STK682-010-E

Thick Film Hybrid IC

2-phase Stepping Motor Driver Application Note

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Overview

The STK682-010-E is a hybrid IC for use as a Bipolar, 2-phase stepping motor driver with PWM current control.

Function

- Output on-resistance (High side 0.3 Ω, Low side 0.25 Ω, Total 0.55 Ω; Ta = 25℃, I_O = 2.5A)
- VMmax=36V(DC), Iopmax=3.0A
- 2, 1-2, W1-2, 2W1-2, 4W1-2, 8W1-2, 16W1-2, 32W1-2 phase excitation are selectable
- With built-in automatic half current maintenance energizing function
- Over current protection circuit
- Thermal shutdown circuit
- Input pull down resistance
- With reset pin and enable pin•

Specifications

bsolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	VMmax		36.0	V
Peak output current	Iopmax		3.0	A
Logic input voltage	VINmax		6.0	V
VREF input voltage	VREFmax		6.0	V
Operating substrate temperature	Tc		–20 to +105	°C
Storage temperature	Tstg		–40 to +125	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range	VM		9.0 to 32.0	V
Logic input voltage range	VIN		0 to 5.0	V
V_{CC} input voltage range	V_{CC}		0 to 5.0	V
VREF input voltage range	VREF		0 to 3.0	V
Output current1	Io1	1-2 Phase-ex, Tc ≤ 90°C	3.0	A
Output current2	Io2	1-2 Phase-ex, Tc=105°C	2.5	A
Output current3	Io3	2 Phase-ex, Tc=105°C	1.8	A

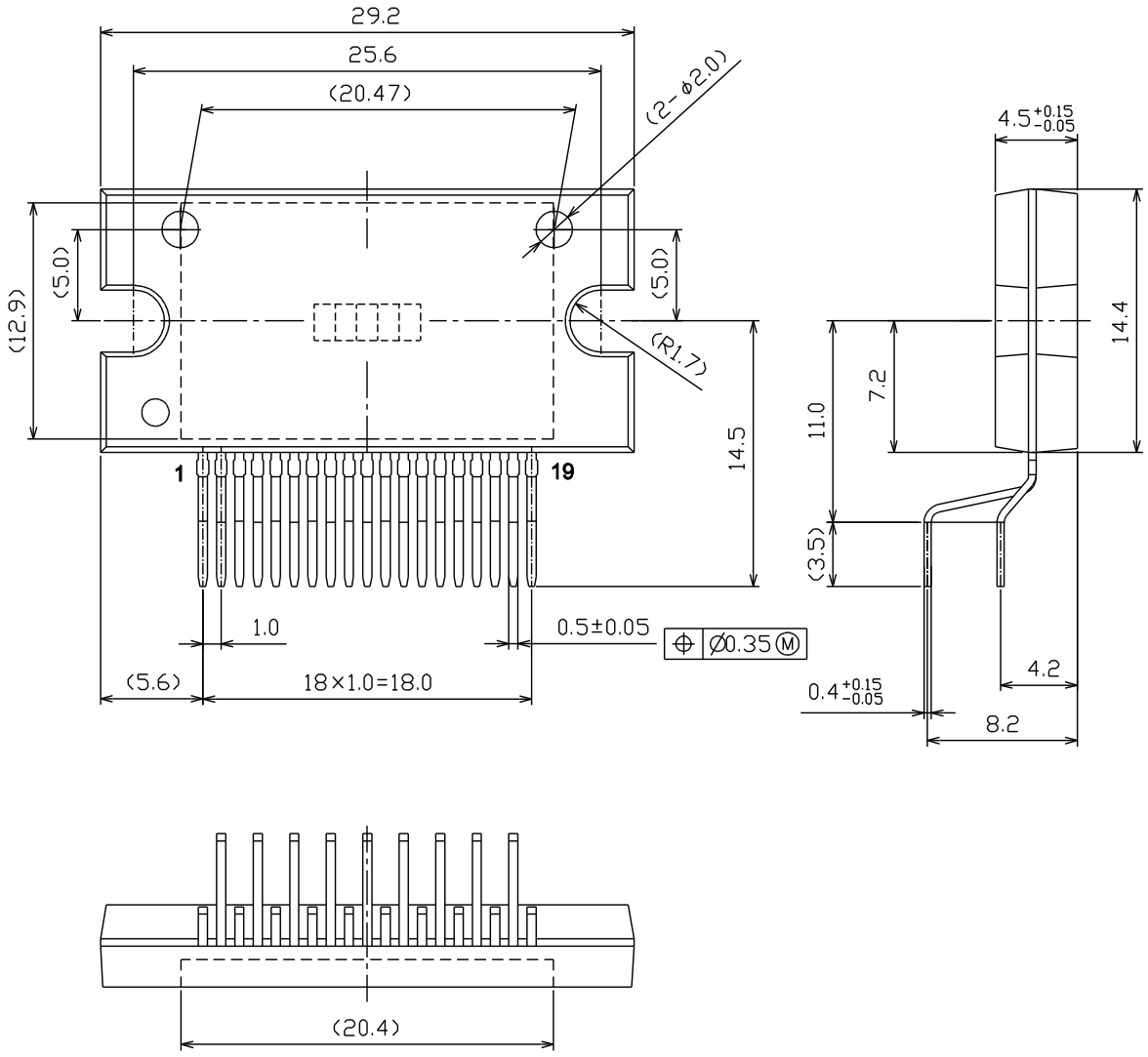
Electrical Characteristics at Ta = 25°C, V_{CC} = 5V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain	IMstn	VCC="L"		70	100	μA
Current drain	IM	VCC="H", ENABLE="H" No Load		3.3	4.6	mA
Thermal shutdown temperature	TSD	Design guarantee	150	180	210	°C
Thermal hysteresis width	ΔTSD	Design guarantee		40		°C
Logic pin input current	IinL1	VIN=0.8V	3	8	15	μA
	IinH1	VIN=5V	30	50	70	μA
V_{CC} pin input current	V_{CC}	15pin=5V	51	83	115	μA
Logic input high-level voltage	Vinh	Pins 2,3,16,17,18,19	2.0			V
Logic input low-level voltage	Vinl	Pins 2,3,16,17,18,19			0.8	V
FDT pin high-level voltage	Vfdth	Pin 6	3.5			V
FDT pin middle-level voltage	Vfdtm	Pin 6	1.1		3.1	V
FDT pin low-level voltage	Vfdtl	Pin 6			0.8	V
Chopping frequency	Fch	C1=100pF	58	83	108	kHz
Chopping frequency	Iosc1			10		μA
Chopping oscillator circuit threshold voltage	Vtup1			1		V
	Vtdown1			0.5		V
VREF pin input voltage	Iref	VREF=1.5V, CLK=10kHz	−0.5			μA
DOWN output residual voltage	VolDO	Idown=1mA, CLK=Low		40		mV
Hold current switching frequency	Falert			1.6		Hz
Blanking time	Tb1			1		μs
Output block						
Output on-resistance	Ronu	I_O=2.0A, high-side ON resistance		0.30	0.42	Ω
	Rond	I_O=2.0A, low-side ON resistance		0.25	0.35	Ω
Output leakage current	Ioleak	VM=36V			50	μA
Diode forward voltage	VD	ID=−2.0A		1.1	1.4	V
Current setting reference voltage	VRF	VREF=1.5V, Current ratio 100%		300		mV
Output short-circuit protection block						
Timer latch time	Tscp			256		μs

Package Dimensions

unit : mm (typ)

