2-Phase Stepper Motor Unipolar Driver ICs

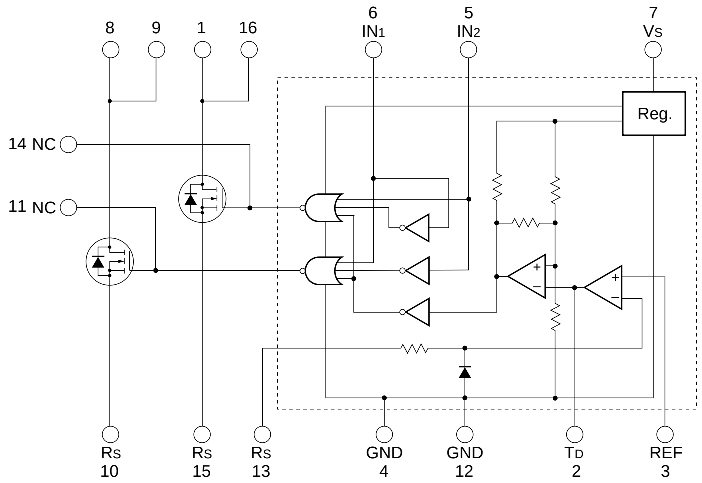
■Absolute Maximum Ratings

Parameter	Symbol	Ratings	Units
Motor supply voltage	V_{CC}	46	V
FET Drain-Source voltage	V_{DSS}	100	V
Control supply voltage	V_S	46	V
TTL input voltage	V_{IN}	7	V
Reference voltage	V_{REF}	2	V
Output current	I_O	1	A
Power dissipation	P_D	2.5 (Without Heatsink)	W
Channel temperature	T_{ch}	+150	°C
Storage temperature	T_{stg}	–40 to +150	°C

■Electrical Characteristics

	Parameter	Symbol	Ratings min	Ratings typ	Ratings max	Units
DC characteristics	Control supply current	I_S		5	7.5	mA
		Condition		V_S=44V		
	Control supply voltage	V_S	10	24	44	V
	FET Drain-Source voltage	V_{DSS}	100			V
		Condition		V_S=44V, I_{DSS}=250μA		
	FET ON voltage	V_{DS}			0.85	V
		Condition		I_D=1A, V_S=14V		
	FET drain leakage current	I_{DSS}			4	mA
		Condition		V_{DSS}=100V, V_S=44V		
	FET diode forward voltage	V_{SD}			1.2	V
		Condition		I_D=1A		
	TTL input current	I_{IH}			40	μA
		Condition		V_{IH}=2.4V, V_S=44V		
		I_{IL}			–0.8	mA
		Condition		V_{IL}=0.4V, V_S=44V		
	TTL input voltage (Active High)	V_{IH}	2			V
		Condition		I_D=1A		
		V_{IL}			0.8	
		Condition		V_{DSS}=100V		
	TTL input voltage (Active Low)	V_{IH}	2			V
		Condition		V_{DSS}=100V		
		V_{IL}			0.8	
		Condition		I_D=1A		
AC characteristics	Switching time	T_r		0.5		μs
		Condition		V_S=24V, I_D=0.8A		
		T_{stg}		0.7		
		Condition		V_S=24V, I_D=0.8A		
		T_f		0.1		
		Condition		V_S=24V, I_D=0.8A		

■Internal Block Diagram

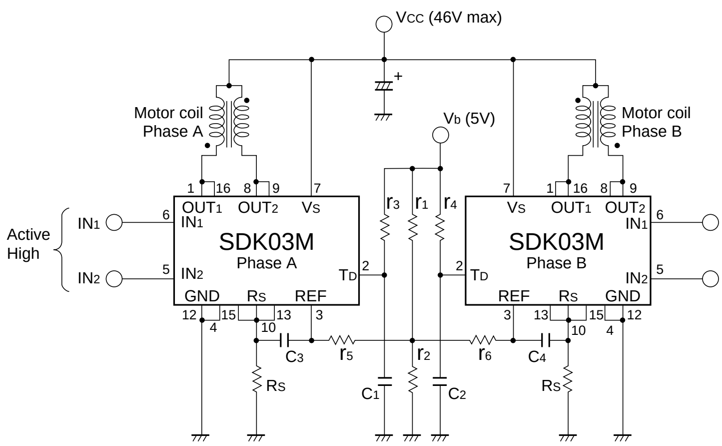


1, 8, 9, 16pin Description of pins

	Excitation input	
	Active H	Active L
Pin 1 / Pin 16	OUT_1	OUT_2
Pin 8 / Pin 9	OUT_2	OUT_1

