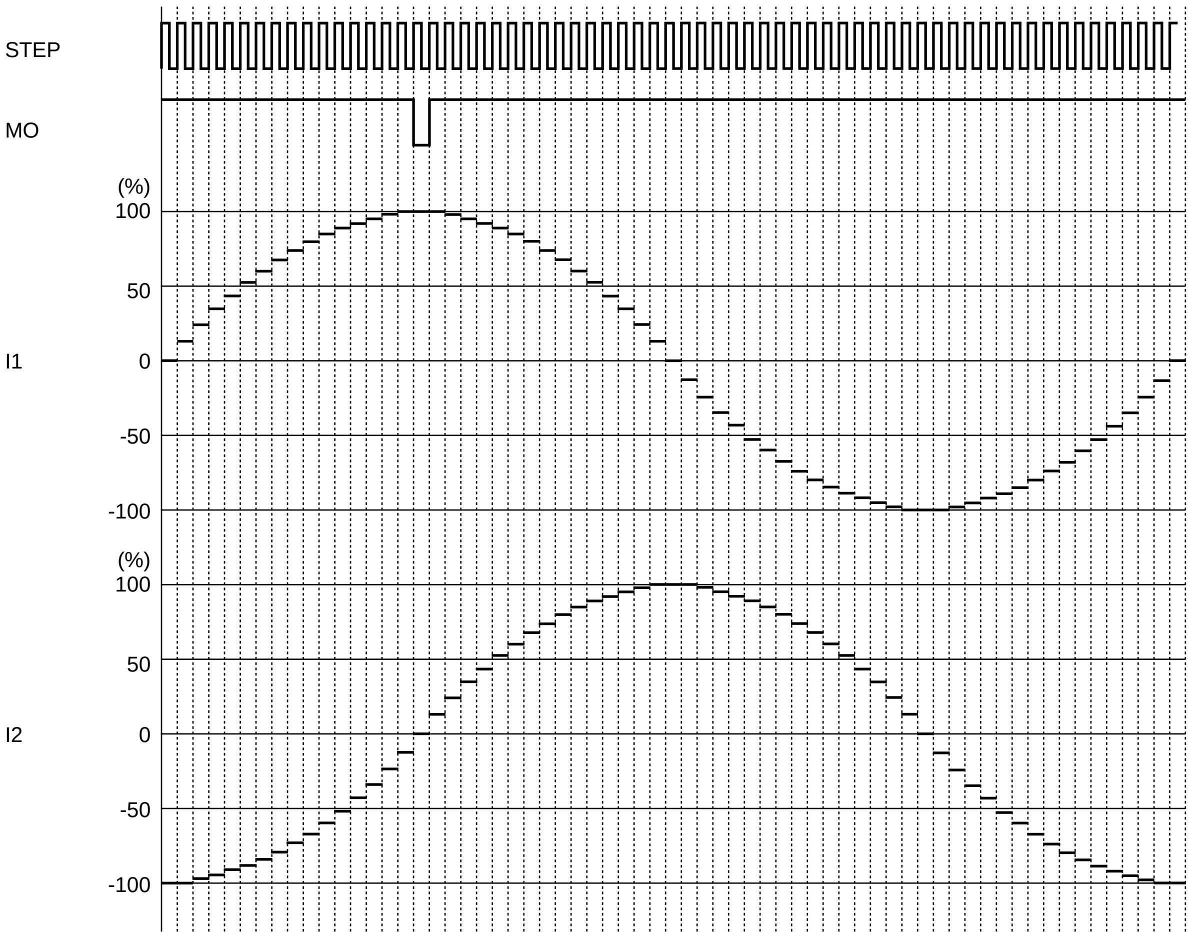
STEP	1/20 (%)		1/10 (%)	
	1ch	2ch	1ch	2ch
θ0	100	0	100	0
θ1	100	8		
θ2	99	16	99	16
θ3	97	23		
θ4	95	31	95	31
θ5	92	38		
θ6	89	45	89	45
θ7	85	52		
θ8	81	59	81	59
θ9	76	65		
θ10	71	71	71	71
θ11	65	76		
θ12	59	81	59	81
θ13	52	85		
θ14	45	89	45	89
θ15	38	92		
θ16	31	95	31	95
θ17	23	97		
θ18	16	99	16	99
θ19	8	100		
θ20	0	100	0	100

(12) Current wave example in each micro step resolution (Half, 1/16, 1/128, 1/20 STEP)

