

SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

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 ; 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.
- IO 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	Α
Output peak current	I _O peak	tw≤10ms, duty 20%	4.6	Α
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.

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LV8727

Recommendation Operating Ratings at Ta = 25°C

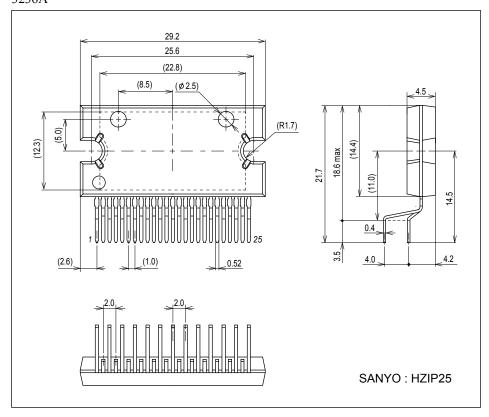
Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range	v _M		9 to 45	V
Logic input voltage	V _{IN}		0 to 5	V
VREF input voltage range	VREF		0 to 3	V

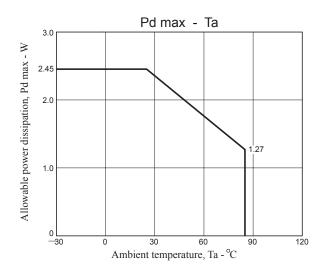
Electrical Characteristics at $Ta=25^{\circ}C,\,V_{\mbox{\scriptsize M}}=24V,\,VREF=1.5V$

D	0	O continue		Ratings		Unit
Parameter	Symbol	Conditions	min	typ	max	
Standby mode current drain	I _M st	ST = "L"		70	100	μΑ
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	μΑ
	I _{IN} H	V _{IN} = 5V	30	50	70	μА
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	losc1		7	10	13	μΑ
Chopping oscillation circuit	Vtup1		0.8	1	1.2	V
threshold voltage	Vtdown1		0.3	0.5	0.7	V
VREF pin input voltage	Iref	VREF = 1.5V	-0.5			μΑ
DOWN output residual voltagr	V _O 1DOWN	Idown = 1mA		50	200	mV
MO pin residual voltage	V _O 1MO	Imo = 1mA		50	200	mV
Hold current switching frequency	Fdown	Cosc2 = 1500pF	1.12	1.6	2.08	Hz
OSC2 pin charge/discharge current	losc2		7	10	13	μΑ
Hold current switching frequency	Vtup2		0.8	1	1.2	V
threshold voltage	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	l _O leak	V _M = 50V			50	μА
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

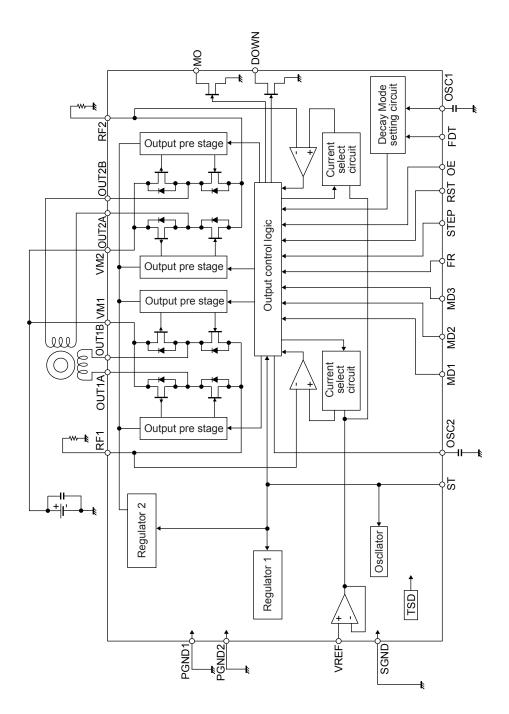
Package Dimensions unit: mm (typ)