■Diagram of Standard External Circuit (Recommended Circuit Constants)

Active High



Excitation signal time chart
2-phase excitation

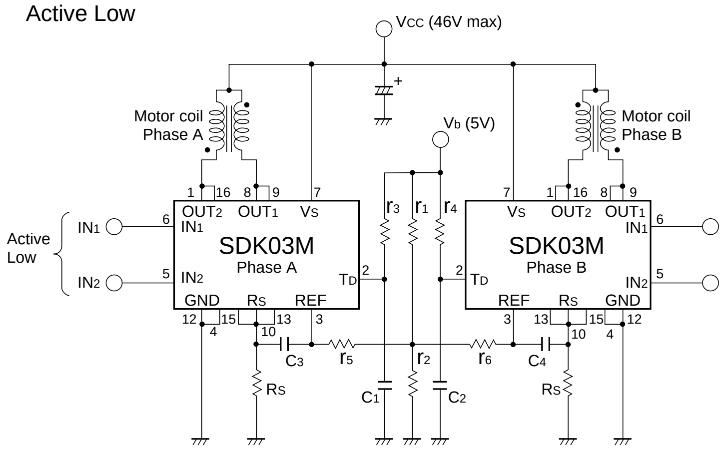
Phase	clock	0	1	2	3	0	1
Phase A	IN_1	H	L	L	H	H	L
	IN_2	L	H	H	L	L	H
Phase B	IN_1	H	H	L	L	H	H
	IN_2	L	L	H	H	L	L

r_1 : 510Ω
r_2 : 100Ω (VR)
r_3 : 47kΩ
r_4 : 47kΩ
r_5 : 2.4kΩ
r_6 : 2.4kΩ
C_1 : 470pF
C_2 : 470pF
C_3 : 2200pF
C_4 : 2200pF
R_S : 1.8Ω typ (1 to 2W)

1-2-phase excitation

Phase	clock	0	1	2	3	4	5	6	7	0	1	2	3
Phase A	IN_1	H	H	L	L	L	L	L	H	H	H	L	L
	IN_2	L	L	L	H	H	H	L	L	L	L	L	H
Phase B	IN_1	L	H	H	H	L	L	L	L	L	H	H	H
	IN_2	L	L	L	L	L	H	H	H	L	L	L	L

Active Low



Excitation signal time chart
2-phase excitation

Phase	clock	0	1	2	3	0	1
Phase A	IN_1	L	H	H	L	L	H
	IN_2	H	L	L	H	H	L
Phase B	IN_1	L	L	H	H	L	L
	IN_2	H	H	L	L	H	H

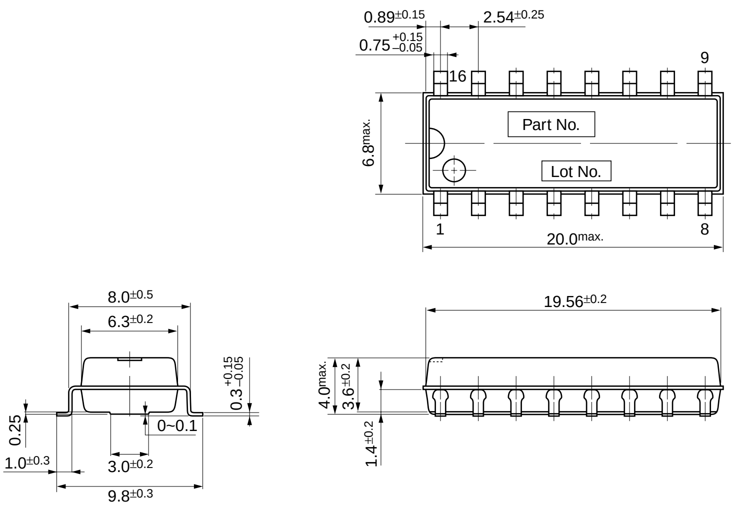
r_1 : 510Ω
r_2 : 100Ω (VR)
r_3 : 47kΩ
r_4 : 47kΩ
r_5 : 2.4kΩ
r_6 : 2.4kΩ
C_1 : 470pF
C_2 : 470pF
C_3 : 2200pF
C_4 : 2200pF
R_S : 1.8Ω typ (1 to 2W)

1-2-phase excitation

Phase	clock	0	1	2	3	4	5	6	7	0	1	2	3
Phase A	IN_1	L	L	H	H	H	H	H	L	L	L	H	H
	IN_2	H	H	H	L	L	L	H	H	H	H	H	L
Phase B	IN_1	H	L	L	L	H	H	H	H	H	L	L	L
	IN_2	H	H	H	H	H	L	L	L	H	H	H	H

■External Dimensions

(Unit: mm)



Application Notes

■Determining the Output Current

Fig. 1 shows the waveform of the output current (motor coil current). The method of determining the peak value of the output current (I_O) based on this waveform is shown below.