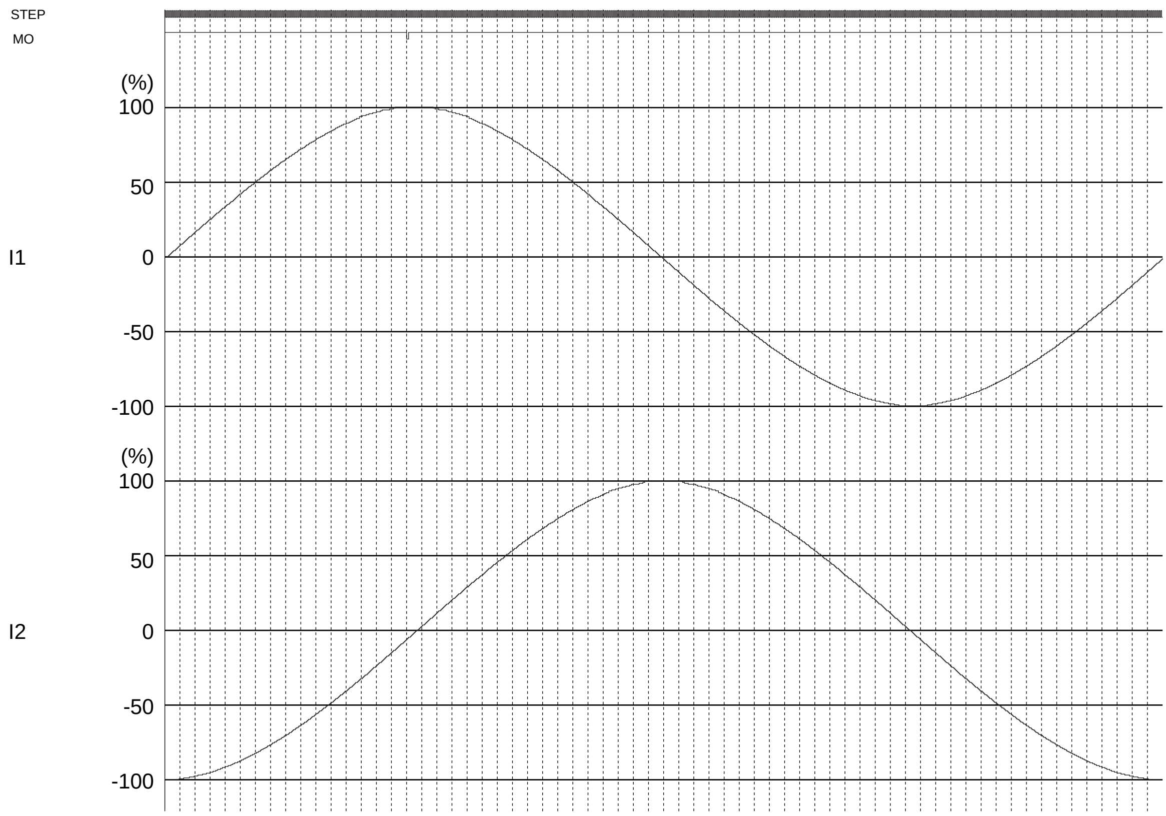
Half STEP (CW mode)



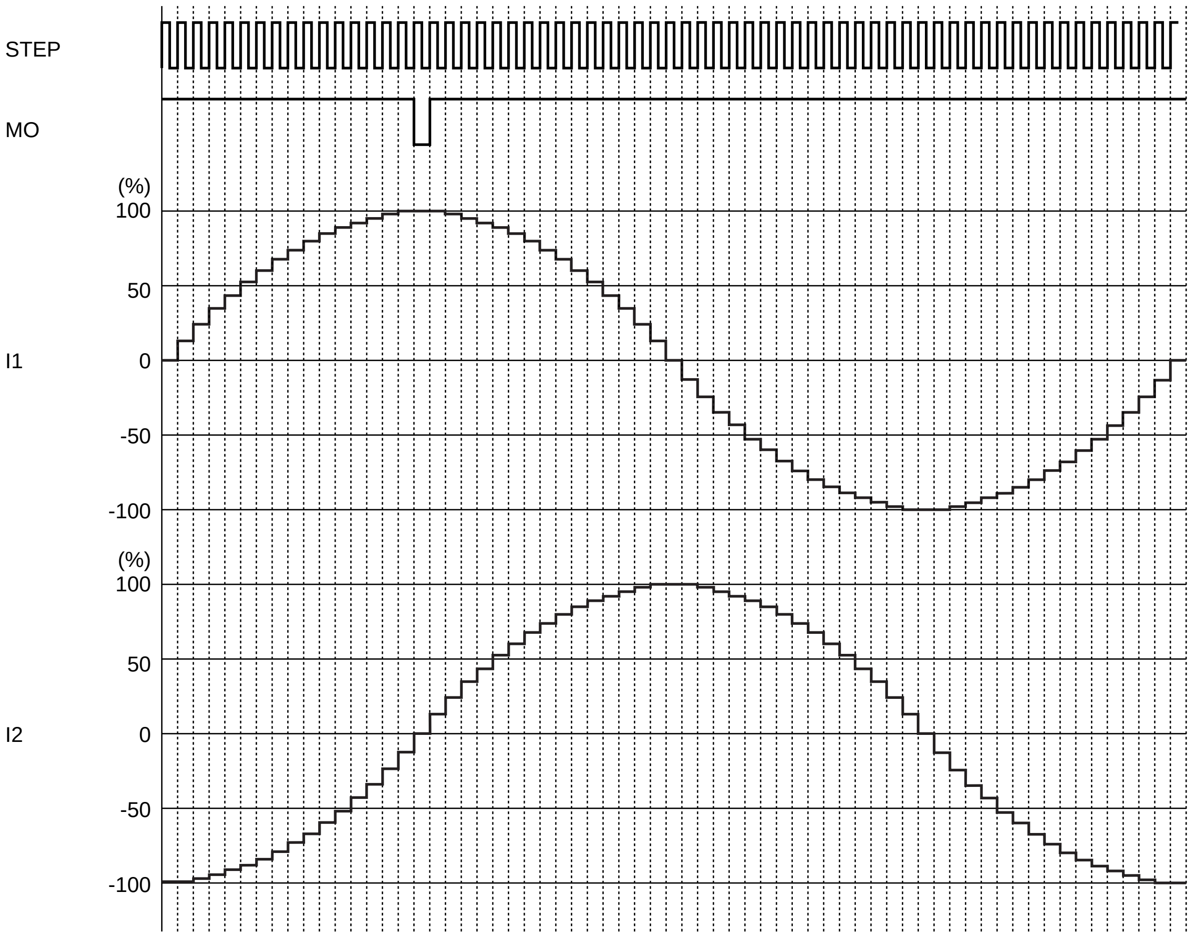
1/16 STEP (CW mode)