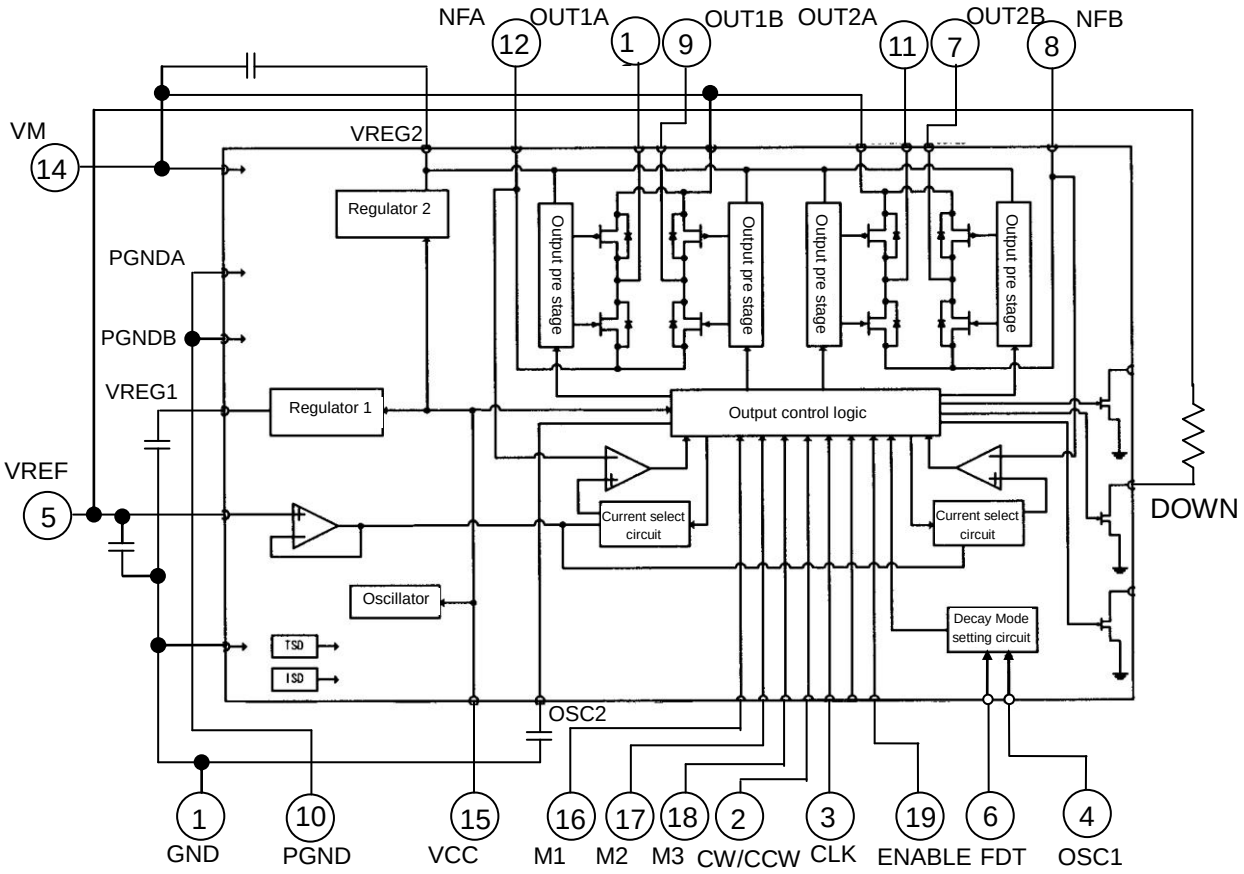
SIP19 29.2x14.4
CASE 127CF
ISSUE O



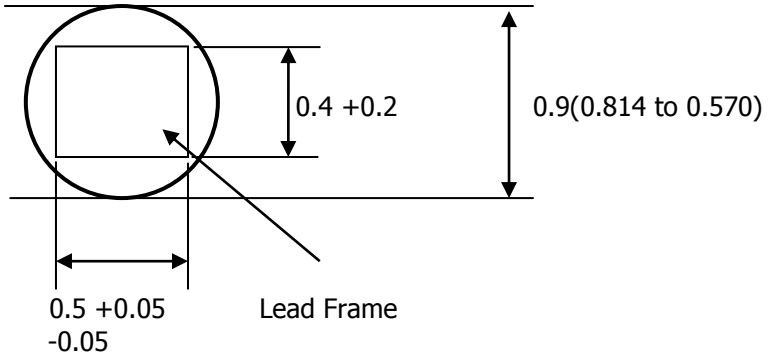
Pin Assignment

Pin No.	Pin symbol	Pin Functions
1	GND	Circuit GND
2	CW/CCW	Forward / Reverse signal input
3	CLK	Clock pulse signal input
4	OSC1	Chopping frequency setting capacitor connection
5	VREF	Constant-current control reference voltage input
6	FDT	Decay mode select voltage input
7	OUT2B	B phase OUTB output
8	NFB	B phase current sense resistance connection
9	OUT1B	B phase OUTA output
10	PGND	Power GND
11	OUT2A	A phase OUTB output
12	NFA	A phase current sense resistance connection
13	OUT1A	A phase OUTA output
14	VM	Motor supply connection
15	VCC	Chip enable input
16	M1	Excitation-mode switching pin
17	M2	
18	M3	
19	ENABLE	Output enable signal input

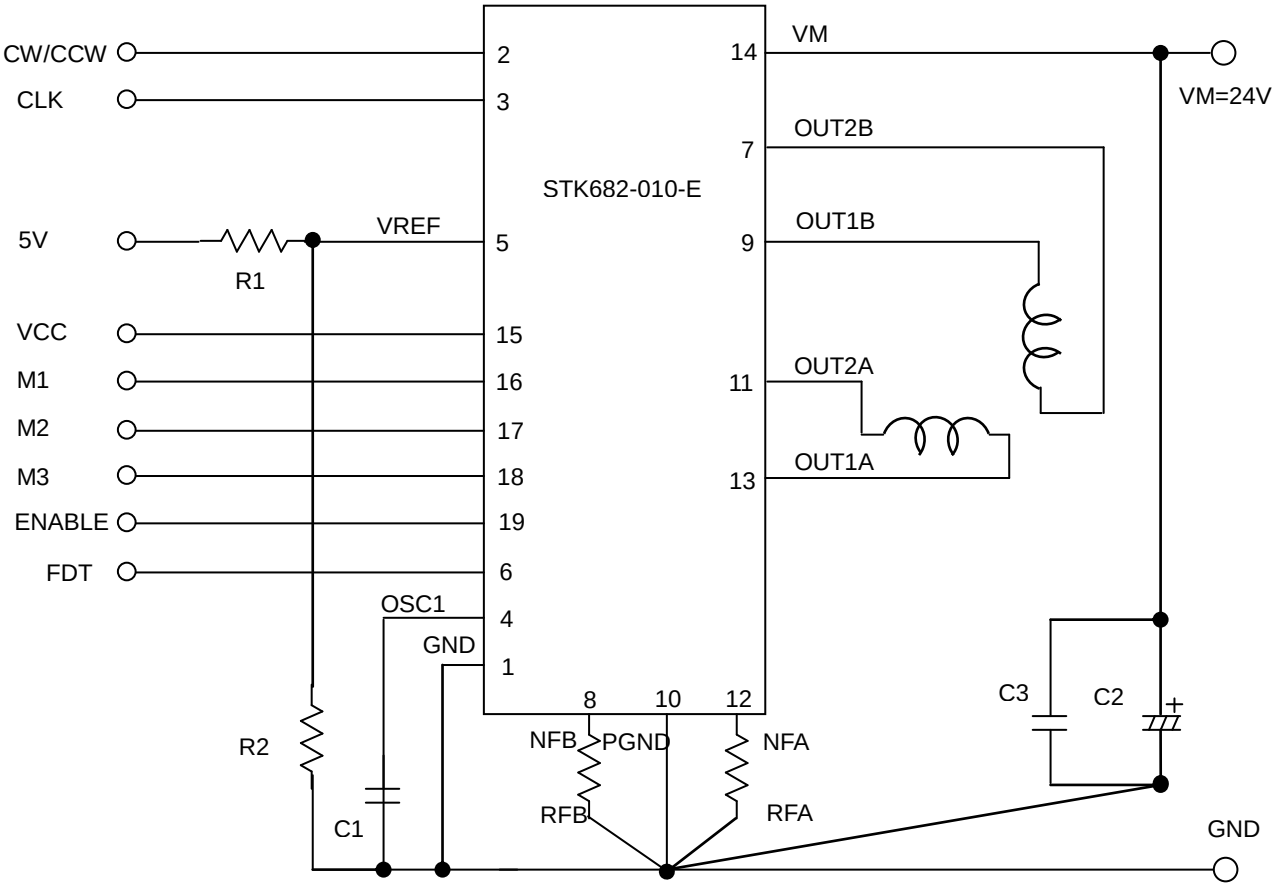
Block Diagram



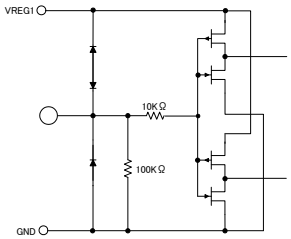
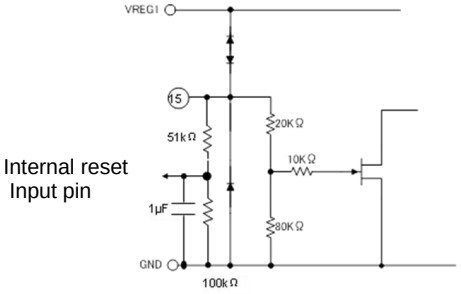
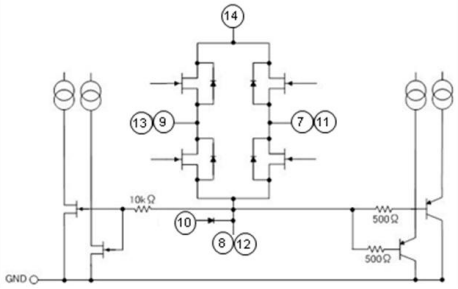
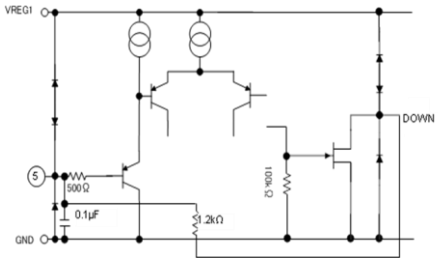
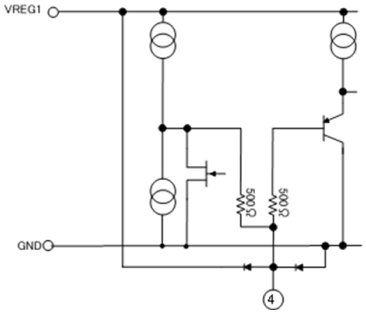
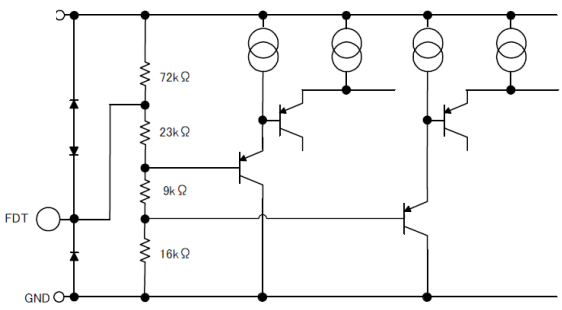
Recommend hole size for Lead Frame on PCB; 0.9 mm(max)