unit : mm (typ) 3236A

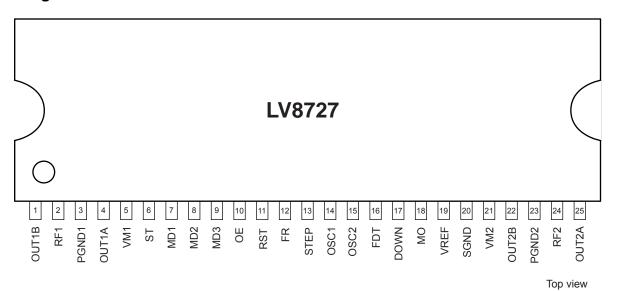




Block Diagram



Pin Assignment



Pin Functions

Pin Fi	unctions		
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	Internal 5V regulator 10kΩ GND O
6	ST	Chip enable input pin.	Internal 5V regulator 20kΩ 10kΩ W SROKΩ
1 2 3 4 5 21 22 23 24 25	OUT1B RF1 PGND1 OUT1A V _M 1 V _M 2 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.	521 425 10kΩ 500Ω 500Ω 500Ω 224

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Pin No.	Pin Name	Pin Functtion	Equivalent Circuit
19	VREF	Constant-current control reference voltage input pin.	Internal 5V regulator 5000Ω GND O
17	DOWN	Holding current output pin.	Internal 5V
18	МО	Position detecting monitor pin.	Internal 5V regulator The state of the sta
14 15	OSC1 OSC2	Chopping frequency setting capacitor connection pin. Holding current detection time setting capacitor connection pin.	Internal 5V regulator
16	FDT	Decay mode select voltage input	Internal 5V regulator $72k\Omega$ $9k\Omega$ $16k\Omega$

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).

Inj	out	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 p	oosition
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	МО
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

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

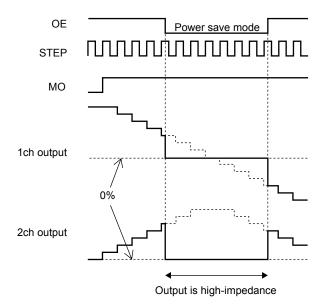
$$I_{OUT} = (0.9V/3)/0.1\Omega = 3A$$

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

(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.

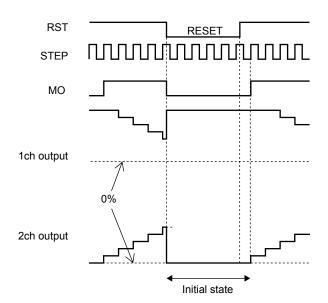
OE	Operation mode
L	Output: OFF
Н	Output: ON



(7) Reset function

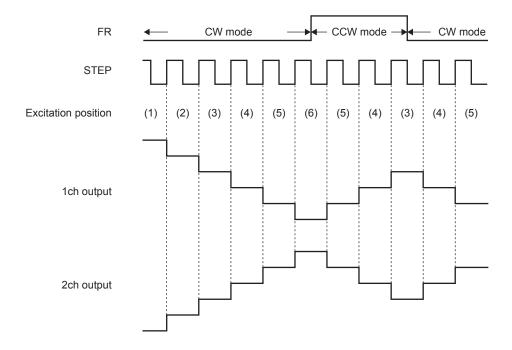
When the RST pin is set Low, the output goes to initial mode and excitation position is fixed in the initial position for STEP pin and FR pin input. MO pin outputs at low levels at the initial position. (Open drain connection)

RST	Operation mode
Н	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.

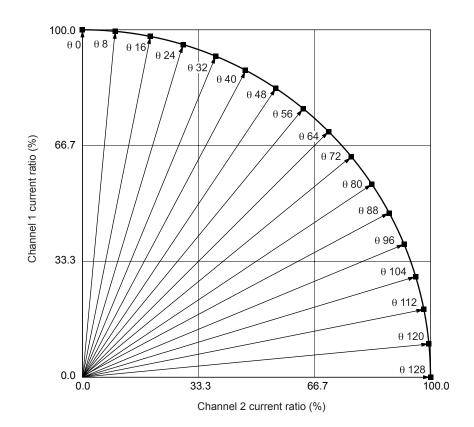
Fcp =
$$1 / (Cosc1 / 10 \times 10^{-6})$$
 (Hz)