(Parameters for determining the output current I_O)

- V_b: Reference supply voltage
- r_1,r_2: Voltage-divider resistors for the reference supply voltage
- R_S: Current sense resistor

(1) Normal rotation mode

I_O is determined as follows when current flows at the maximum level during motor rotation. (See Fig.2.)

$$I_O \cong \frac{r_2}{r_1+r_2} \bullet \frac{V_b}{R_S} \quad \cdots\cdots (1)$$

(2) Power down mode

The circuit in Fig.3 (r_x and T_r) is added in order to decrease the coil current. I_O is then determined as follows.

$$I_{OPD} \cong \frac{1}{1+\dfrac{r_1(r_2+r_x)}{r_2 \bullet r_x}} \bullet \frac{V_b}{R_S} \quad \cdots\cdots (2)$$

Equation (2) can be modified to obtain equation to determine r_x.

$$r_x = \frac{1}{\dfrac{1}{r_1}\left(\dfrac{V_b}{R_s \bullet I_{OPD}} - 1\right) - \dfrac{1}{r_2}}$$

Fig. 4 and 5 show the graphs of equations (1) and (2) respectively.

Fig. 1 Waveform of coil current (Phase A excitation ON)

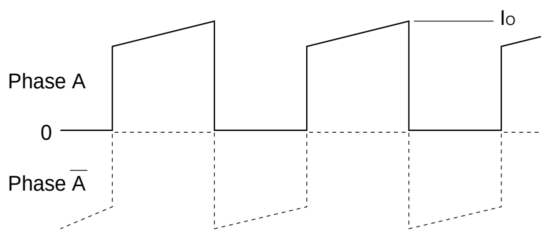


Fig. 2 Normal mode

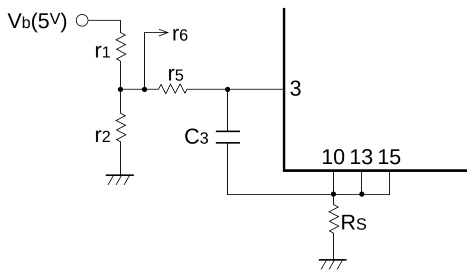


Fig. 3 Power down mode

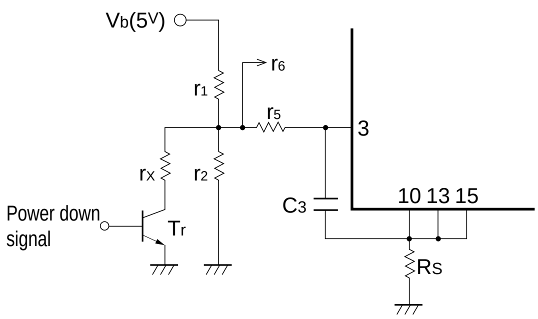


Fig. 4 Output current I_O vs. Current sense resistor R_S

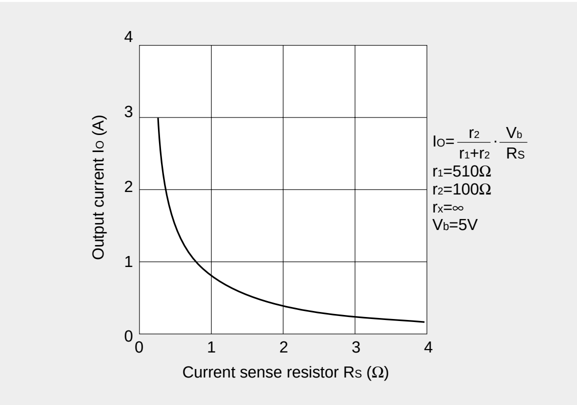
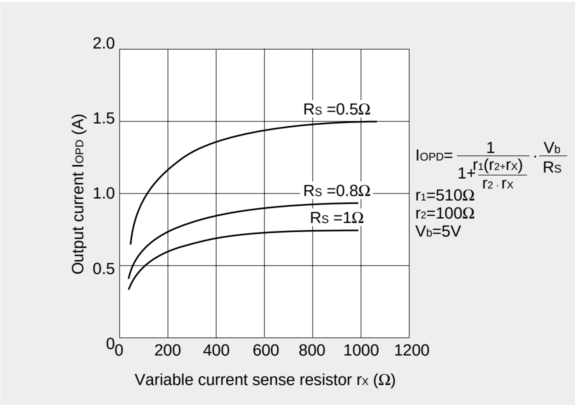