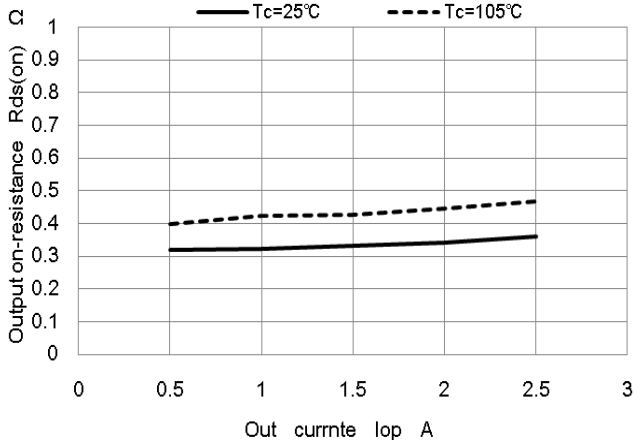
Application Circuit Example



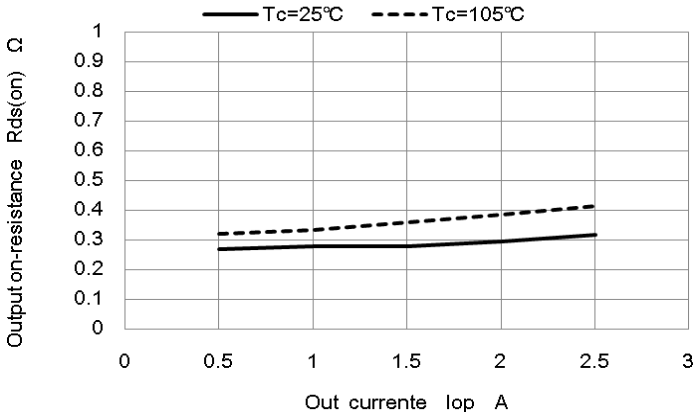
Equivalent circuit diagram

Pin No.	Pin type	Equivalent Circuit Diagram
3 2 19 18 17 16	CLK CW/CCW ENABLE M3 M2 M1	
15	VCC	
13 10 14 12 11 9 8 7	OUT1A PGND VM NFA OUT2A OUT1B NFB OUT2B	
5	VREF	
4	OSC1	
6	FDT	

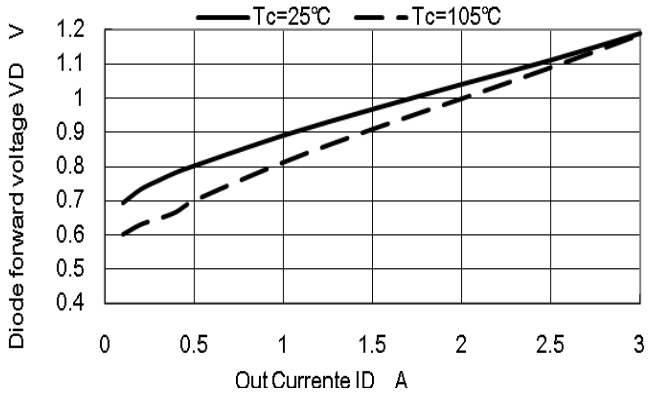
Output on-resistance-Out currnte(high said)



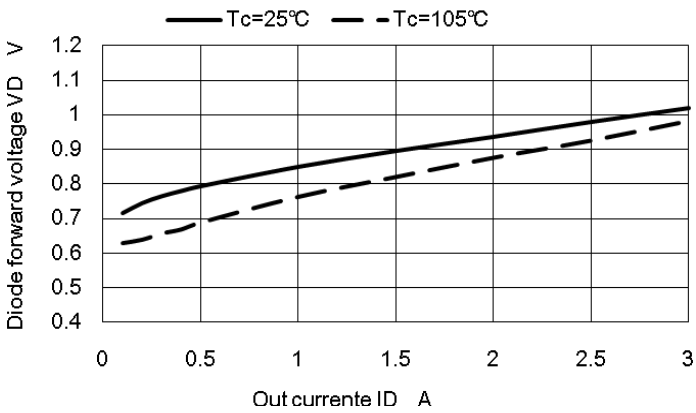
Output on-resistance-Out currente (Low said)



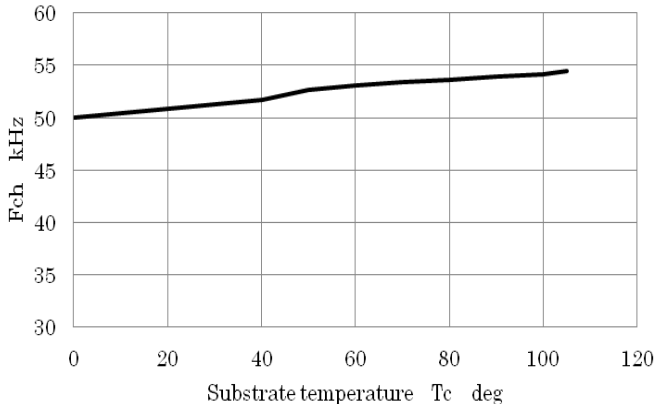
STK682-010-E High side VD - ID



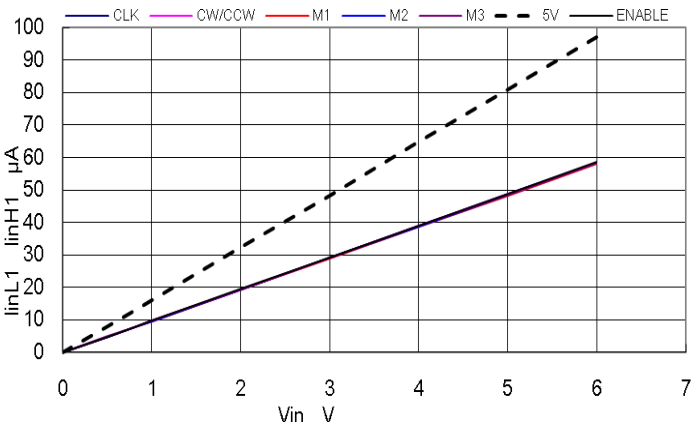
STK682-010-E Low side VD - ID



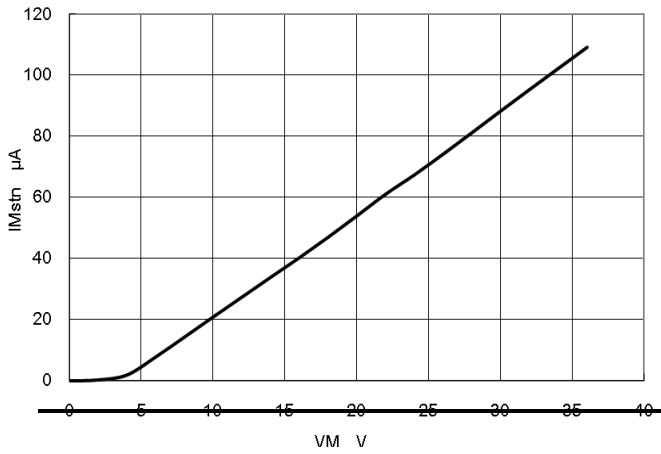
Fch-Tc at：180pf



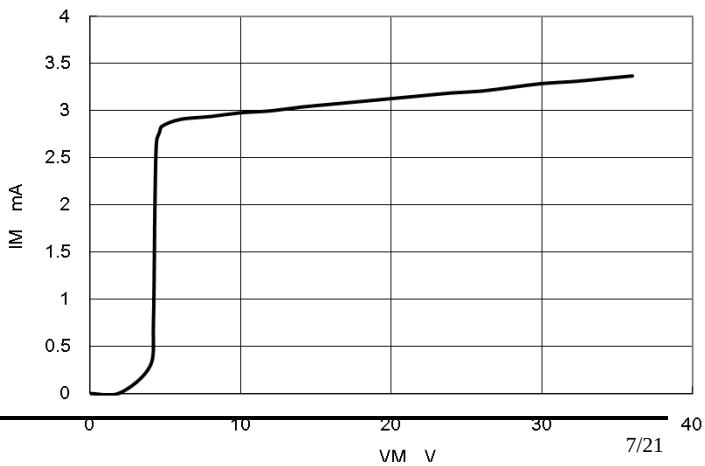
IinI1 IinH1 - Vin



IMstn - VM



IM - VM



Description of functions

(1) Excitation setting method

Set the excitation setting as shown in the following table by setting M1 pin, M2 pin and M3 pin

Input signal			MODE (Excitation)	Initial position	
M3	M2	M1		A phase current	B phase current
L	L	L	2 Phase	100%	−100%
L	L	H	1-2 Phase	100%	0%
L	H	L	W1-2 Phase	100%	0%
L	H	H	2W1-2 Phase	100%	0%
H	L	L	4W1-2 Phase	100%	0%
H	L	H	8W1-2 Phase	100%	0%
H	H	L	16W1-2 Phase	100%	0%
H	H	H	32W1-2 Phase	100%	0%

The initial position is also the default state at start-up and excitation position at counter-reset in each excitation mode

(2) Output current setting

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

I_{OUT} = (VREF / 5) / NFA (B) resistance

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

(Example) When VREF=1.5V and NFA (B) resistance is 0.3 Ω, the setting current is shown below.

I_{OUT} = (1.5 V / 5) / 0.3 Ω = 1.0 A

(3) Chip enable terminal/ VCC function

When Chip enable terminal/ V_{CC} pin is at low levels, the IC enters stand-by mode, all logic is reset and output is turned OFF.

