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LV8727

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 ; $T_a = 25^\circ\text{C}$, $I_O = 4.0\text{A}$)
- 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.
- $I_O \text{ max} = 4.0\text{A}$
- Input pull down resistance
- Available forward reverse control.
- Thermal shutdown circuit.
- With reset pin and enable pin.

Specifications

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

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	$V_M \text{ max}$		50	V
Output current	$I_O \text{ max}$		4	A
Output peak current	$I_O \text{ peak}$	$t_w \leq 10\text{ms}$, duty 20%	4.6	A
Logic input voltage	$V_{IN} \text{ max}$		6	V
VREF input voltage	$V_{REF} \text{ max}$		6	V
MO / DOWN pin input voltage	$V_{MO} / V_{DOWN} \text{ max}$		6	V
Allowable power dissipation	$P_d \text{ max}$	Independent IC	2.45	W
Operating temperature	T_{opr}		-30 to +85	$^\circ\text{C}$
Storage temperature	T_{stg}		-55 to +150	$^\circ\text{C}$

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.

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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

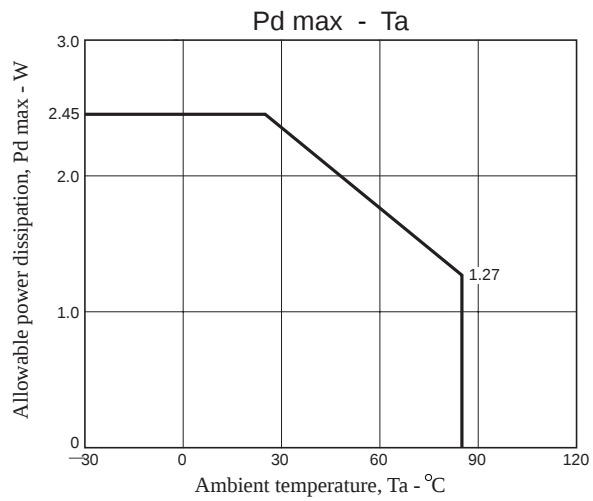
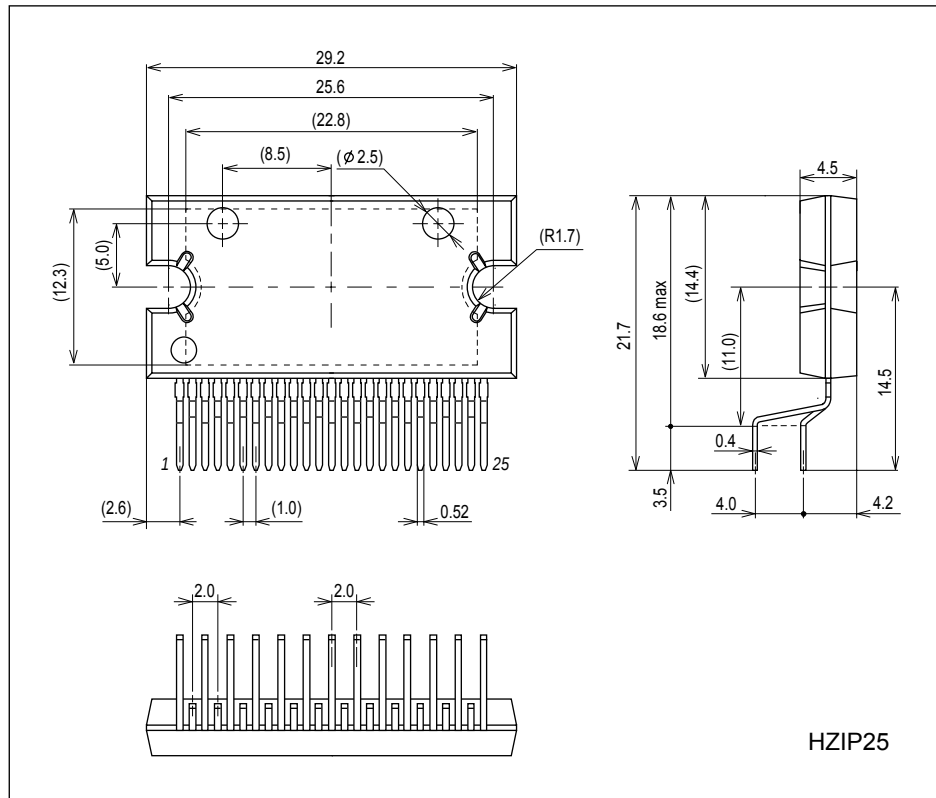
Electrical Characteristics at Ta = 25°C, V_M = 24V, VREF = 1.5V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain	I _{Mst}	ST = "L"		70	100	μA
Current drain	I _M	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 _{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
FDT pin high-level voltage	V _{fdth}		3.5			V
FDT pin middle-level voltage	V _{fdtm}		1.1		3.1	V
FDT pin low-level voltage	V _{fdtl}				0.8	V
Chopping frequency	F _{ch}	Cosc1 = 100pF	70	100	130	kHz
OSC1 pin charge/discharge current	I _{osc1}		7	10	13	μA
Chopping oscillation circuit threshold voltage	V _{tup1}		0.8	1	1.2	V
	V _{tdown1}		0.3	0.5	0.7	V
VREF pin input voltage	I _{ref}	VREF = 1.5V	-0.5			μA
DOWN output residual voltagr	V _{O1DOWN}	I _{down} = 1mA		50	200	mV
MO pin residual voltage	V _{O1MO}	I _{mo} = 1mA		50	200	mV
Hold current switching frequency	F _{down}	Cosc2 = 1500pF	1.12	1.6	2.08	Hz
OSC2 pin charge/discharge current	I _{osc2}		7	10	13	μA
Hold current switching frequency threshold voltage	V _{tup2}		0.8	1	1.2	V
	V _{tdown2}		0.3	0.5	0.7	V
Output on-resistance	R _{onu}	I _O = 4.0A, high-side ON resistance		0.25	0.325	Ω
	R _{ond}	I _O = 4.0A, low-side ON resistance		0.15	0.195	Ω
Output leakage current	I _{Oleak}	V _M = 50V			50	μA
Diode forward voltage	V _D	I _D = -4.0A		1	1.3	V
Current setting reference voltage	V _{RF}	VREF = 1.5V, Current ratio 100%	0.485	0.5	0.515	V