1/128 STEP (CW mode)



1/20 STEP (CW mode)

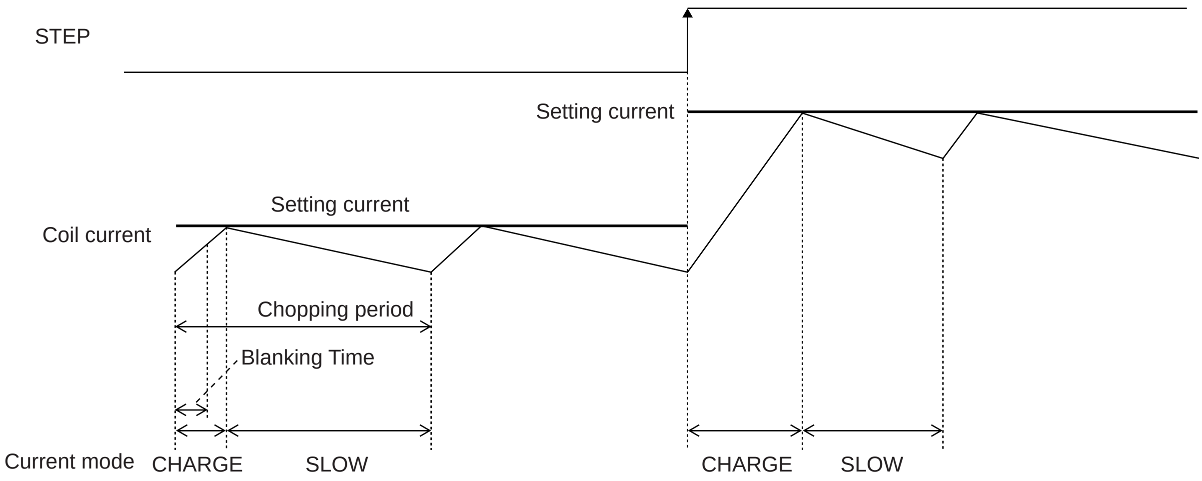


(13) Current control operation

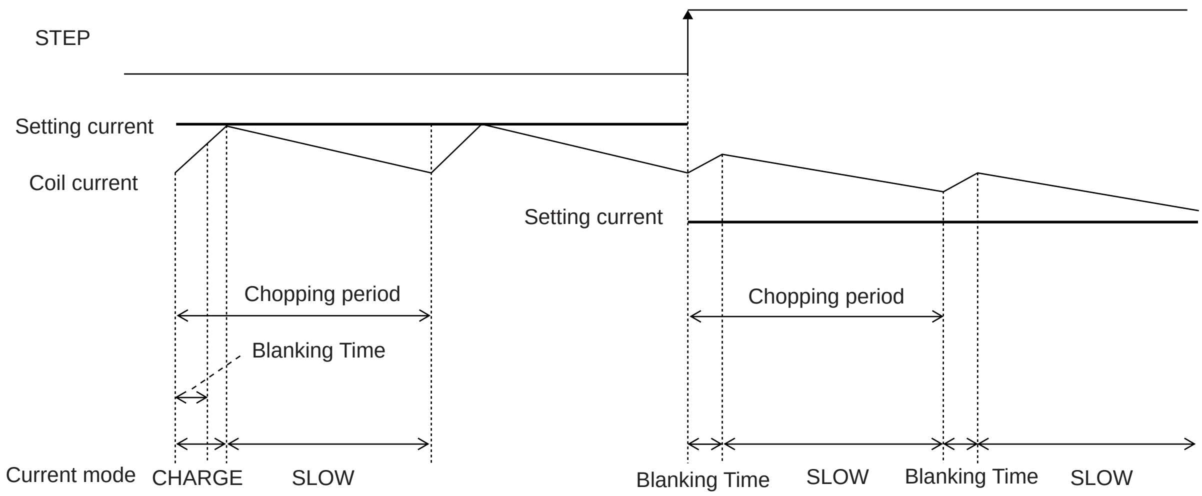
SLOW DECAY current control operation

When FDT pin voltage is a voltage over 3.5V, the constant-current control is operated in SLOW DECAY mode.

(Sine-wave increasing direction)



(Sine-wave decreasing direction)



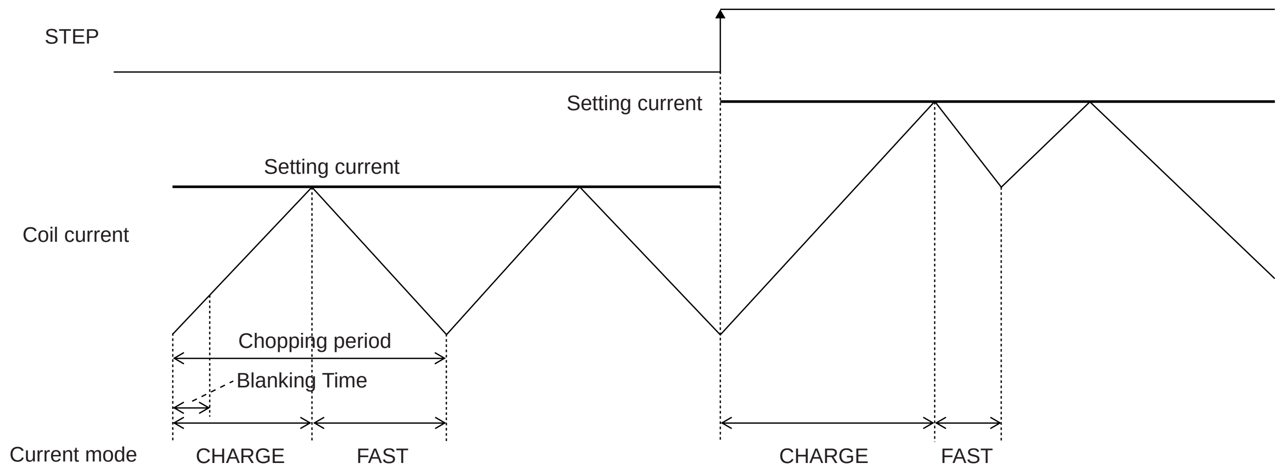
Each of current modes operates with the follow sequence.