Fig. 5 Output current I_{OPD} vs. Variable current sense resistor r_x



(NOTE)

Ringing noise is produced in the current sense resistor R_S when the MOSFET is switched ON and OFF by chopping. This noise is also generated in feedback signals from R_S which may therefore cause the comparator to malfunction. To prevent chopping malfunctions, r_5(r_6) and C_3(C_4) are added to act as a noise filter. However, when the values of these constants are increased, the response from R_S to the comparator becomes slow. Hence the value of the output current I_O is somewhat higher than the calculated value.

■Determining the chopper frequency

Determining T_{OFF}

SDK03M is self-excited choppers. The chopping OFF time T_{OFF} is fixed by r_3/C_1 and r_4/C_2 connected to terminal T_d.

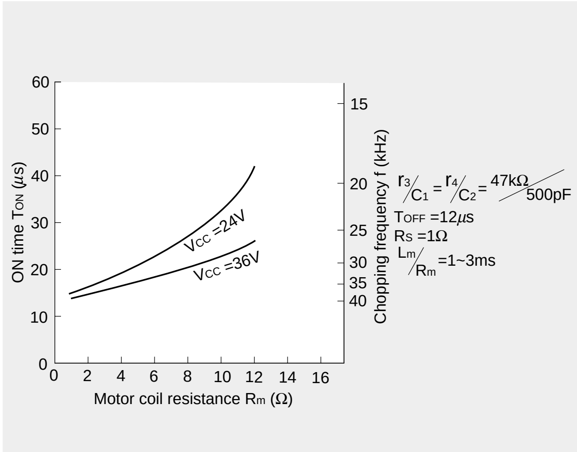
T_{OFF} can be calculated using the following formula:

$$T_{OFF} \cong -r_3 \bullet C_1 \, \ell n \left(1-\frac{2}{V_b}\right) = -r_4 \bullet C_2 \, \ell n \left(1-\frac{2}{V_b}\right)$$

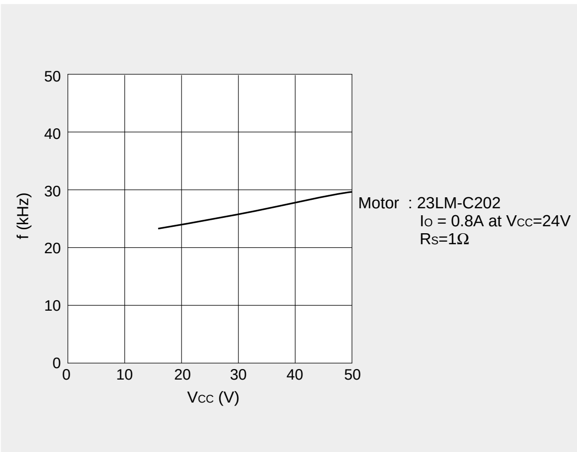
The circuit constants and the T_{OFF} value shown below are recommended.

$T_{OFF} = 12\mu s$ at r_3=47kΩ, C_1=500pF, V_b=5V

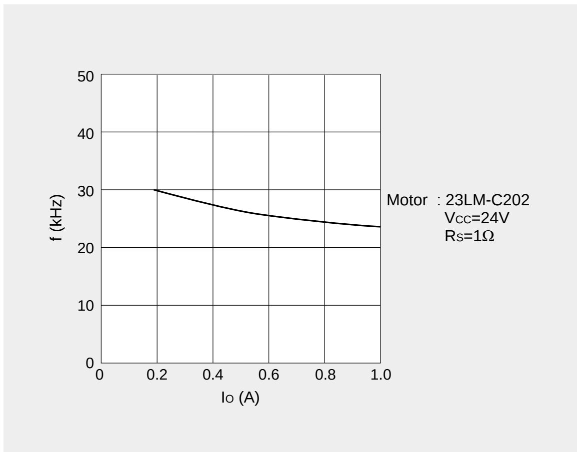
Fig. 6 Chopper frequency vs. Motor coil resistance



■Chopper frequency vs. Supply voltage



■Chopper frequency vs. Output current



■Thermal Design

An outline of the method for computing heat dissipation is shown below.

(1) Obtain the value of P_H that corresponds to the motor coil current I_O from Fig. 7 "Heat dissipation per phase P_H vs. Output current I_O."