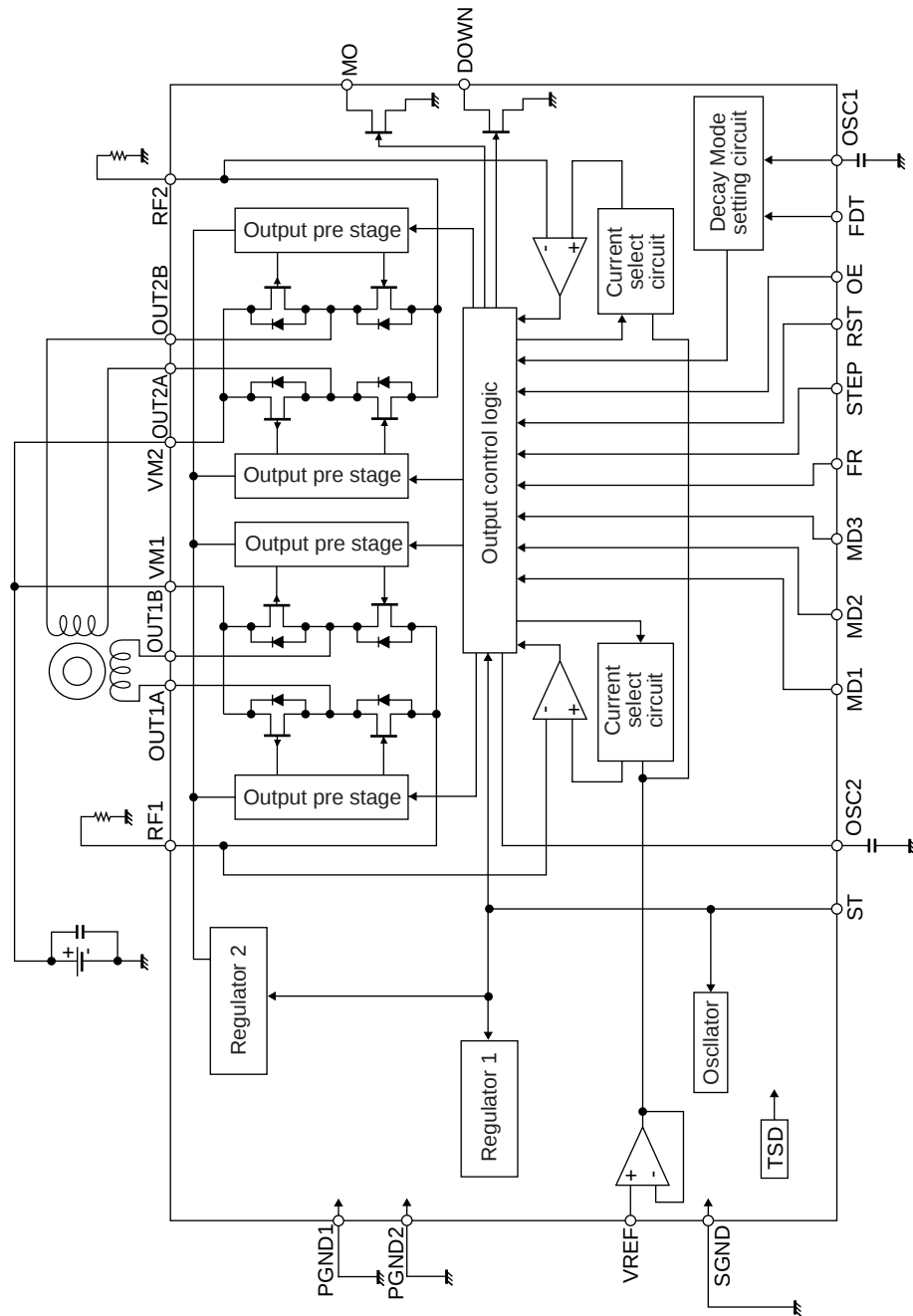
Package Dimensions

unit : mm (typ)

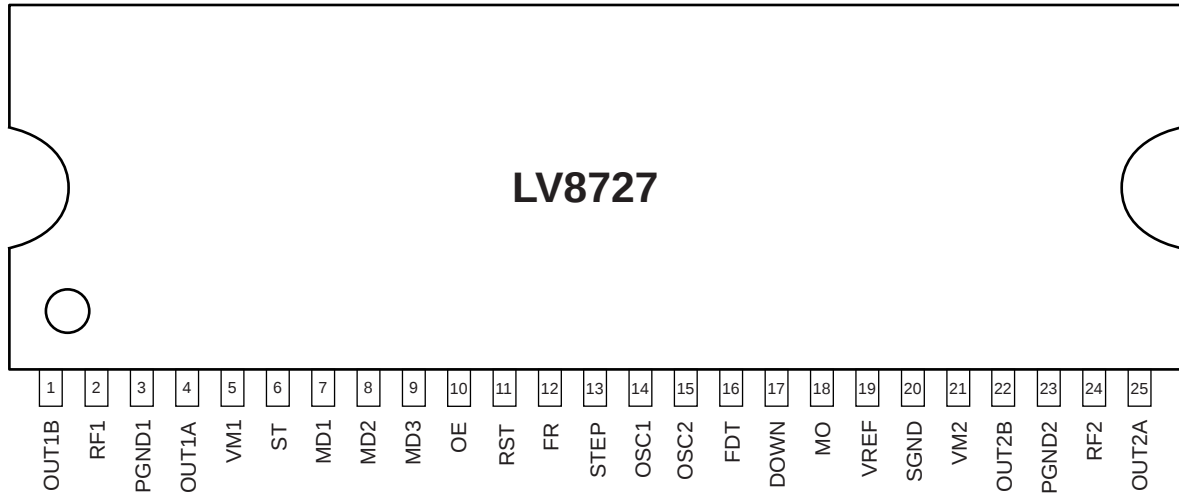
3236A



Block Diagram



Pin Assignment



Top view

Pin Functions

Pin No.	Pin Name	Pin Function	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 VM1 VM2 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.	

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Pin No.	Pin Name	Pin Function	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 rising 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 (Excitation)	Initial position	
MD3	MD2	MD1		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.

$$I_{OUT} = (VREF / 3) / RF1(2) \text{ resistance}$$

* The setting value above is a 100% output current in each excitation mode.

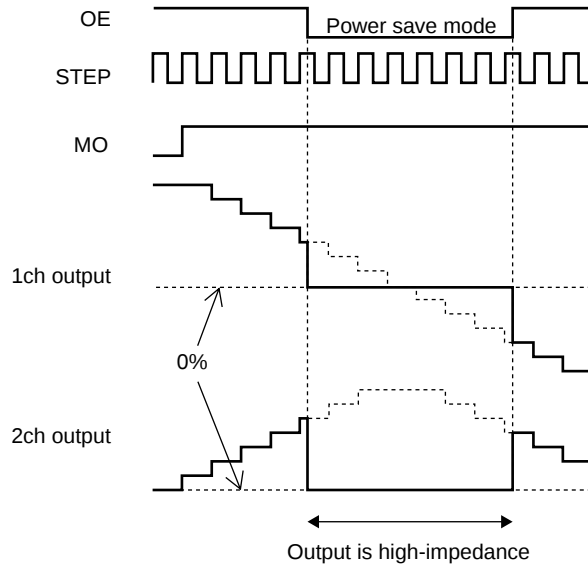
(Example) When VREF = 0.9V and RF1(2) resistance is 0.1Ω, the setting is shown below.

$$I_{OUT} = (0.9V / 3) / 0.1\Omega = 3A$$

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

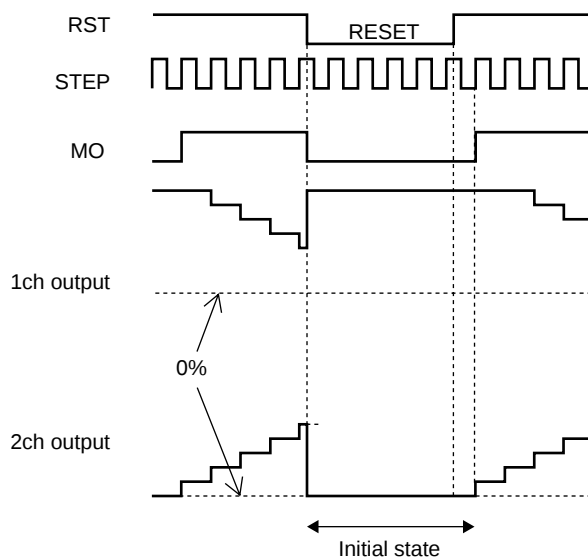
OE	Operation mode
L	Output: OFF
H	Output: ON