The IC enters CHARGE mode at a rising edge of the chopping oscillation. (A period of CHARGE mode (Blanking Time) is forcibly present in approximately 1μs, regardless of the current value of the coil current (ICOIL) and set current (IREF)).

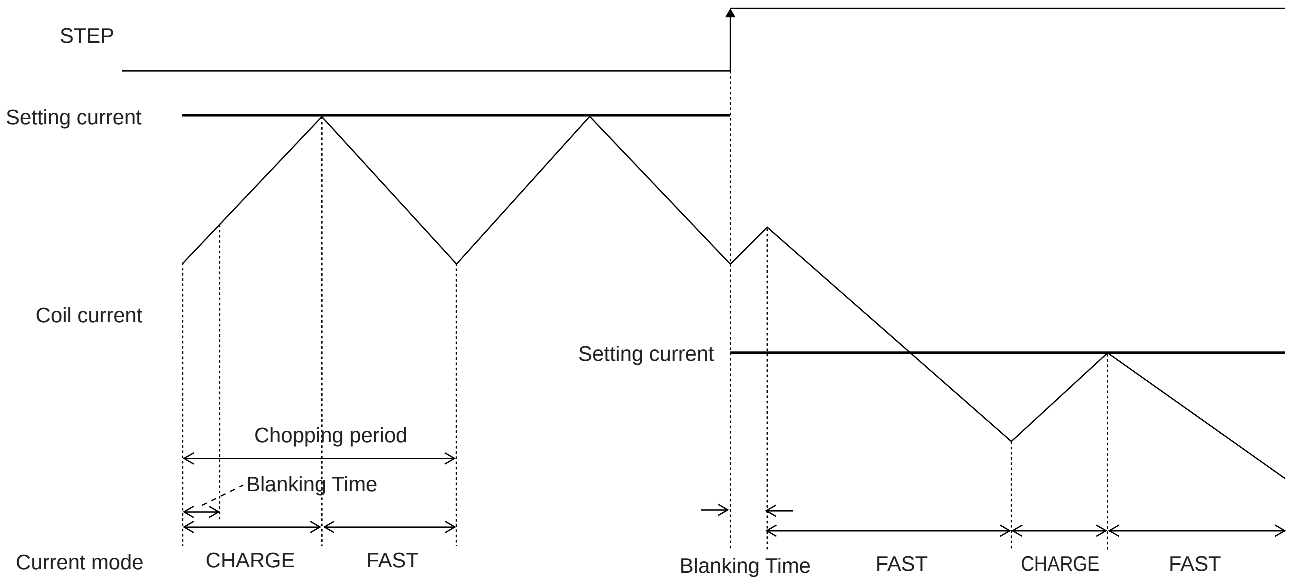
After the period of the blanking time, the IC operates in CHARGE mode until ICOIL ≥ IREF. After that, the mode switches to the SLOW DECAY mode and the coil current is attenuated until the end of a chopping period.