When Chip enable terminal/ V_{CC} pin is at high levels, the stand-by mode is released

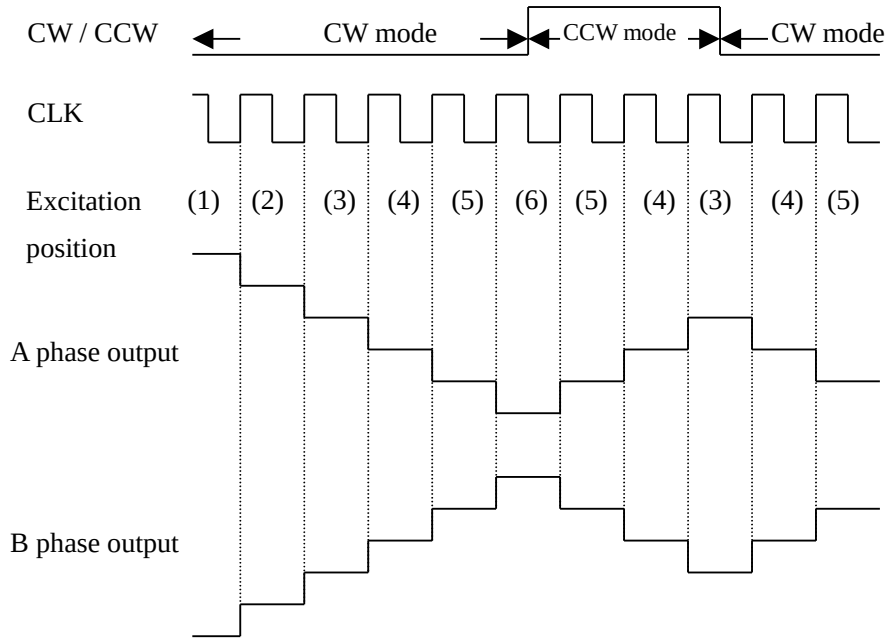
(4) Step pin function

CLK pin step signal input allows advancing excitation step

Input		Operation
V_{CC}	CLK	
L	*	Stand-by mode
H		Excitation step feed
H		Excitation step hold

(5) Forward / reverse switching function

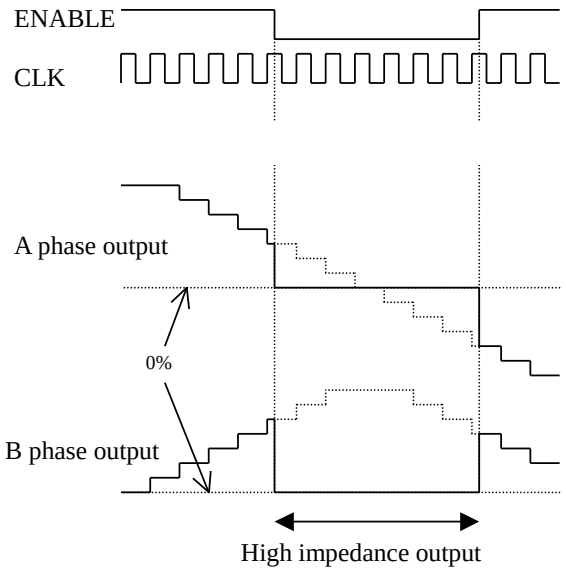
CW/CCW	Operation
L	CW
H	CCW



The internal D/A converter proceeds by a bit on the rising edge of the step signal input to the CLK pin. In addition, CW and CCW mode are switched by CW and CCW pin setting.
In CW mode, the B phase current is delayed by 90° relative to the A phase current. In CCW mode, the B phase current is advanced by 90° relative to the A phase current.

(6) Output enable function

When the ENABLE 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 CLK is input. Therefore, when ENABLE pin is returned to High, the output level conforms to the excitation position proceeded by the CLK input.



(7) DECAY mode

The DECAY mode of the output current becomes only MIXED DECAY.

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

(8) Chopping frequency setting function

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

$Fch = 1 / (C1+20pF / 10\times10^{-6})$ (Hz)

(Example) When Cosc1=100pF, the chopping frequency is shown below.

$Fch = 1 / ((20+ 100)\times10^{-12} / 10\times10^{-6})$ (Hz) = 83.3 (kHz)

Note

- The 20pF is a stray capacitance which is involved by the package of STK682-010-E.

(9) Output short-circuit protection circuit

Build-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 starts the operating and output is once turned OFF. After the timer latch time (typ : 256μs), output is turned ON again. Still the output is at short state, the output is turned OFF and fixed in stand-by mode.

When output is fixed in stand-by mode by output short protection circuit, output is released the latch by setting Chip enable terminal/ V_{CC}="L"

(10) Internal DOWN pin

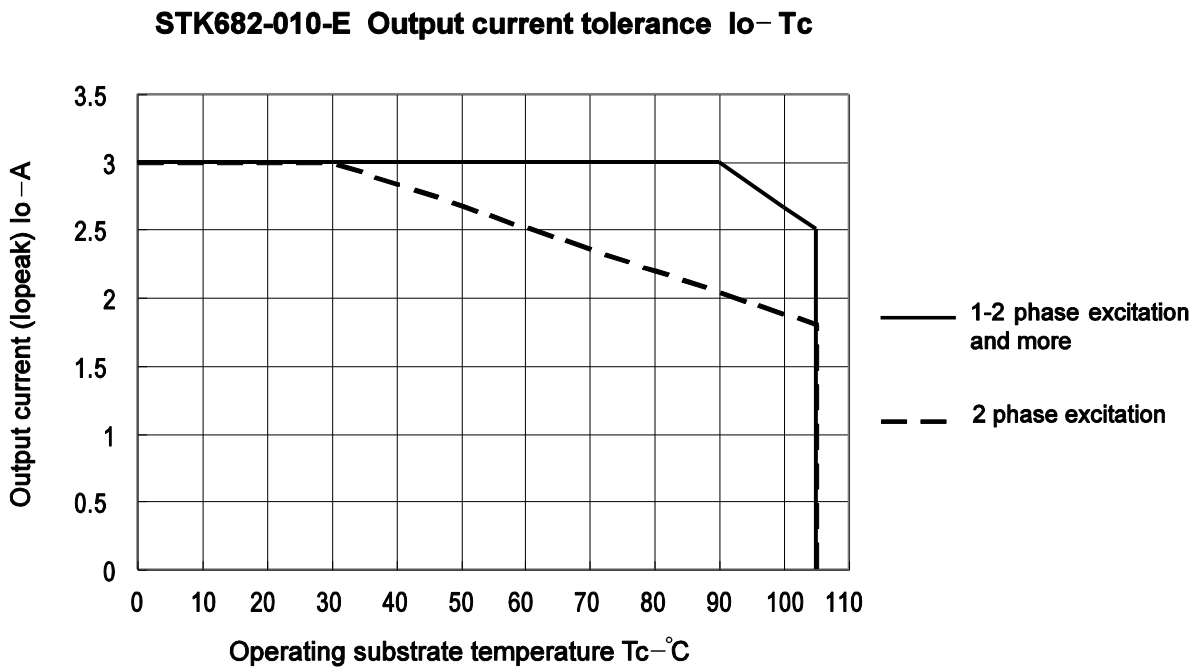
The DOWN pin is an open drain connection.

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

The DOWN pin output in once turned ON, is turned OFF at the next rising edge of CLK.

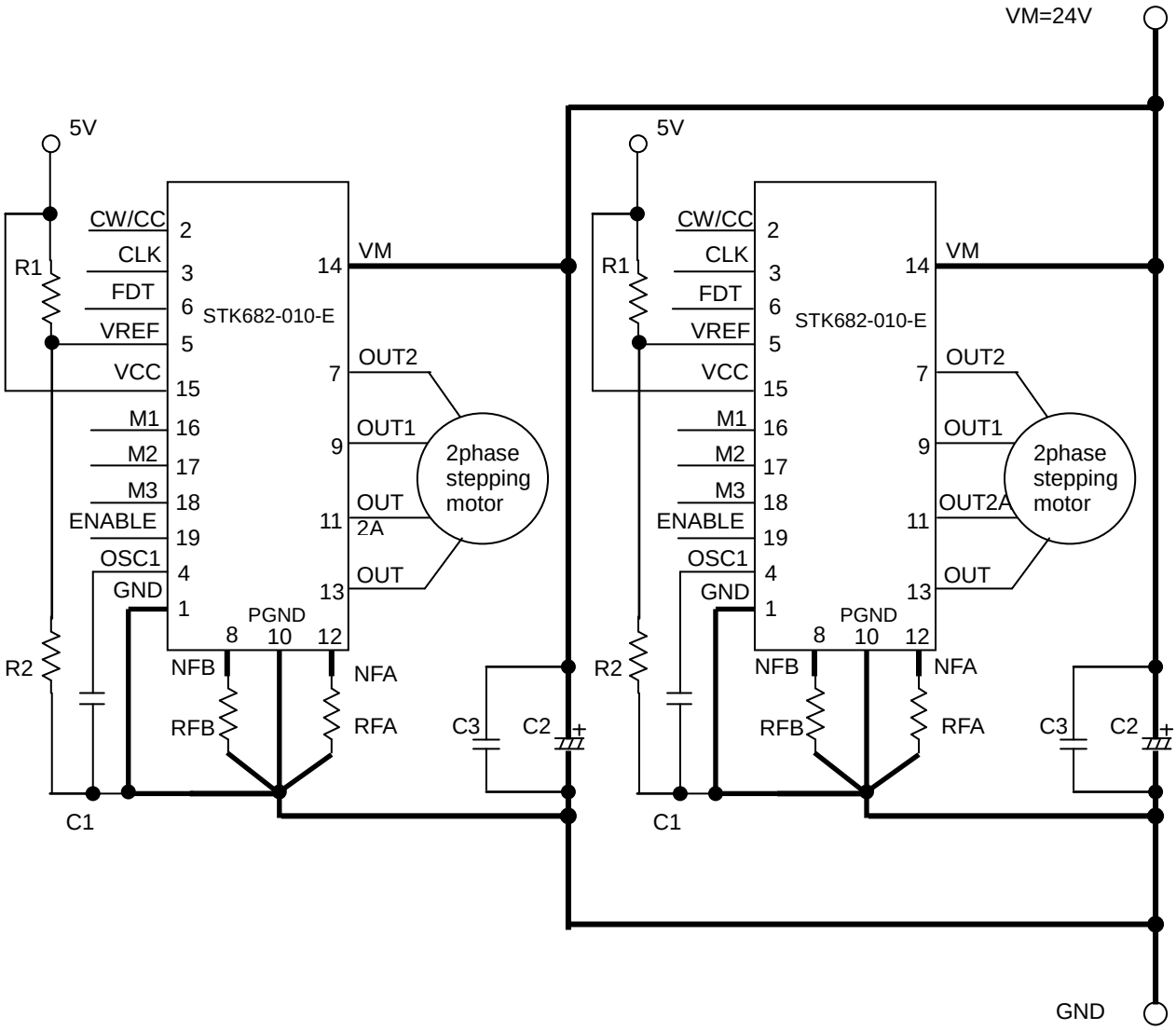
Holding current switching time (0.6sectyp) is set by an internal capacitor between OSC2 pin and GND.