(Example) When Cosc1 = 180pF, the chopping frequency is shown below. Fcp = 1 / ($180 \times 10^{-12} / 10 \times 10^{-6}$) = 55.6(kHz)

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

(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										

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		eding page		(%)	1/22	2 (%)	1/14	5 (%)	1 /0	(%)	Нан	e (%)
STEP	1/120	2ch	1ch	2ch	1/32 1ch	2ch	1ch	2ch	1 ch	2ch	1ch	2ch
θ26	95	31	95	31	TCII	2011	Ten	2011	1011	2011	1011	2011
θ27	95	33	75	- 51								
θ28	94	34	94	34	94	34						
θ29	94	35	71	54	74	34						
θ30	93	36	93	36								
θ31	93	37	93	30								
	92		92	38	92	20	92	20	92	20		
θ32		38	92	36	92	38	92	38	92	38		
θ33	92	39	0.1	41								
θ34	91	41	91	41								
θ35	91	42										
θ36	90	43	90	43	90	43						
θ37	90	44										
θ38	89	45	89	45								
θ39	89	46										
θ40	88	47	88	47	88	47	88	47				
θ41	88	48										
θ42	87	49	87	49								
θ43	86	50										
θ44	86	51	86	51	86	51						
θ45	85	52										
θ46	84	53	84	53								
θ47	84	55										
θ48	83	56	83	56	83	56	83	56	83	56		
θ49	82	57										
θ50	82	58	82	58								
θ51	81	59										
θ52	80	60	80	60	80	60						
θ53	80	61										
θ54	79	62	79	62								
θ55	78	62										
θ56	77	63	77	63	77	63	77	63				
θ57	77	64	- / /	03	- / /	03	- / /	03				
θ58	76	65	76	65								
			70	03								
059	75	66	7.4	(7	74	(7						
θ60	74	67	74	67	74	67						
θ61	73	68										
θ62	72	69	72	69								
θ63	72	70										
θ64	71	71	71	71	71	71	71	71	71	71	71	71
θ65	70	72										
θ66	69	72	69	72								
θ67	68	73										
θ68	67	74	67	74	67	74						
θ69	66	75										
θ70	65	76	65	76								
θ71	64	77			ļ			ļ				
θ72	63	77	63	77	63	77	63	77				
θ73	62	78										
θ74	62	79	62	79								
θ75	61	80										
θ76	60	80	60	80	60	80						
θ77	59	81										
θ78	58	82	58	82								
θ79	57	82										
θ80	56	83	56	83	56	83	56	83	56	83		
θ81	55	84										
082	53	84	53	84								
θ83	52	85		, J.								
θ84	51	86	51	96	51	86						
	50		31	86	31	86		 				-
085		86	40	07	 			 				
θ86	49	87	49	87	 			 				-
087	48	88		0.0	4.5	0.0	45	00				
θ88	47	88	47	88	47	88	47	88				
θ89	46	89										
θ90	45	89	45	89								

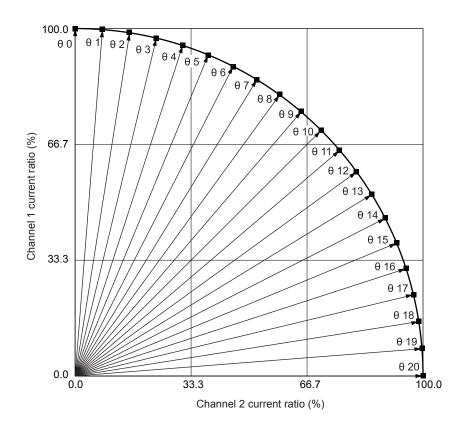
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STEP	1/128 (%)		1/64 (%)		1/32 (%)		1/16 (%)		1/8 (%)		Half (%)	
SIEP	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch	1ch	2ch
θ91	44	90										
θ92	43	90	43	90	43	90						
θ93	42	91										
θ94	41	91	41	91								
θ95	39	92										
θ96	38	92	38	92	38	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