At the constand-current in SLOW DECAY mode, following to the setting current from the coil current may take time (or not follow) for the current delay attenuation.

FAST DECAY current control operation
When FDT pin voltage is a voltage under 0.8V, the constant-current control is operated in FAST DECAY mode.
(Sine-wave inxreasing direction)



(Sine-wave decreasing direction)

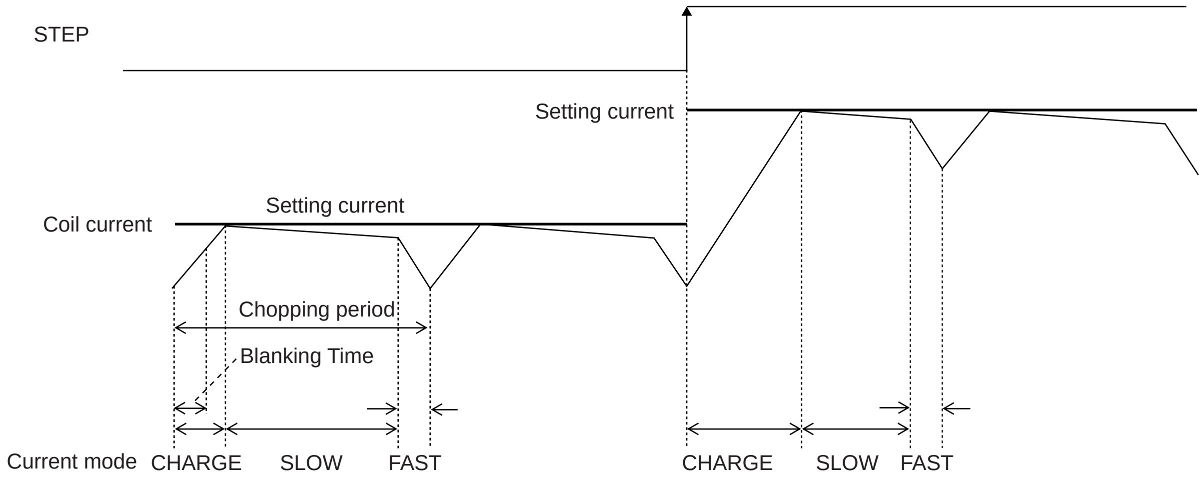


Each of current modes operates with the follow sequence.
The IC enters CHARGE mode at a rising edge of the chopping oscillation. (A period of CHARGE mode (Blanking Time) is forcibly present in approximately 1μs, regardless of the current value of the coil current (ICOIL) and set current (IREF)).
After the period of the blanking time, the IC operates in CHARGE mode until ICOIL ≥ IREF. After that, the mode switches to the FAST DECAY mode and the coil current is attenuated until the end of a chopping period.
At the constand-current control in FAST DECAY mode, following to the setting current from the coil current take short-time for the current fast attenuation, but, the current ripple value may be higher.