(11) Output current tolerance

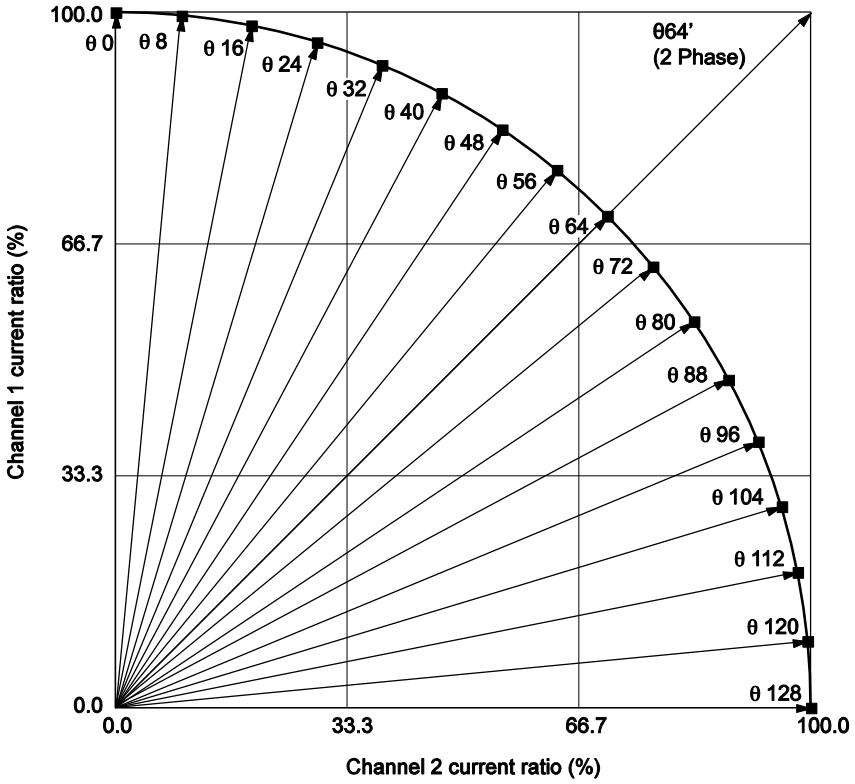


(12) When mounting multiple drivers on a single PC board

When mounting multiple drivers on a single PC board, the GND design should mount a VCC decoupling capacitor,C2 and C3, for each driver to stabilize the GND potential of the other drivers. The key wiring points are as follows.



(13) Output current vector locus (1 step normalized 90°)

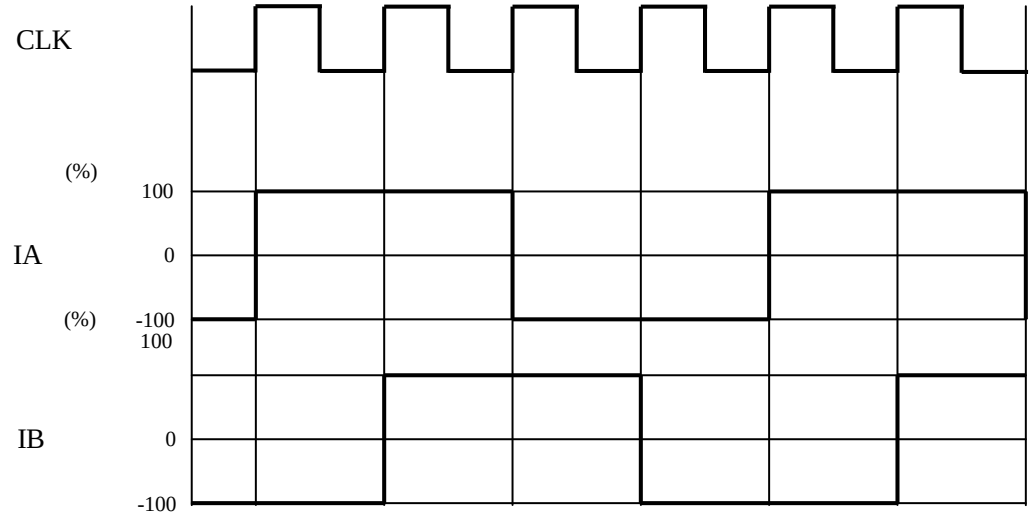


(14) Current setting ratio in each excitation mode

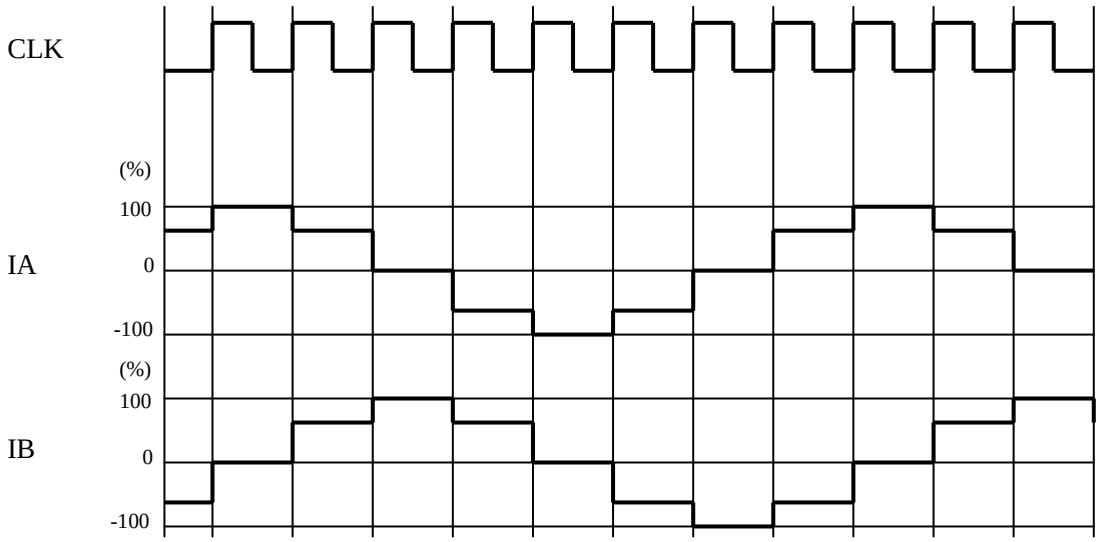
	32W1-2 phase(%)		16W1-2 phase(%)		8W1-2 phase(%)		4W1-2 phase(%)		2W1-2 phase(%)		W1-2 phase(%)		1-2 phase(%)		2 phase(%)			32W1-2 phase(%)		16W1-2 phase(%)		8W1-2 phase(%)		4W1-2 phase(%)		2W1-2 phase(%)		W1-2 phase(%)		1-2 phase(%)		2 phase(%)	
STEP	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	STEP	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch	Ach	Bch
000	100	0	100	0	100	0	100	0	100	0	100	0	100	0			065	70	72														
001	100	1															066	69	72	69	72												
002	100	2	100	2													067	68	73														
003	100	4															068	67	74	67	74	67	74										
004	100	5	100	5	100	5											069	66	75														
005	100	6															070	65	76	65	76												
006	100	7	100	7													071	64	77														
007	100	9															072	63	77	63	77	63	77	63	77								
008	100	10	100	10	100	10	100	10									073	62	78														
009	99	11															074	62	79	62	79												
010	99	12	99	12													075	61	80														
011	99	13															076	60	80	60	80	60	80										
012	99	15	99	15	99	15											077	59	81														
013	99	16															078	58	82	58	82												
014	99	17	99	17													079	57	82														
015	98	18															080	56	83	56	83	56	83	56	83	56	83						
016	98	20	98	20	98	20	98	20	98	20							081	55	84														
017	98	21															082	53	84	53	84												
018	98	22	98	22													083	52	85														
019	97	23															084	51	86	51	86	51	86										
020	97	24	97	24	97	24											085	50	86														
021	97	25															086	49	87	49	87												
022	96	27	96	27													087	48	88														
023	96	28															088	47	88	47	88	47	88	47	88								
024	96	29	96	29	96	29	96	29									089	46	89														
025	95	30															090	45	89	45	89												
026	95	31	95	31													091	44	90														
027	95	33															092	43	90	43	90	43	90										
028	94	34	94	34	94	34											093	42	91														
029	94	35															094	41	91	41	91												
030	93	36	93	36													095	39	92														
031	93	37															096	38	92	38	92	38	92	38	92	38	92						
032	92	38	92	38	92	38	92	38	92	38	92	38					097	37	93														
033	92	39															098	36	93	36	93												
034	91	41	91	41													099	35	94														
035	91	42															100	34	94	34	94	34	94										
036	90	43	90	43	90	43											101	33	95														
037	90	44															102	31	95	31	95												
038	89	45	89	45													103	30	95														
039	89	46															104	29	96	29	96	29	96	29	96								
040	88	47	88	47	88	47	88	47									105	28	96														
041	88	48															106	27	96	27	96												
042	87	49	87	49													107	25	97														
043	86	50															108	24	97	24	97	24	97										
044	86	51	86	51	86	51											109	23	97														
045	85	52															110	22	98	22	98												
046	84	53	84	53													111	21	98														
047	84	55															112	20	98	20	98	20	98	20	98	20	98						
048	83	56	83	56	83	56	83	56	83	56							113	18	98														
049	82	57															114	17	99	17	99												
050	82	58	82	58													115	16	99														
051	81	59															116	15	99	15	99	15	99										
052	80	60	80	60	80	60											117	13	99														
053	80	61															118	12	99	12	99												
054	79	62	79	62													119	11	99														
055	78	62															120	10	100	10	100	10	100	10	100								
056	77	63	77	63	77	63	77	63									121	9	100														
057	77	64															122	7	100	7	100												
058	76	65	76	65													123	6	100														
059	75	66															124	5	100	5	100	5	100										
060	74	67	74	67	74	67											125	4	100														
061	73	68															126	2	100	2	100												
062	72	69	72	69													127	1	100														
063	72	70															128	0	100	0	100	0	100	0	100	0	100	0	100				
064	71	71	71	71	71	71	71	71	71	71	71	71	71	71	100	100																	