(7) Reset function

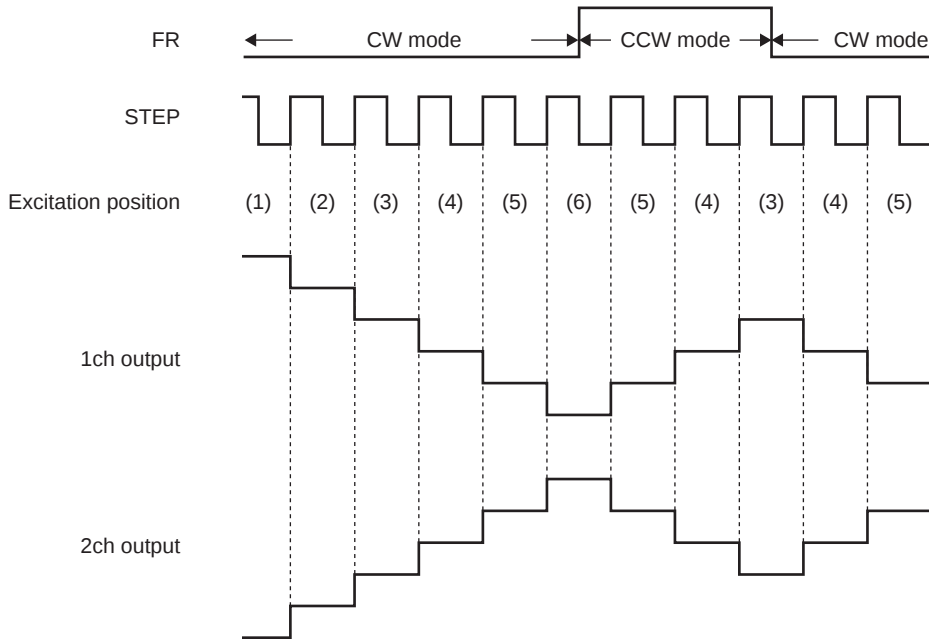
When the RST pin is set Low, the output goes to initial mode and excitation position is fixed in the initial position for STEP pin and FR pin input. MO pin outputs at low levels at the initial position. (Open drain connection)

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.

$$F_{cp} = 1 / (C_{osc1} / 10 \times 10^{-6}) \text{ (Hz)}$$

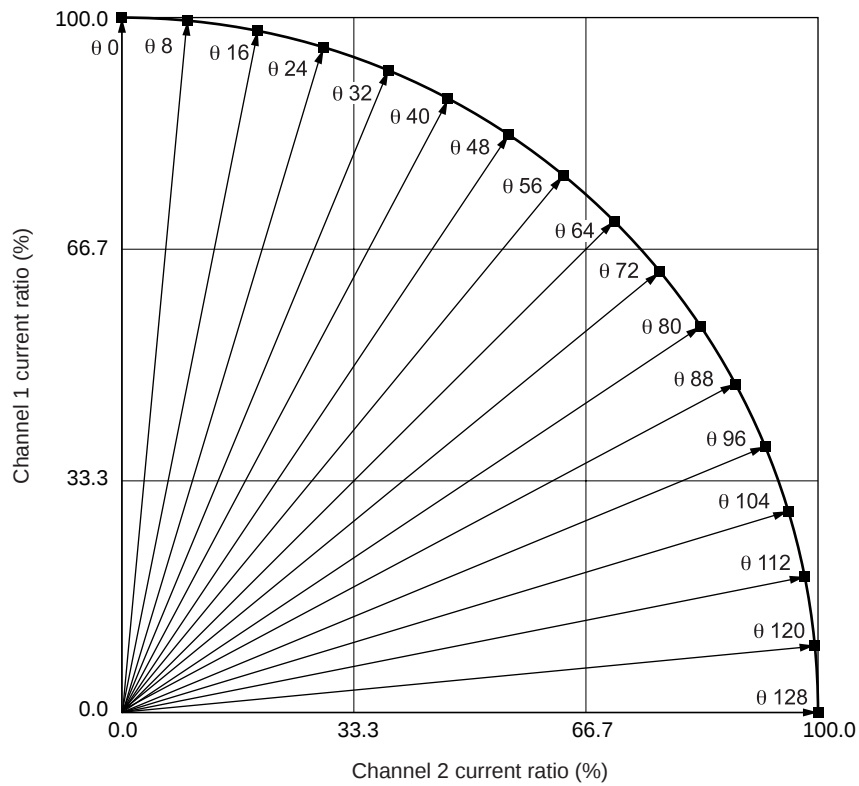
(Example) When $C_{osc1} = 180\text{pF}$, the chopping frequency is shown below.

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

(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
00	100	0	100	0	100	0	100	0	100	0	100	0
01	100	1										
02	100	2	100	2								
03	100	4										
04	100	5	100	5	100	5						
05	100	6										
06	100	7	100	7								
07	100	9										
08	100	10	100	10	100	10	100	10				
09	99	11										
010	99	12	99	12								
011	99	13										
012	99	15	99	15	99	15						
013	99	16										
014	99	17	99	17								
015	98	18										
016	98	20	98	20	98	20	98	20	98	20		
017	98	21										
018	98	22	98	22								
019	97	23										
020	97	24	97	24	97	24						
021	97	25										
022	96	27	96	27								
023	96	28										
024	96	29	96	29	96	29	96	29				
025	95	30										

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STEP	1/128 (%)		1/64 (%)		1/32 (%)		1/16 (%)		1/8 (%)		Halfe (%)	
	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch
026	95	31	95	31								
027	95	33										
028	94	34	94	34	94	34						
029	94	35										
030	93	36	93	36								
031	93	37										
032	92	38	92	38	92	38	92	38	92	38		
033	92	39										
034	91	41	91	41								
035	91	42										
036	90	43	90	43	90	43						
037	90	44										
038	89	45	89	45								
039	89	46										
040	88	47	88	47	88	47	88	47				
041	88	48										
042	87	49	87	49								
043	86	50										
044	86	51	86	51	86	51						
045	85	52										
046	84	53	84	53								
047	84	55										
048	83	56	83	56	83	56	83	56	83	56		
049	82	57										
050	82	58	82	58								
051	81	59										
052	80	60	80	60	80	60						
053	80	61										
054	79	62	79	62								
055	78	62										
056	77	63	77	63	77	63	77	63				
057	77	64										
058	76	65	76	65								
059	75	66										
060	74	67	74	67	74	67						
061	73	68										
062	72	69	72	69								
063	72	70										
064	71	71	71	71	71	71	71	71	71	71	71	71
065	70	72										
066	69	72	69	72								
067	68	73										
068	67	74	67	74	67	74						
069	66	75										
070	65	76	65	76								
071	64	77										
072	63	77	63	77	63	77	63	77				
073	62	78										
074	62	79	62	79								
075	61	80										
076	60	80	60	80	60	80						
077	59	81										
078	58	82	58	82								
079	57	82										
080	56	83	56	83	56	83	56	83	56	83		
081	55	84										
082	53	84	53	84								
083	52	85										
084	51	86	51	86	51	86						
085	50	86										
086	49	87	49	87								
087	48	88										
088	47	88	47	88	47	88	47	88				
089	46	89										
090	45	89	45	89								