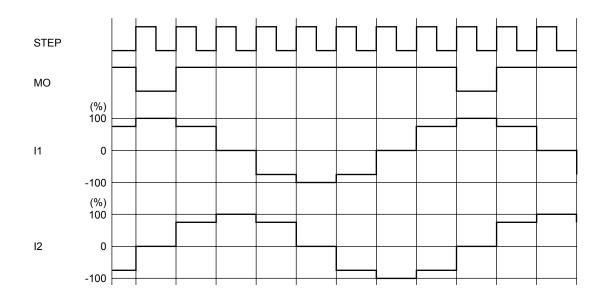
Output current vector locus (one step is normalized to 90 degrees) $1/10,\,1/20$ STEP



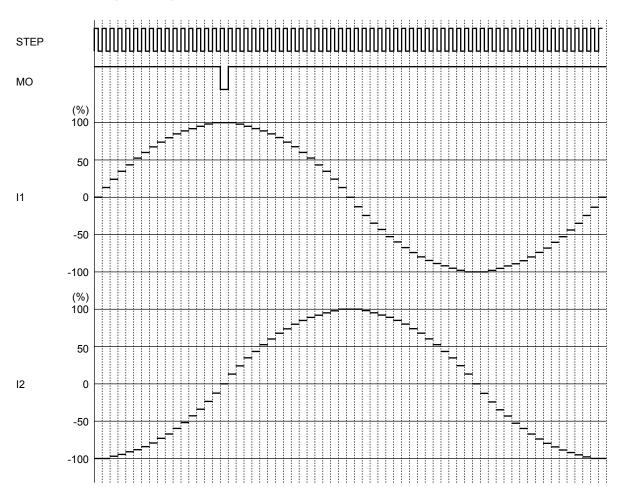
Current setting ratio in each micro step resolution 1/10, 1/20 STEP

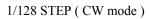
STEP	1/20	(%)	1/10 (%)				
SIEP	1ch	2ch	1ch	2ch			
θ0	100	0	100	0			
θ1	100	8					
θ2	99	16	99	16			
θ3	97	23					
θ4	95	31	95	31			
θ5	92	38					
θ6	89	45	89	45			
θ7	85	52					
θ8	81	59	81	59			
θ9	76	65					
θ10	71	71	71	71			
θ11	65	76					
θ12	59	81	59	81			
θ13	52	85					
θ14	45	89	45	89			
θ15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

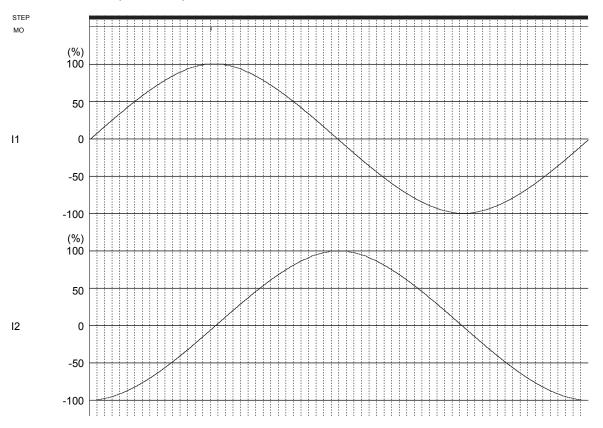
(12) Current wave example in each micro step resolution (Half, 1/16, 1/128, 1/20 STEP) Half STEP (CW mode)



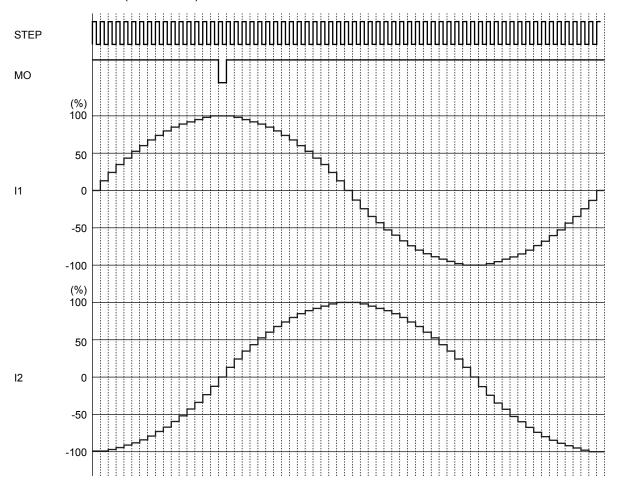
1/16 STEP (CW mode)