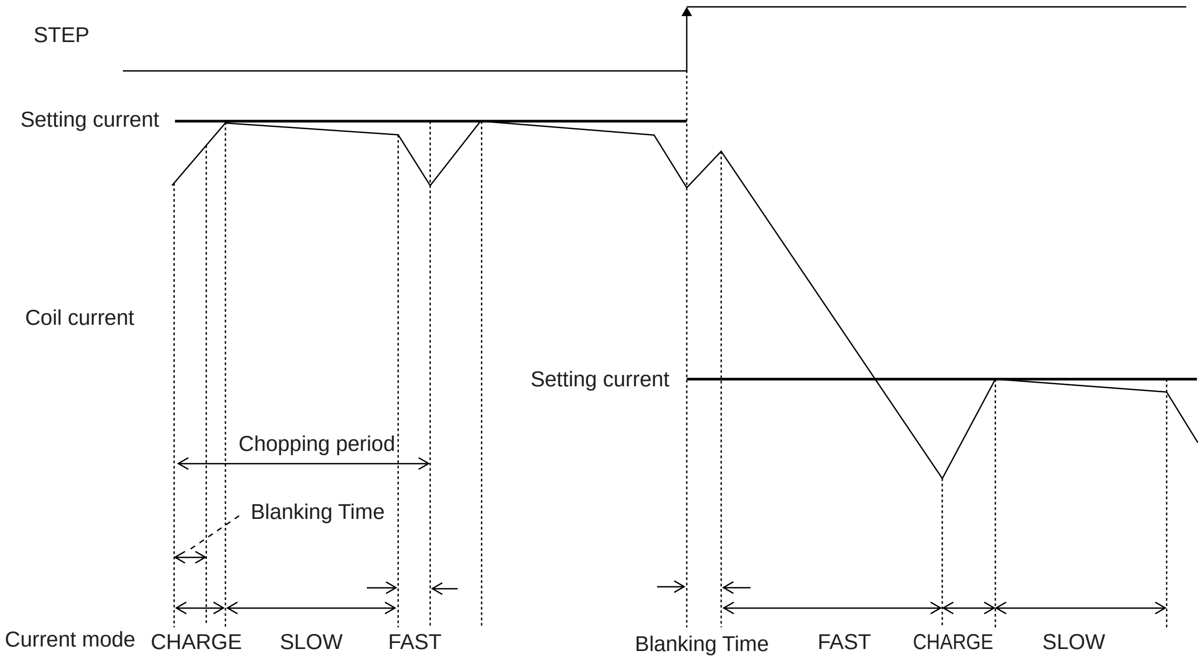
MIXED DECAY current control operation

When FDT pin voltage is a voltage between 1.1V to 3.1V or OPEN, the constant-current control is operated in MIXED DECAY mode.

(Sine-wave increasing direction)



(Sine-wave decreasing direction)



Each of current modes operates with the follow sequence.

The IC enters CHARGE mode at a rising edge of the chopping oscillation. (A period of CHARGE mode (Blanking Time) is forcibly present in approximately 1μs, regardless of the current value of the coil current (ICOIL) and set current (IREF)).

In a period of Blanking Time, the coil current (ICOIL) and the setting current (IREF) are compared.

If an ICOIL < IREF state exists during the charge period:

The IC operates in CHARGE mode until ICOIL ≥ IREF. After that, it switches to SLOW DECAY mode and then switches to FAST DECAY mode in the last approximately 1μs of the period.

If no ICOIL < IREF state exists during the charge period:

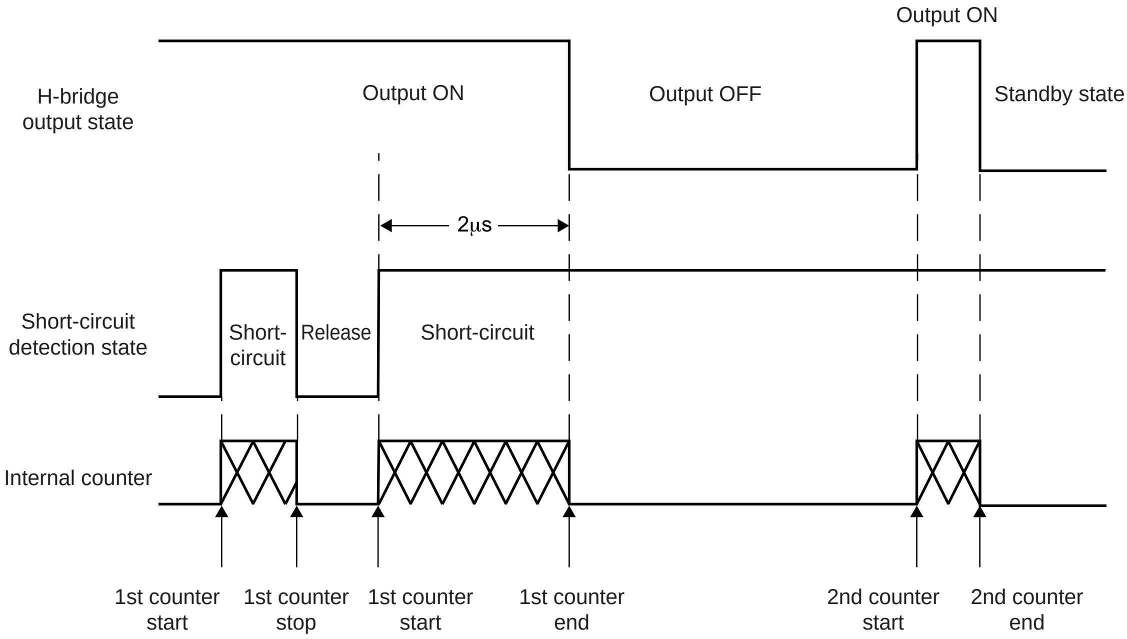
The IC switches to FAST DECAY mode and the coil current is attenuated with the FAST DECAY operation until the end of a chopping period.