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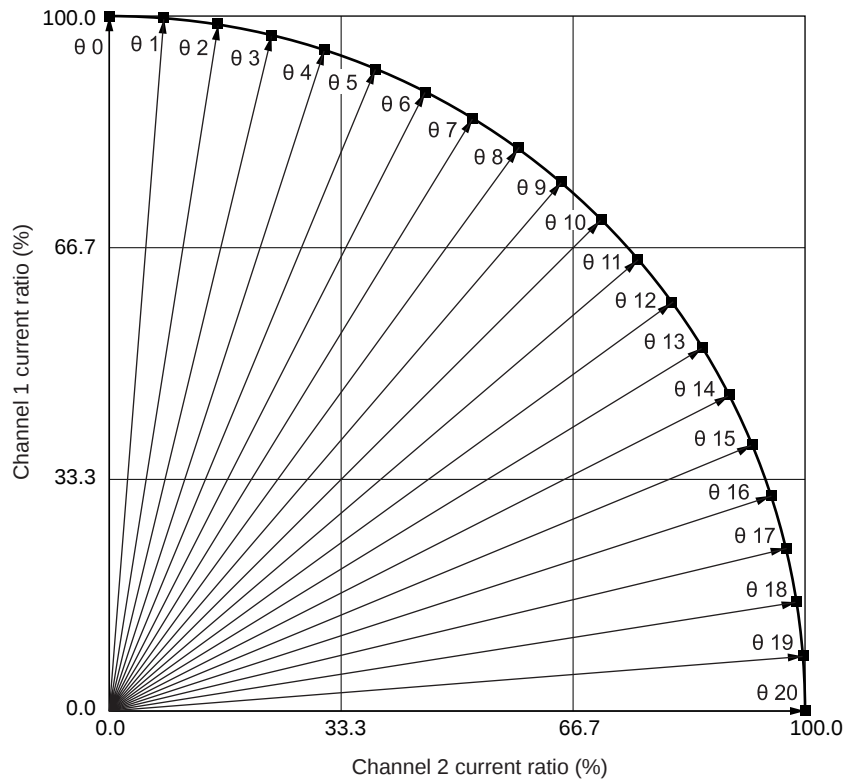
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STEP	1/128 (%)		1/64 (%)		1/32 (%)		1/16 (%)		1/8 (%)		Half (%)	
	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch
091	44	90										
092	43	90	43	90	43	90						
093	42	91										
094	41	91	41	91								
095	39	92										
096	38	92	38	92	38	92	38	92	38	92		
097	37	93										
098	36	93	36	93								
099	35	94										
0100	34	94	34	94	34	94						
0101	33	95										
0102	31	95	31	95								
0103	30	95										
0104	29	96	29	96	29	96	29	96				
0105	28	96										
0106	27	96	27	96								
0107	25	97										
0108	24	97	24	97	24	97						
0109	23	97										
0110	22	98	22	98								
0111	21	98										
0112	20	98	20	98	20	98	20	98	20	98		
0113	18	98										
0114	17	99	17	99								
0115	16	99										
0116	15	99	15	99	15	99						
0117	13	99										
0118	12	99	12	99								
0119	11	99										
0120	10	100	10	100	10	100	10	100				
0121	9	100										
0122	7	100	7	100								
0123	6	100										
0124	5	100	5	100	5	100						
0125	4	100										
0126	2	100	2	100								
0127	1	100										
0128	0	100	0	100	0	100	0	100	0	100	0	100

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

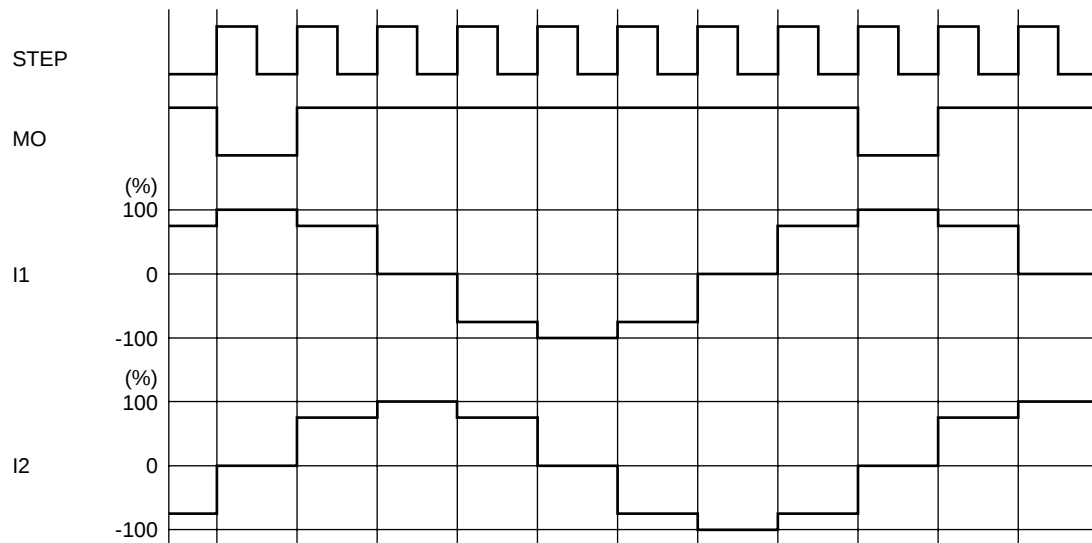


Current setting ratio in each micro step resolution
1/10, 1/20 STEP

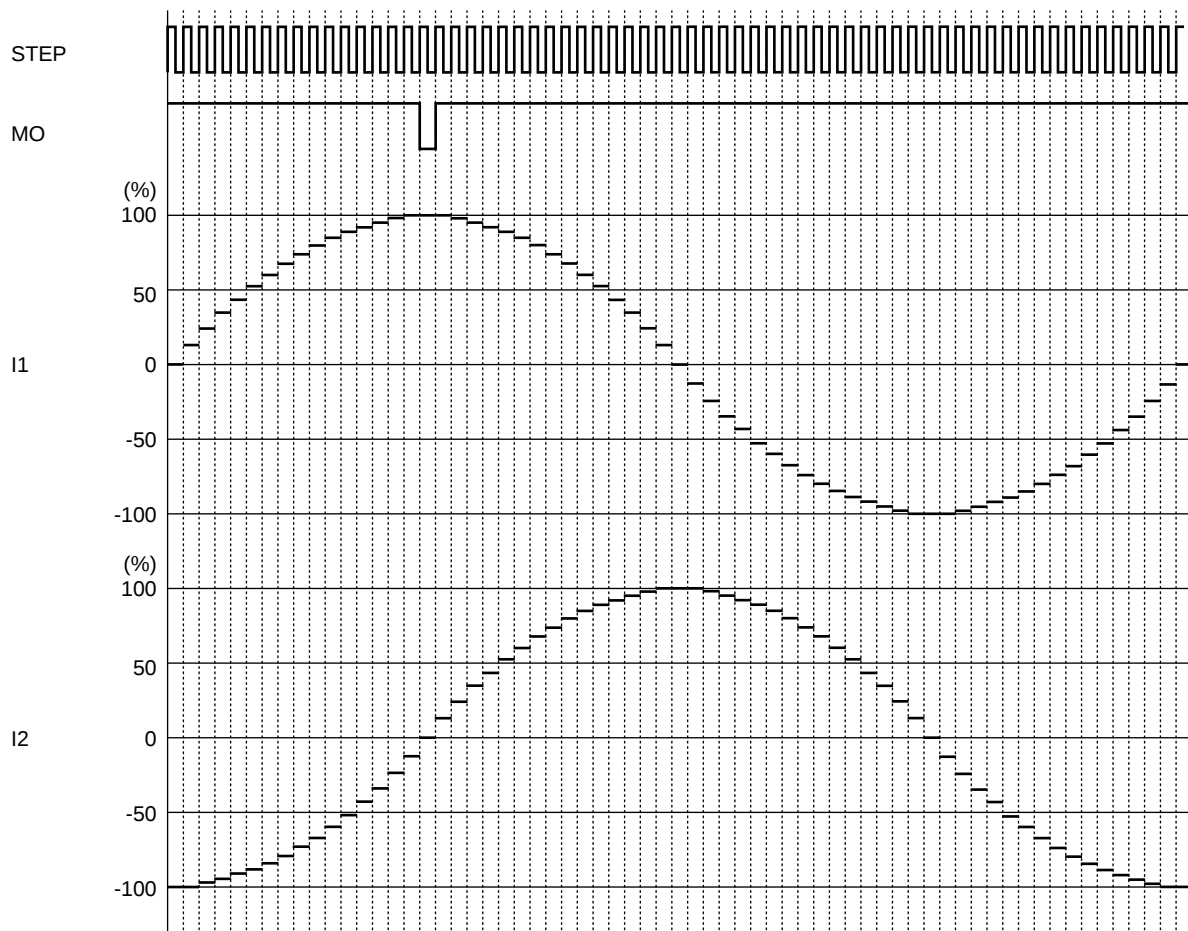
STEP	1/20 (%)		1/10 (%)	
	1ch	2ch	1ch	2ch
θ0	100	0	100	0
θ1	100	8		
θ2	99	16	99	16
θ3	97	23		
θ4	95	31	95	31
θ5	92	38		
θ6	89	45	89	45
θ7	85	52		
θ8	81	59	81	59
θ9	76	65		
θ10	71	71	71	71
θ11	65	76		
θ12	59	81	59	81
θ13	52	85		
θ14	45	89	45	89
θ15	38	92		
θ16	31	95	31	95
θ17	23	97		
θ18	16	99	16	99
θ19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