(2) The power dissipation Pdiss is obtained using the following formula.

2-phase excitation: $P_{diss} \cong P_H + 0.0075 \times V_S$ (W)

1-2 phase excitation: $P_{diss} \cong \frac{3}{4} P_H + 0.0075 \times V_S$ (W)

(3) Obtain the temperature rise that corresponds to the calculated value of P_{diss} from Fig. 8 "Temperature rise."

Fig. 7 Heat dissipation per phase P_H vs. Output current I_O

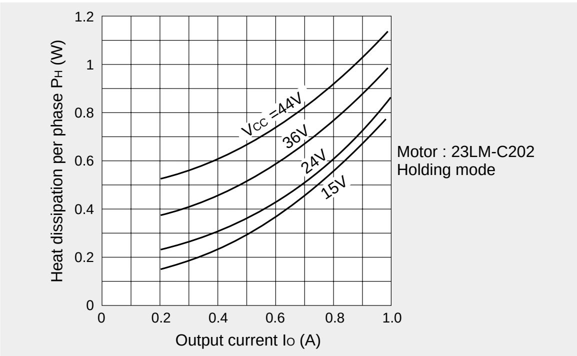
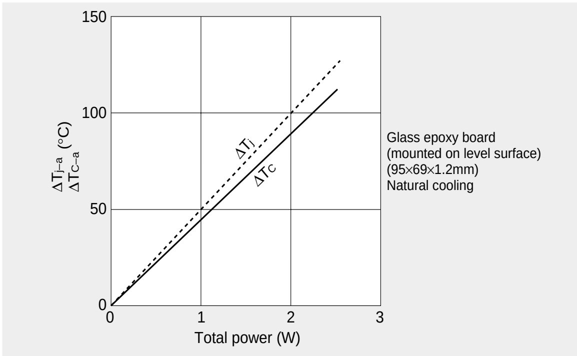
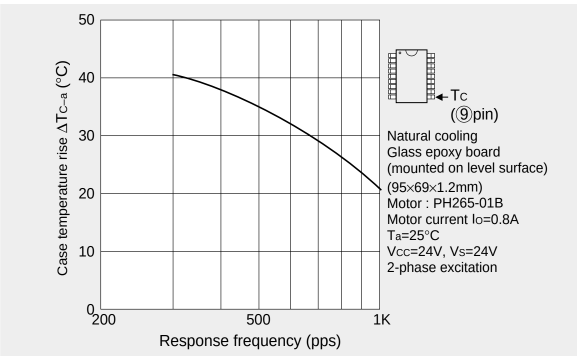


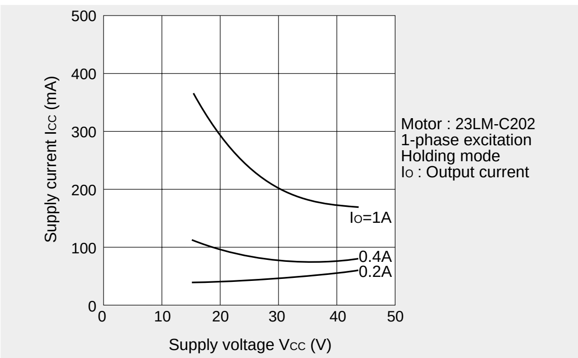
Fig. 8 Temperature rise



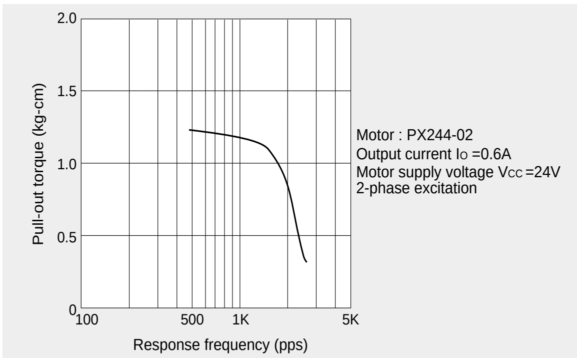
Thermal characteristics



■Supply Voltage V_{CC} vs. Supply Current I_{CC}



■Torque Characteristics



■Note

The excitation input signals of the SDK03M can be used as either Active High or Active Low. Note, However, that the corresponding output (OUT) changes depending on the input (IN).

Active High

Input	Corresponding output
IN_1 (pin6)	OUT_1 (pin1, 16)
IN_2 (pin5)	OUT_2 (pin8, 9)

Active Low

Input	Corresponding output
IN_1 (pin6)	OUT_1 (pin8, 9)
IN_2 (pin5)	OUT_2 (pin1, 16)