The above operation is repeated. Normally, in the sine wave increasing direction the IC operates in SLOW (+ FAST) DECAY mode, and in the sine wave decresing direction the IC operates in FAST DECAY mode until the current is attenuated and reaches the set value and the IC operates in SLOW (+ FAST) DECAY mode.

(13) Output short-circuit protection circuit

Built-in output short-circuit protection circuit makes output to enter in stand-by mode. This function prevents the IC from damaging when the output shorts circuit by a voltage short or a ground short, etc. When output short state is detected, short-circuit detection circuit state the operating and output is once turned OFF. Subsequently, the output is turned ON again after the timer latch period (typ. 256μs). If the output remains in the short-circuit state, turn OFF the output, fix the output to the wait mode, and turn ON the EMO output.

When output is fixed in stand-by mode by output short protection circuit, output is released the latch by setting ST = "L".



(15) DOWN output pin

The DOWN output pin is an open-drain connection.

This pin is turned ON when no rising edge of STEP between the input signals while a period determined by a capacitor between OSC2 and GND, and outputs at low levels.

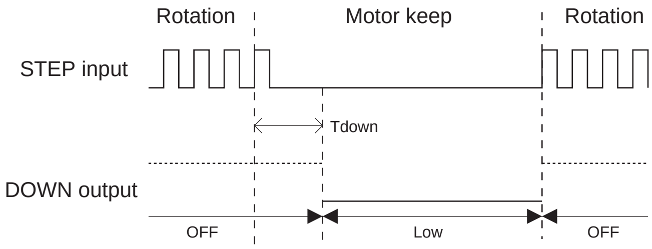
The open-drain output in once turned ON, is turned OFF at the next rising edge of STEP.

Holding current switching time (Tdown) is set as shown below by a capacitor between OSC2 pin and GND.

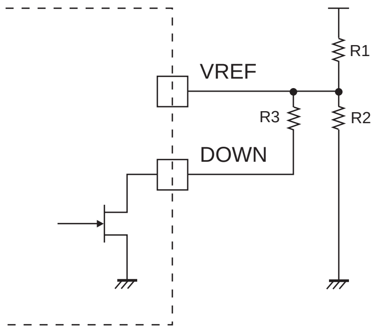
$T_{down} = C_{osc2} \times 0.4 \times 10^9$ (s)

(Example) When Cosc2 = 1500pF, the STEP signal detection time is shown below.

Tdown = 1500pF x 0.4 x 109 = 0.6 (s)



By connecting circumference parts like the example of the following circuit diagram using a DOWN pin, that is a STEP signal is not inputted more than detection time, it is a DOWN output's turning on in the state of holding turning on electricity the position of a stepping motor, and setting current's falling because VREF input voltage's falls, and stopping power consumption -- it can do.