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

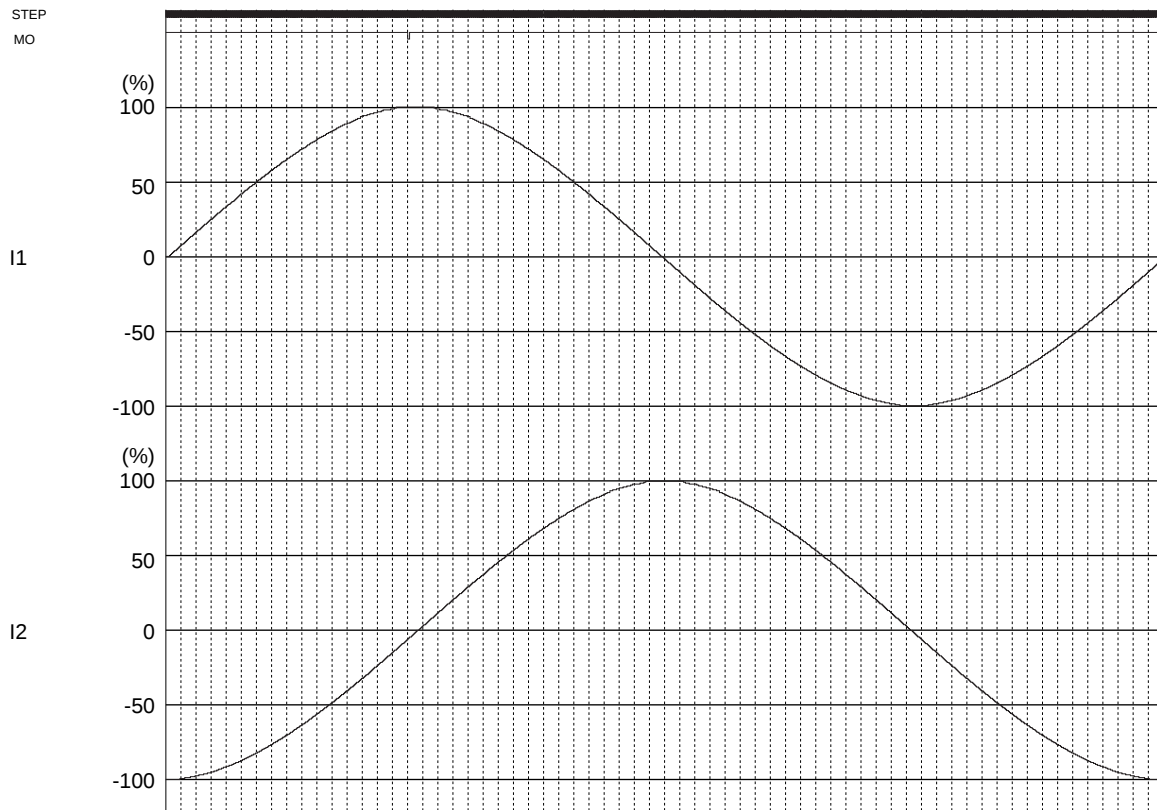
Half STEP (CW mode)



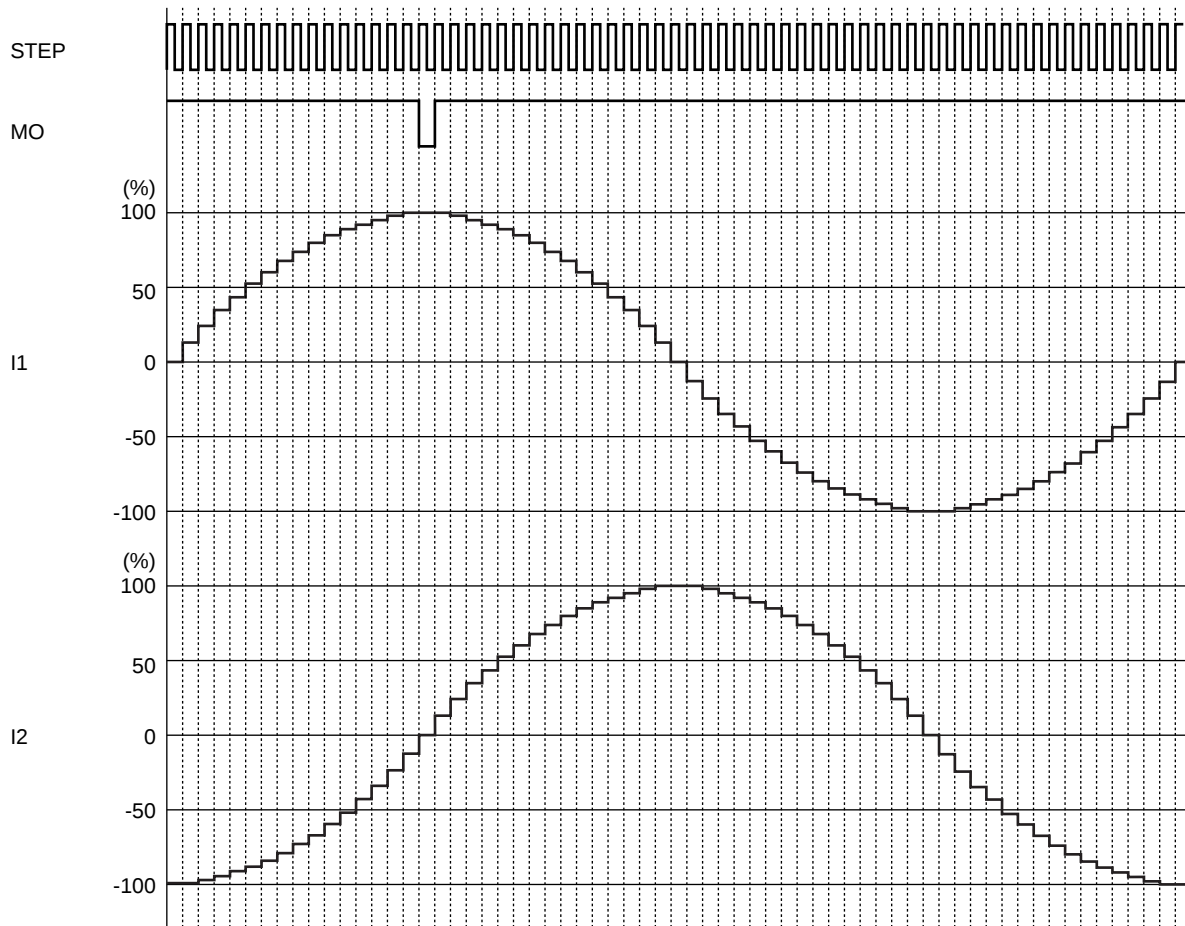
1/16 STEP (CW mode)