(15) Current wave example in each excitation mode (2 phase, 1-2 phase, W1-2 phase, 4W1-2 phase)

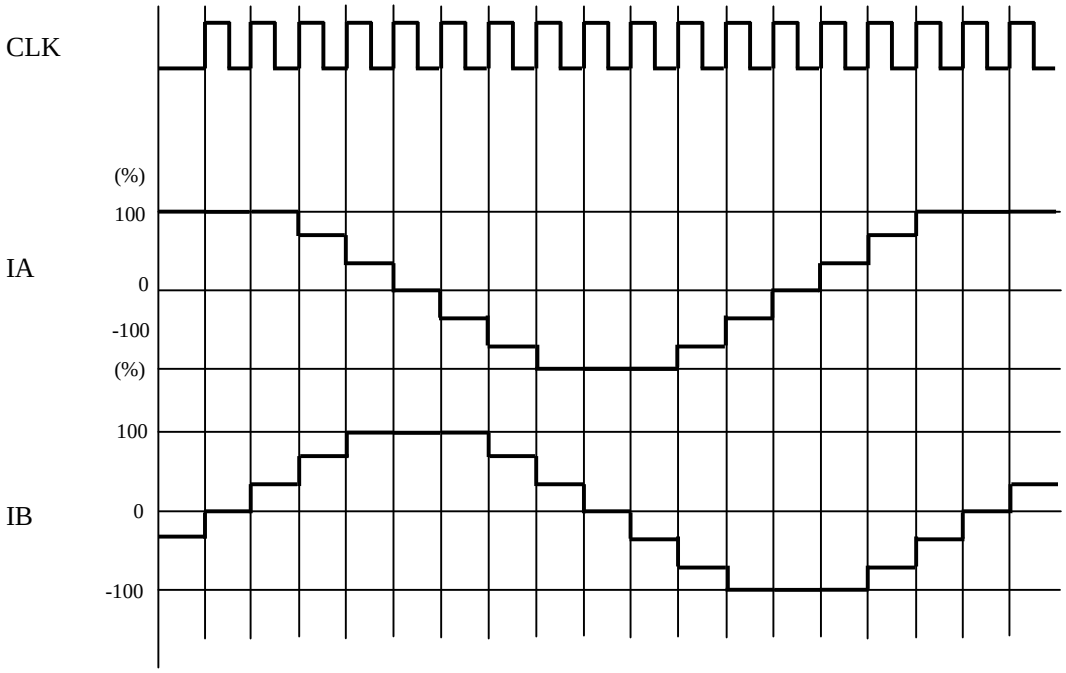
2 phase excitation (CW mode)



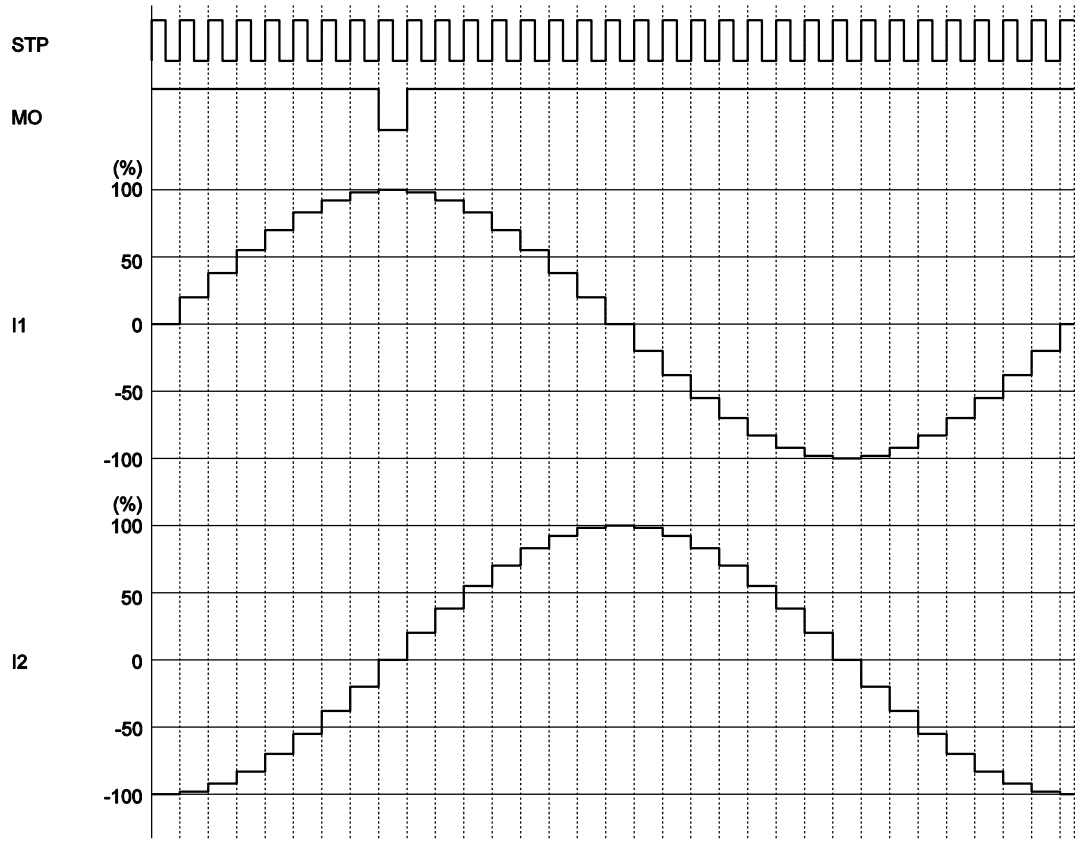
1-2 phase excitation (CW mode)



W1-2 phase excitation (CW mode)



4W1-2 phase excitation (CW mode)