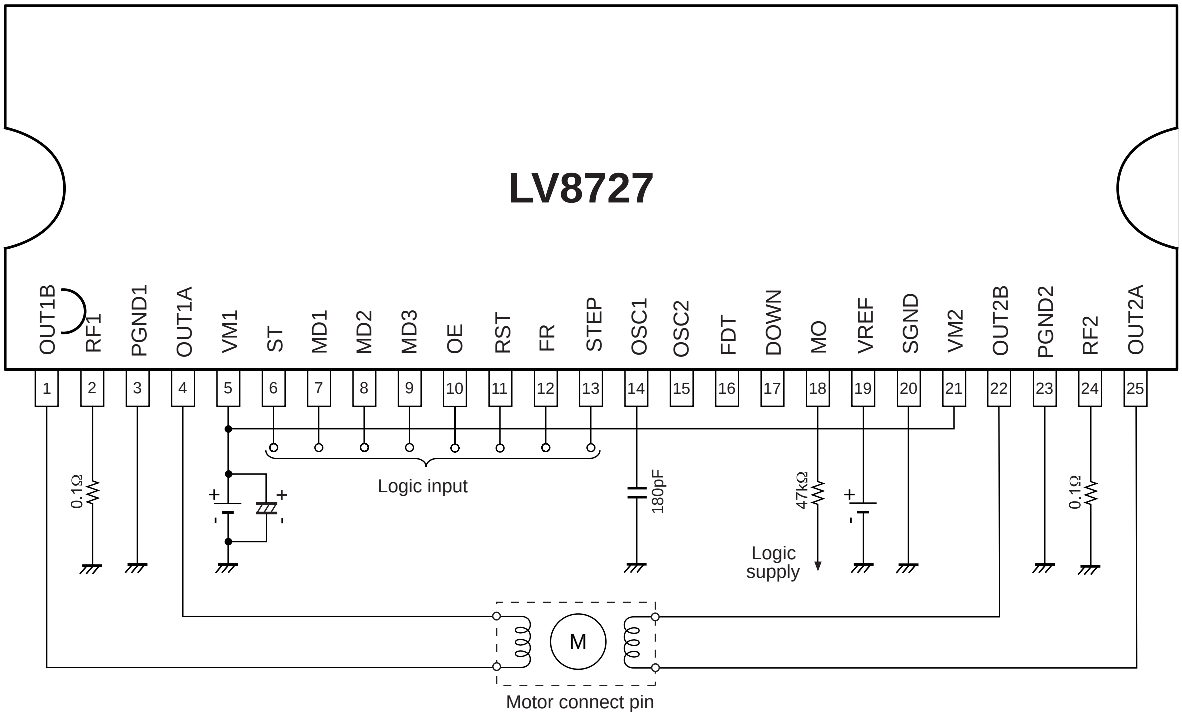


(Example) When V1=5V, R1=27kΩ, R2=4.7kΩ, R3=1kΩ, the VREF input voltage is shown below.

DOWN output OFF: VREF=V1×R2/(R1+R2)=0.741V

DOWN output ON: VREF=V1×(R2║R3)/ (R1+(R2║R3))=0.126V

Application Circuit Example



The above sample application circuit is set to the following conditions:

· Constant-current setting

I_{OUT}=VREF/3/RF

(Example) When is VREF=0.9V

I_{OUT}=0.9V/3/0.1Ω=3A

· Chopping frequency setting

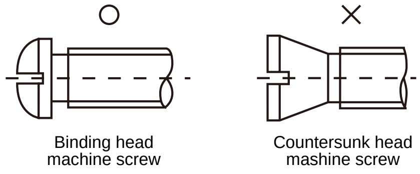
Fchop=Ichop/(Cchop×Vt×2)

=10μA/(180pF×0.5V×2)=55.6kHz

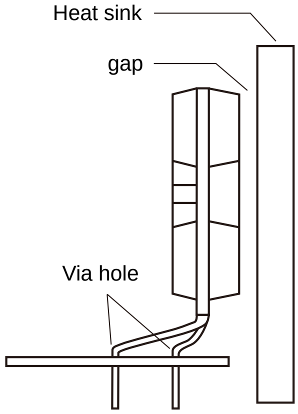
HZIP25 Heat sink attachment

Heat sinks are used to lower the semiconductor device junction temperature by leading the head generated by the device to the outer environment and dissipating that heat.

a. Unless otherwise specified, for power ICs with tabs and power ICs with attached heat sinks, solder must not be applied to the heat sink or tabs.



b. Heat sink attachment
- · Use flat-head screws to attach heat sinks.
- · Use also washer to protect the package.
- · Use tightening torques in the ranges 39-59Ncm(4-6kgcm) .
- · If tapping screws are used, do not use screws with a diameter larger than the holes in the semiconductor device itself.
- · Do not make gap, dust, or other contaminants to get between the semiconductor device and the tab or heat sink.
- · Take care a position of via hole .
- · Do not allow dirt, dust, or other contaminants to get between the semiconductor device and the tab or heat sink.
- · Verify that there are no press burrs or screw-hole burrs on the heat sink.
- · Warping in heat sinks and printed circuit boards must be no more than 0.05 mm between screw holes, for either concave or convex warping.
- · Twisting must be limited to under 0.05 mm.
- · Heat sink and semiconductor device are mounted in parallel. Take care of electric or compressed air drivers
- · The speed of these torque wrenches should never exceed 700 rpm, and should typically be about 400 rpm.



c. Silicone grease
- · Spread the silicone grease evenly when mounting heat sinks.
- · Recommends YG-6260 (Momentive Performance Materials Japan LLC)

d. Mount
- · First mount the heat sink on the semiconductor device, and then mount that assembly on the printed circuit board.
- · When attaching a heat sink after mounting a semiconductor device into the printed circuit board, when tightening up a heat sink with the screw, the mechanical stress which is impossible to the semiconductor device and the pin doesn't hang.

e. When mounting the semiconductor device to the heat sink using jigs, etc.,
- · Take care not to allow the device to ride onto the jig or positioning dowel.
- · Design the jig so that no unreasonable mechanical stress is not applied to the semiconductor device.

f. Heat sink screw holes
- · Be sure that chamfering and shear drop of heat sinks must not be larger than the diameter of screw head used.
- · When using nuts, do not make the heat sink hole diameters larger than the diameter of the head of the screws used. A hole diameter about 15% larger than the diameter of the screw is desirable.
- · When tap screws are used, be sure that the diameter of the holes in the heat sink are not too small. A diameter about 15% smaller than the diameter of the screw is desirable.

g. There is a method to mount the semiconductor device to the heat sink by using a spring band. But this method is not recommended because of possible displacement due to fluctuation of the spring force with time or vibration.