1/128 STEP (CW mode)



1/20 STEP (CW mode)

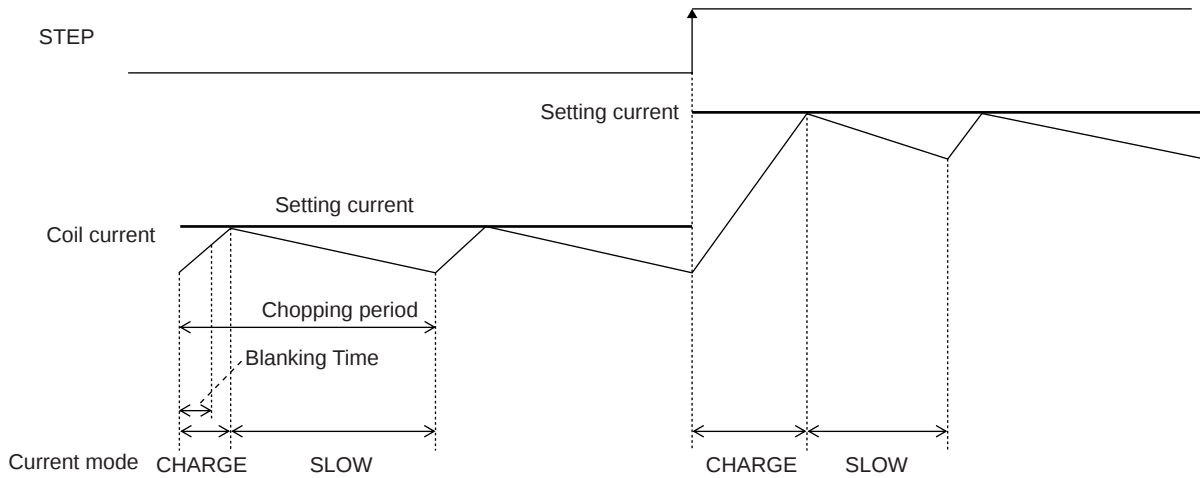


(13) Current control operation

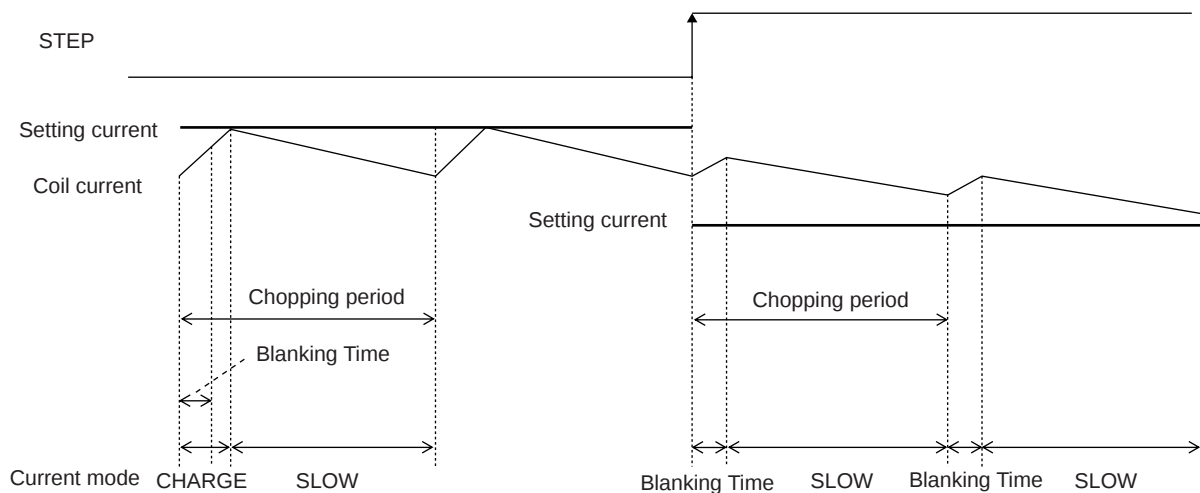
SLOW DECAY current control operation

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.

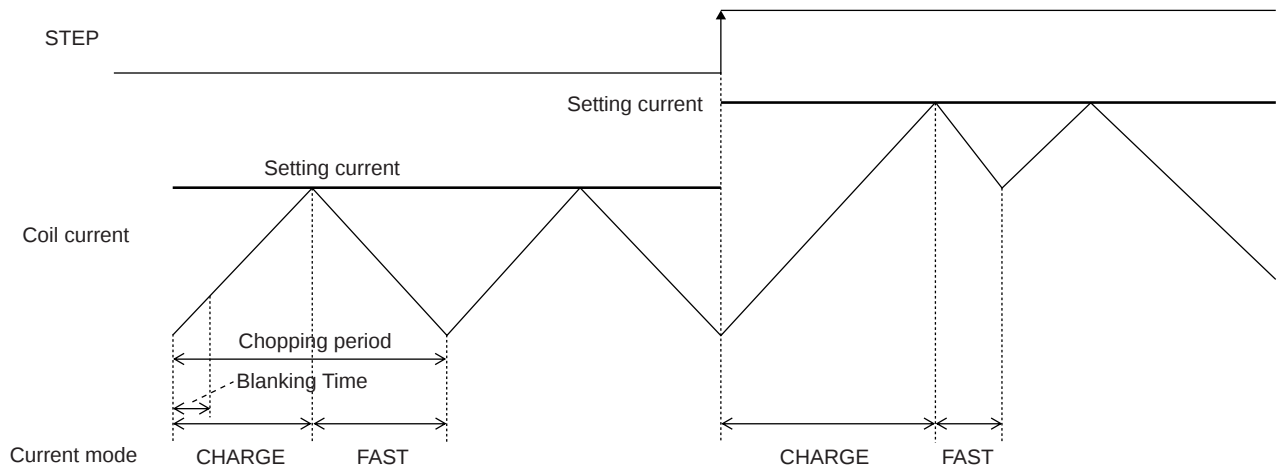
The IC enters CHARGE mode at a rising edge of the chopping oscillation. (A period of CHARGE mode (Blanking Time) is forcibly present in approximately 1 μ s, regardless of the current value of the coil current (ICOIL) and set current (IREF)).