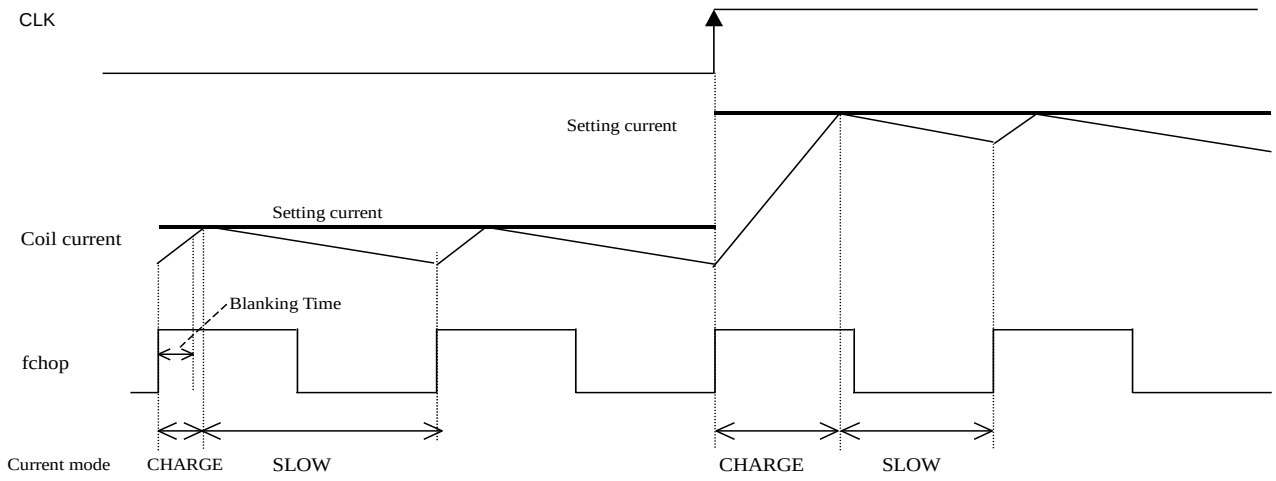


(16) Current control operation

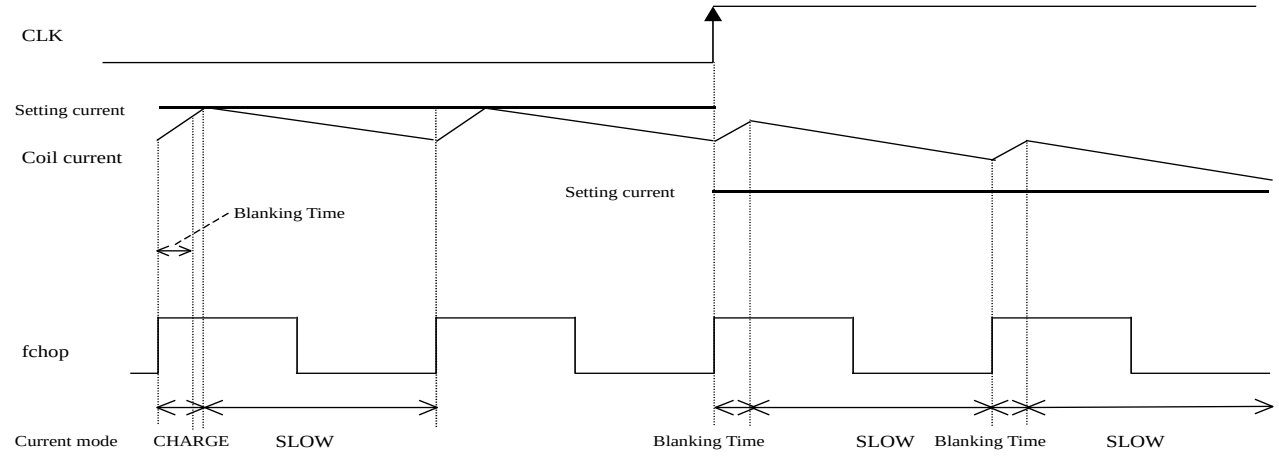
SLOW DECAY current control operation

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

(Sine-wave increasing direction)



(Sine-wave decreasing direction)



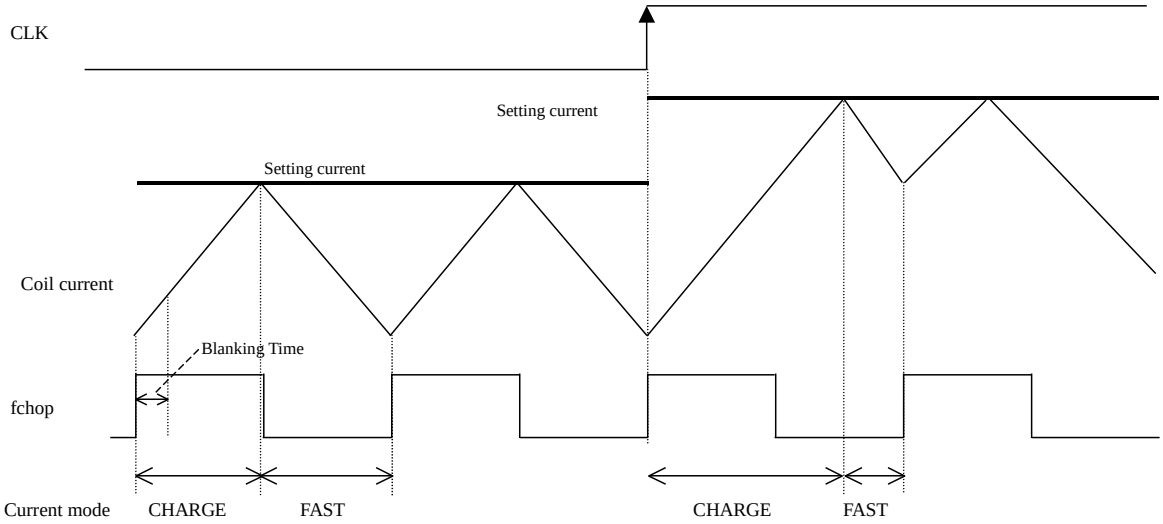
Each of current modes operates with the follow sequence.

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

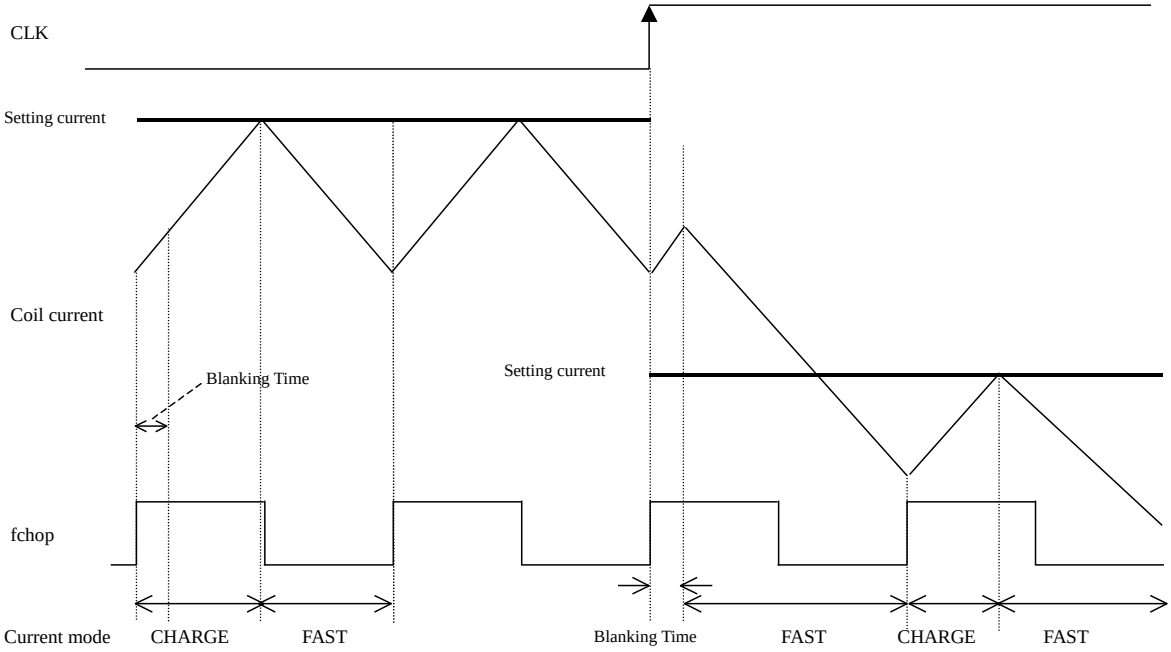
FAST DECAY current control operation

When FDT pin voltage is a voltage under 0.8V, the constant-current control is operated in FAST DECAY mode.

(Sine-wave increasing direction)



(Sine-wave decreasing direction)



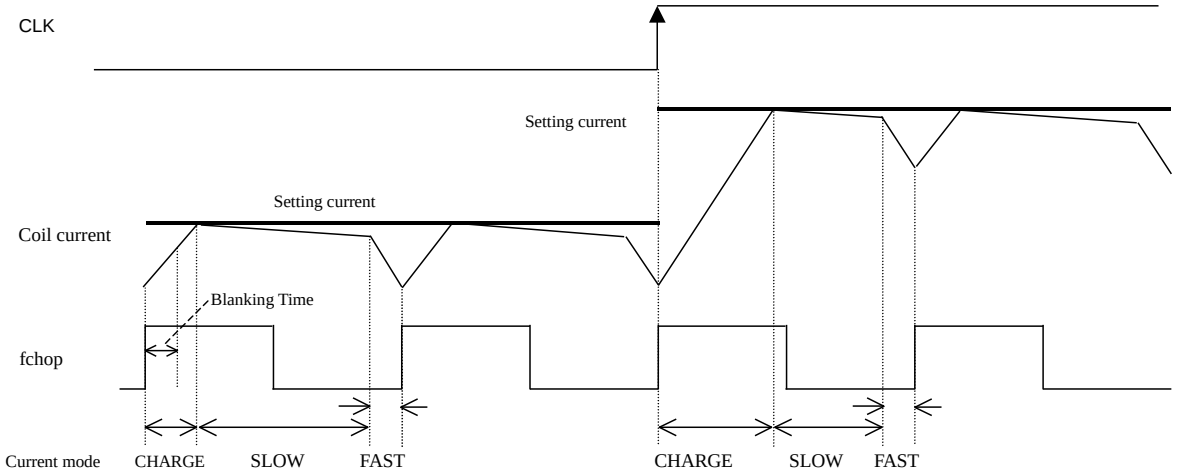
Each of current modes operates with the follow sequence.

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)).