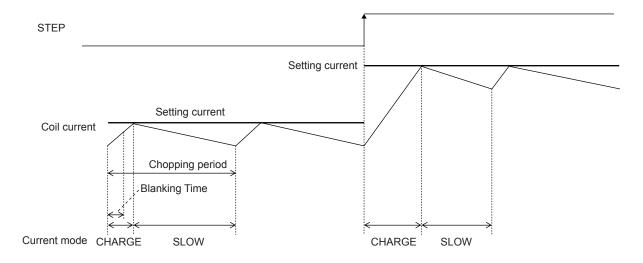
1/20 STEP (CW mode)



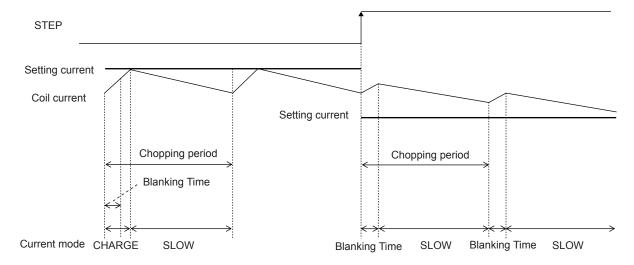
(13) Current control operation

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)



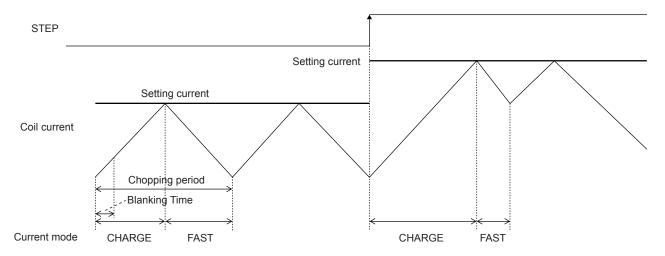
Each of current modes operates with the follow sequence.

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)).

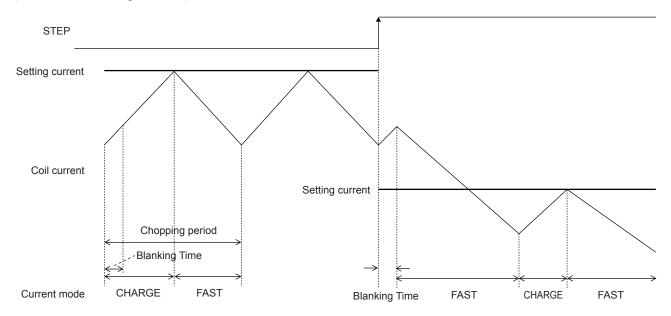
After the period of the blanking time, the IC operates in CHARGE mode until ICOIL \geq IREF. After that, the mode switches to the SLOW DECAY mode and the coil current is attenuated until the end of a chopping period. At the constand-current in SLOW DECAY mode, following to the setting current from the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

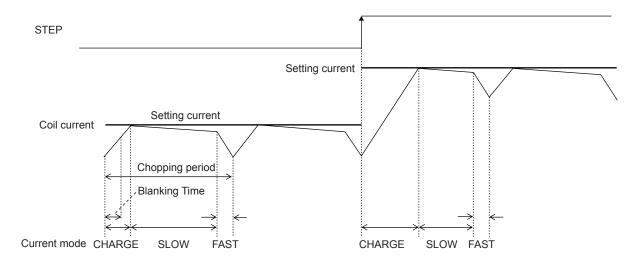
The IC enters CHARGE mode at a rising edge of the chopping oscillation. (A period of CHARGE mode (Blanking Time) is forcibly present in approximately 1µs, regardless of the current value of the coil current (ICOIL) and set current (IREF)).

After the period of the blanking time, the IC operates in CHARGE mode until ICOIL \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.