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

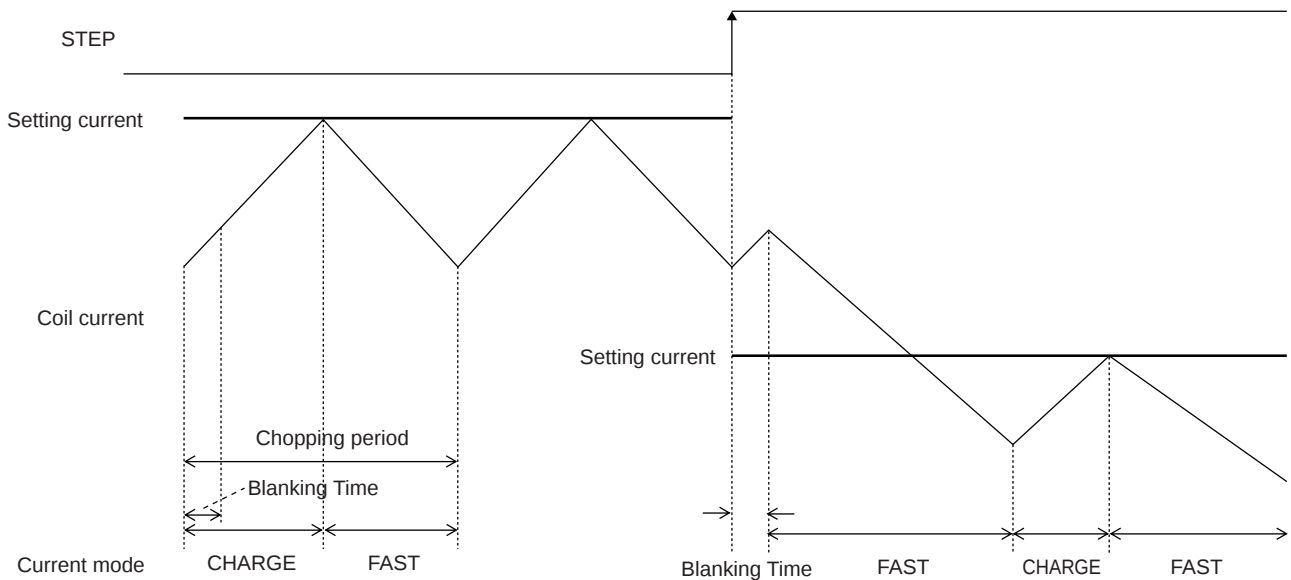
At the constant-current in SLOW DECAY mode, following to the setting current from the coil current may take time (or not follow) for the current delay attenuation.

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 1 μ s, regardless of the current value of the coil current (ICOIL) and set current (IREF)).

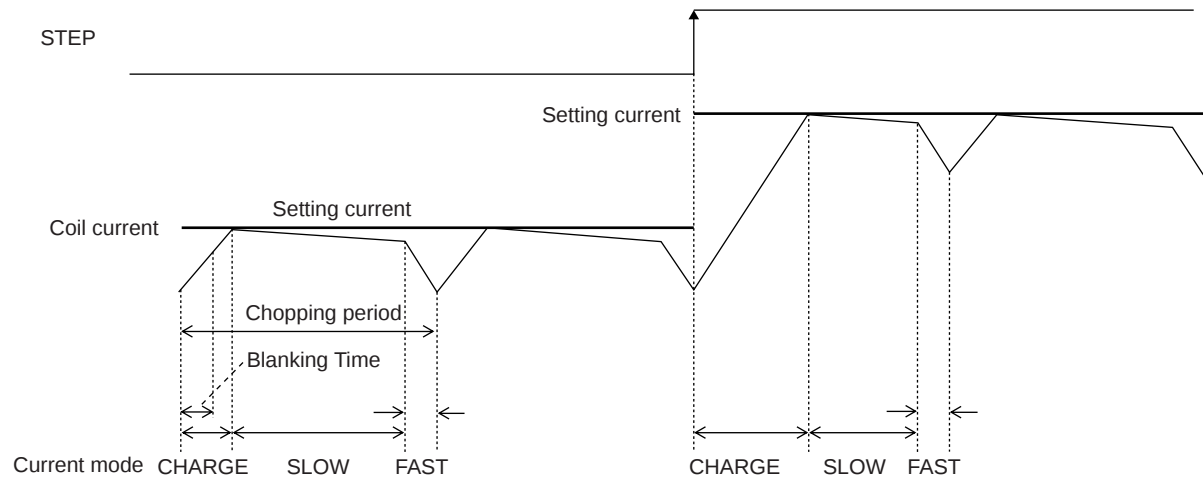
After the period of the blanking time, the IC operates in CHARGE mode until $ICOIL \geq IREF$. After that, the mode switches to the FAST DECAY mode and the coil current is attenuated until the end of a chopping period.

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.

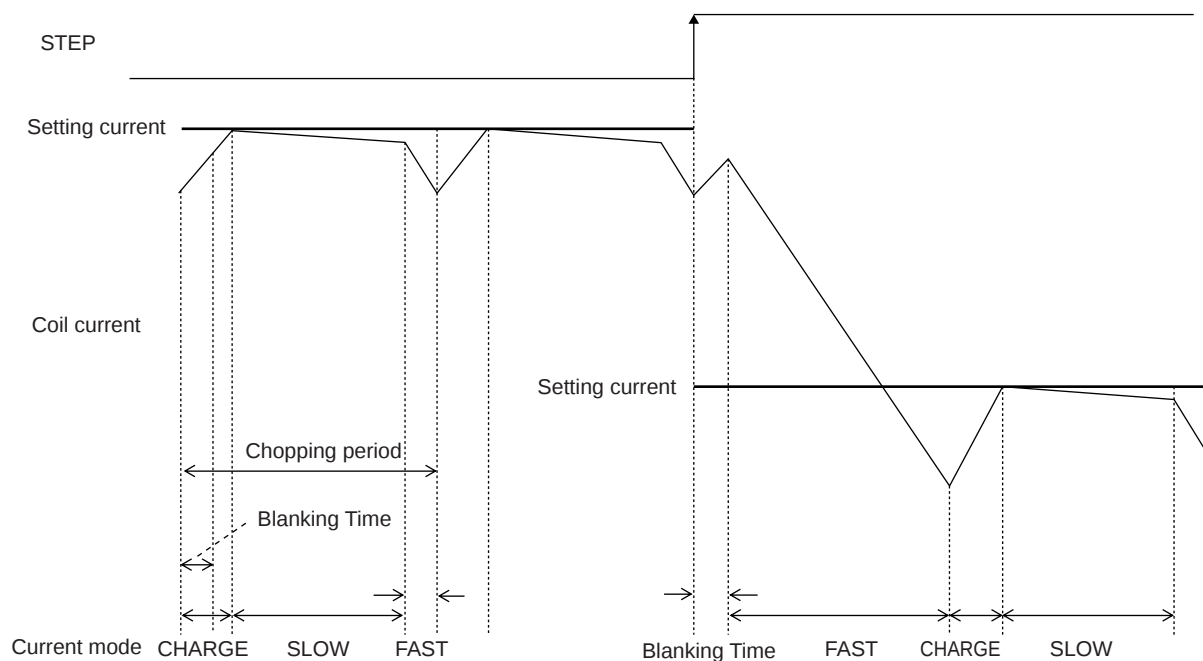
MIXED DECAY current control operation

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 1 μ s, 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 $ICOIL \geq IREF$. After that, it switches to SLOW DECAY mode and then switches to FAST DECAY mode in the last approximately 1 μ s of the period.