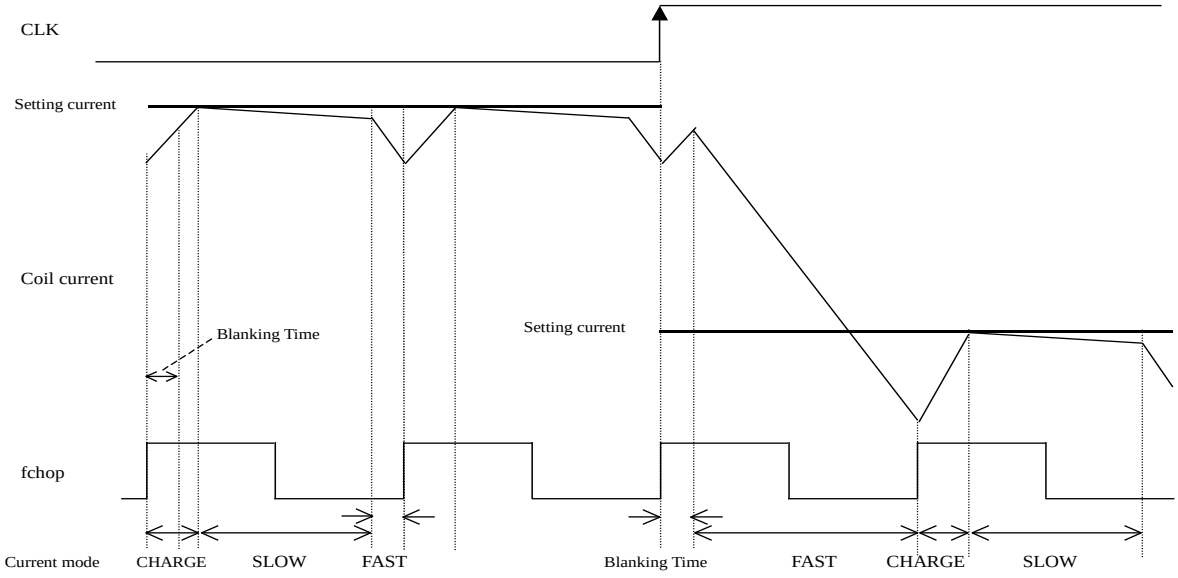
After the period of the blanking time, The IC operates in CHARGE mode until ICOIL ≥ IREF. After that, the mode switches to the FAST DECAY mode and the coil current is attenuated until the end of a chopping period. At the constant-current control in FAST DECAY mode, following to the setting current from the coil current takes short-time for the current fast attenuation, but, the current ripple value may be higher.

MIXED DECAY current control operation

(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 μs, 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 CHAGE mode until ICOIL ≥ IREF. After that, it switches to SLOW DECAY mode and then switches to FAST DECAY mode in the last approximately 1 μs 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.

Power Dissipation

Power dissipation calculation of STK682-010-E following becomes.
2-phase excitation
$Pd=IOH\times(Ronu + Rond)^2$
1-2-phase excitation
$Pd=0.71\times IOH\times(Ronu + Rond)^2$

Please by substituting from electrical characteristic table value of Rond and Ronu.

Thermal design

[Operating range in which a heat sink is not used]
Use of a heat sink to lower the operating substrate temperature of the HIC (Hybrid IC) is effective in increasing the quality of the HIC.
The size of heat sink for the HIC varies depending on the magnitude of the average power loss, PdAV, within the HIC. The value of PdAV increases as the output current increases. To calculate PdAV, refer to "Calculating Internal HIC Loss for the STK672-640C-E in the specification document.
Calculate the internal HIC loss, PdAV, assuming repeat operation such as shown in Figure 1 below, since conduction during motor rotation and off time both exist during actual motor operations,

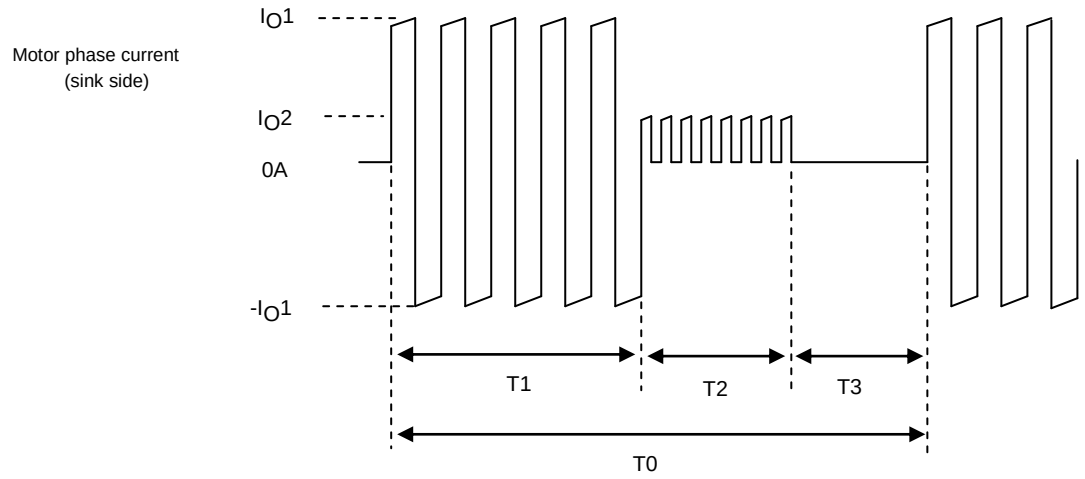


Figure 1 Motor Current Timing

T1 : Motor rotation operation time
T2 : Motor hold operation time
T3 : Motor current off time
T2 may be reduced, depending on the application.
T0 : Single repeated motor operating cycle
IO1 and IO2 : Motor current peak values
Due to the structure of motor windings, the phase current is a positive and negative current with a pulse form.
Note that figure 1 presents the concepts here, and that the on/off duty of the actual signals will differ.
The hybrid IC internal average power dissipation PdAV can be calculated from the following formula.
PdAV= (T1×P1+T2×P2+T3×0) · TO ---------- (I)
(Here, P1 is the PdAV for IO1 and P2 is the PdAV for IO2)
If the value calculated using Equation (I) is 1.5W or less, and the ambient temperature, Ta, is 60°C or less, there is no need to attach a heat sink. Refer to Figure 2 for operating substrate temperature data when no heat sink is used.

[Operating range in which a heat sink is used]
Although a heat sink is attached to lower Tc if PdAV increases, the resulting size can be found using the value of c-a in Equation (II) below and the graph depicted in Figure 3.
c-a = (Tc max-Ta) · PdAV ---------- (II)
Tc max : Maximum operating substrate temperature =105°C
Ta : HIC ambient temperature

Although a heat sink can be designed based on equations (I) and (II) above, be sure to mount the HIC in a set and confirm that the substrate temperature, Tc, is 105°C or less.

Figure 2 Substrate temperature rise, ΔTc (no heat sink) - Internal average power dissipation, PdAV

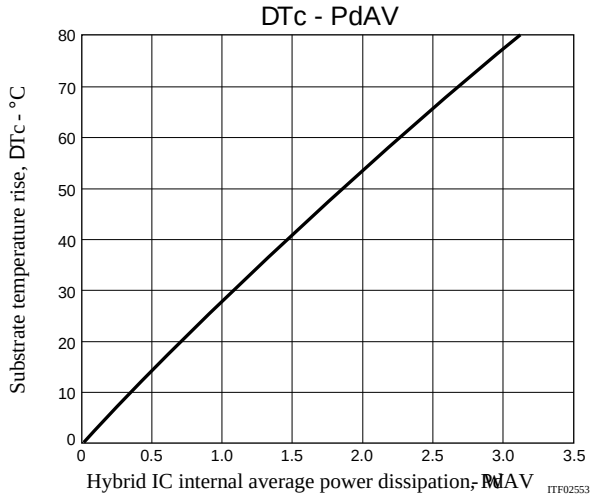
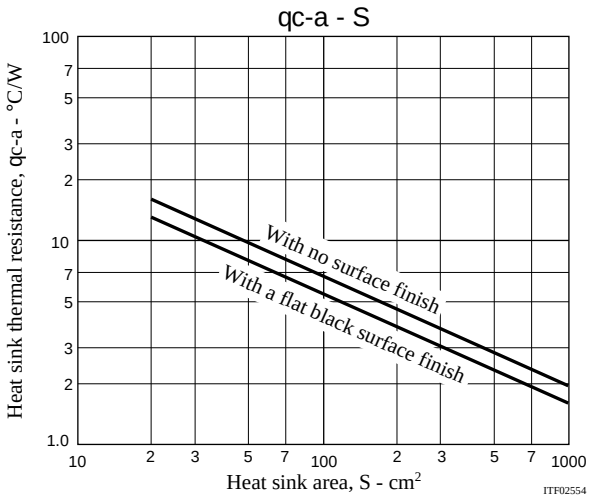
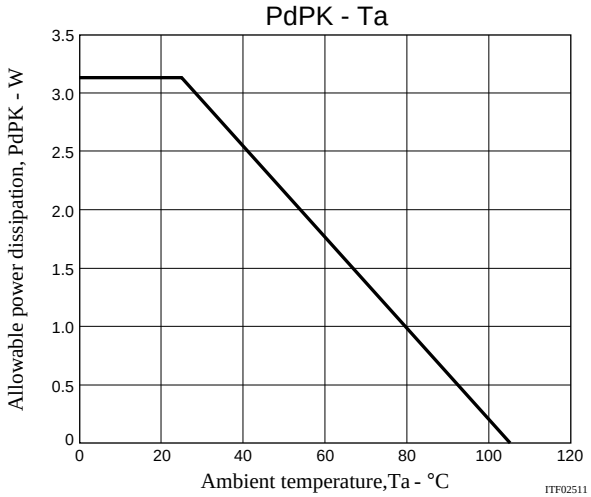


Figure 3 Heat sink area (Board thickness: 2mm) - θc-a



Mitigated Curve of Package Power Loss, PdPK, vs. Ambient Temperature, Ta
Package power loss, PdPK, refers to the average internal power loss, PdAV, allowable without a heat sink.
The figure below represents the allowable power loss, PdPK, vs. fluctuations in the ambient temperature, Ta.
Power loss of up to 3.1W is allowable at Ta=25°C, and of up to 1.75W at Ta=60°C.

Allowable power dissipation, PdPK(no heat sink) - Ambient temperature, Ta



ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
STK682-010-E	SIP-19 (Pb-Free)	15 / Tube