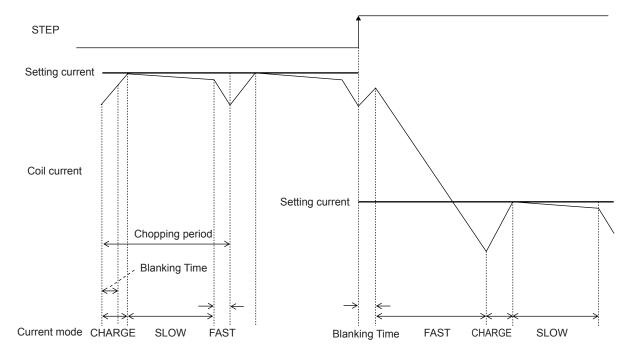
MIXED DECAY current control operation

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 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 \geq 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:

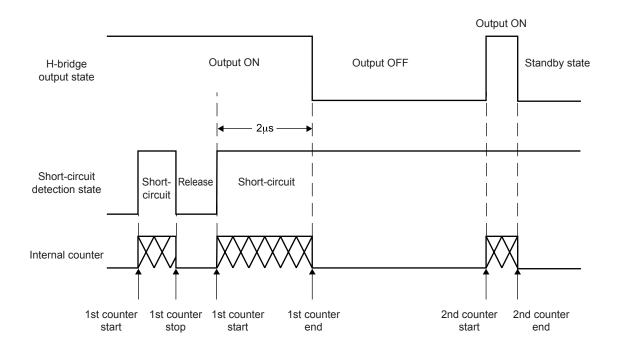
The IC switches to FAST DECAY mode and the coil current is attenuated with the FAST DECAY operation until the end of a chopping period.

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 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. $256\mu s$). 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

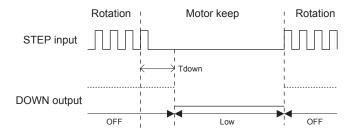
The DOWN output pin is an open-drain connection.

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.

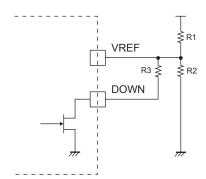
The open-drain output in once turned ON, is turned OFF at the next rising edge of STEP.

Holding current switching time (Tdown) is set as shown below by a capacitor between OSC2 pin and GND. $Tdown = Cosc2 \times 0.4 \times 10^9$ (s)

(Example) When Cosc2 = 1500pF, the STEP signal detection time is shown below. Tdown = $1500pF \times 0.4 \times 109 = 0.6$ (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.

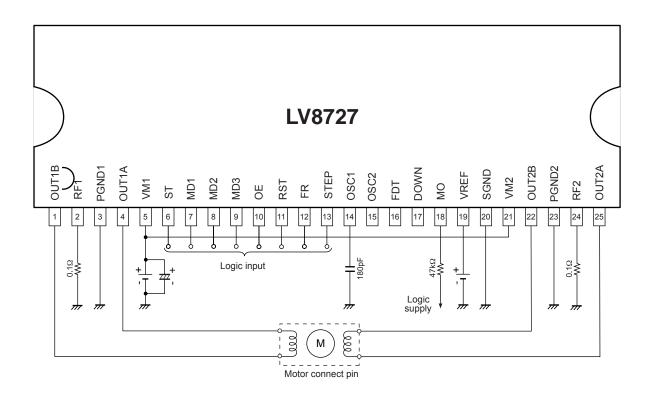


(Example) When V1=5V, R1=27k Ω , R2=4.7k Ω , R3=1k Ω , the VREF input voltage is shown below.

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

DOWN output ON: $VREF=V1\times(R2 \| R3)/(R1+(R2 \| R3))=0.126V$

Application Circuit Example



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

· Constant-current setting

IOUT=VREF/3/RF

(Example) When is VREF=0.9V

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

· Chopping frequency setting

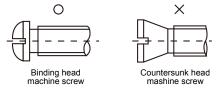
Fchop=Ichop/(Cchop×Vt×2)

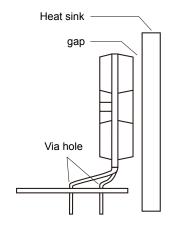
 $=10\mu A/(180pF\times0.5V\times2)=55.6kHz$

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
 - \cdot 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.
- · Sanyo 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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