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

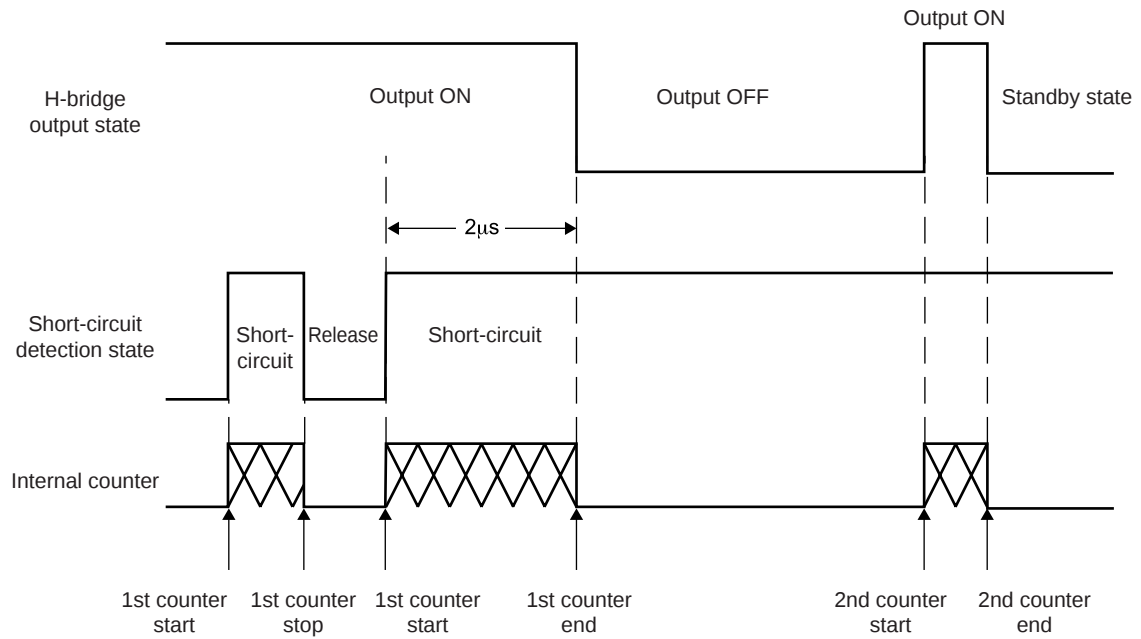
The IC switches to FAST DECAY mode and the coil current is attenuated with the FAST DECAY operation until the end of a chopping period.

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 decreasing 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. $256\mu\text{s}$). 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.

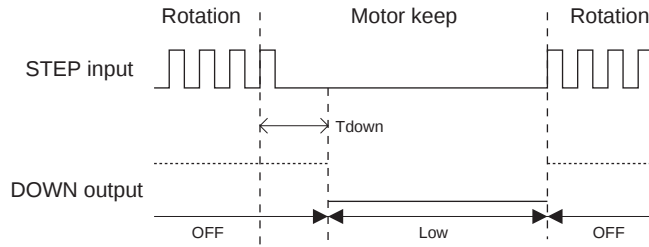
The open-drain output in once turned ON, is turned OFF at the next rising edge of STEP.

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

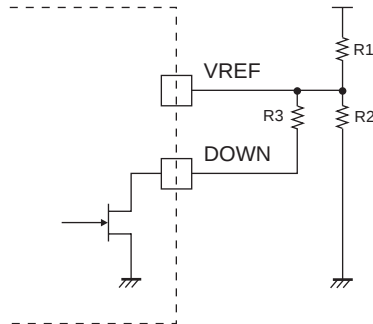
$$T_{down} = C_{osc2} \times 0.4 \times 10^9 \text{ (s)}$$

(Example) When $C_{osc2} = 1500\text{pF}$, the STEP signal detection time is shown below.

$$T_{down} = 1500\text{pF} \times 0.4 \times 10^9 = 0.6 \text{ (s)}$$



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.

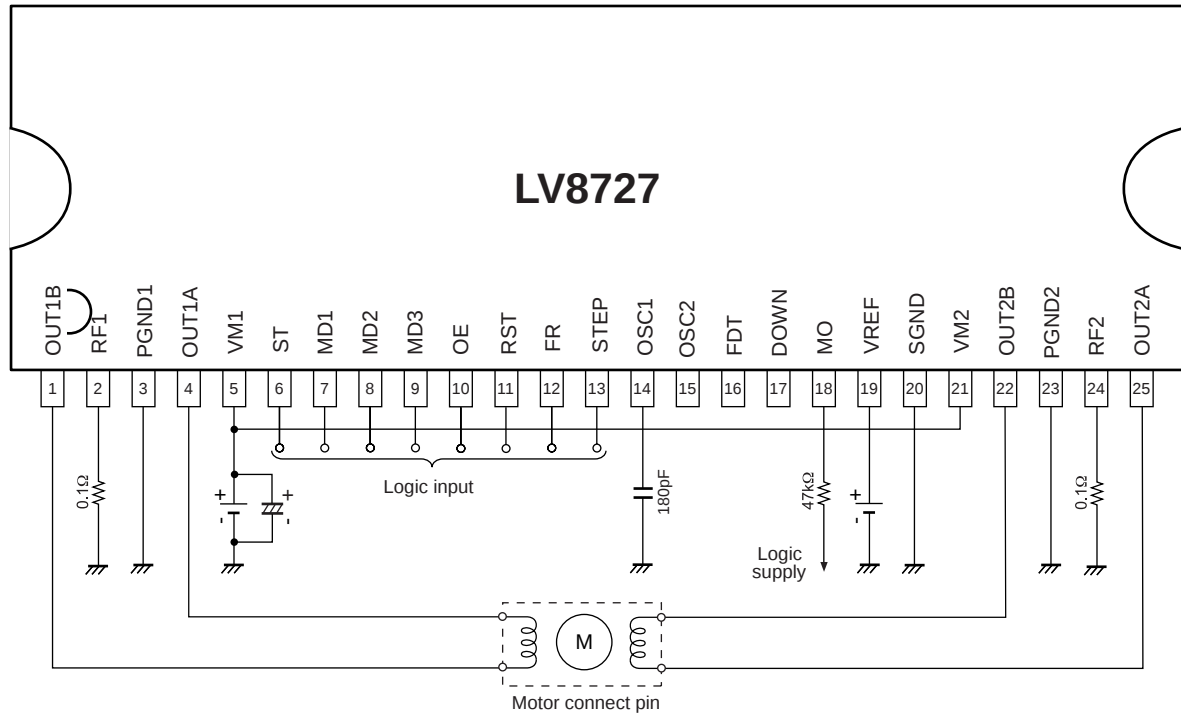


(Example) When $V1=5\text{V}$, $R1=27\text{k}\Omega$, $R2=4.7\text{k}\Omega$, $R3=1\text{k}\Omega$, the VREF input voltage is shown below.

DOWN output OFF: $V_{REF} = V1 \times R2 / (R1 + R2) = 0.741\text{V}$

DOWN output ON: $V_{REF} = V1 \times (R2 \parallel R3) / (R1 + (R2 \parallel R3)) = 0.126\text{V}$

Application Circuit Example



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

- Constant-current setting

$$I_{OUT} = V_{REF} / 3 / R_F$$
 (Example) When is $V_{REF} = 0.9V$

$$I_{OUT} = 0.9V / 3 / 0.1\Omega = 3A$$
- Chopping frequency setting

$$F_{chop} = I_{chop} / (C_{chop} \times V_t \times 2)$$

$$= 10\mu A / (180pF \times 0.5V \times 2) = 55.6kHz$$

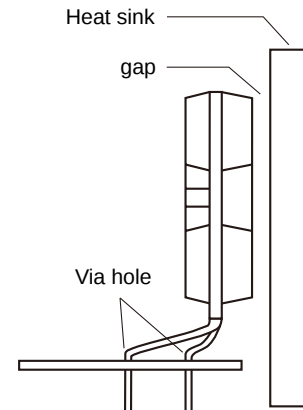
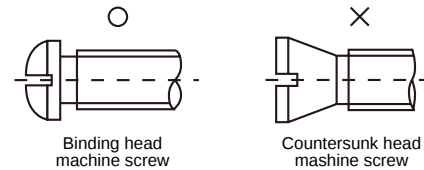
HZIP25 Heat sink attachment

Heat sinks are used to lower the semiconductor device junction temperature by leading the heat 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.

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