

TOSHIBA Bi-CMOS INTEGRATED CIRCUIT MULTICHIP

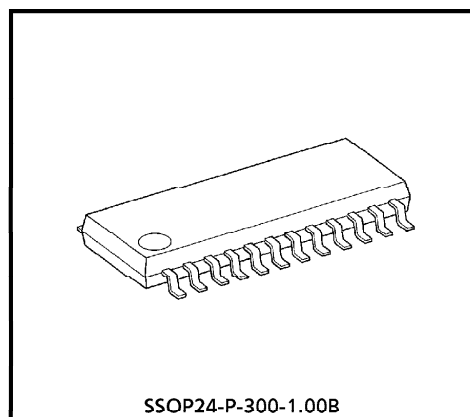
T B 6 5 1 2 A F**PWM CHOPPER TYPE BIPOLAR STEPPING MOTOR DRIVER**

The TB6512AF is PWM chopper type sinusoidal micro step bipolar stepping motor driver.

Sinusoidal micro step operation is accomplished only a clock signal inputting by means of built-in hard ware.

FEATURES

- 1 chip bipolar sinusoidal micro step stepping motor driver.
- Output Current up to 150mA
- PWM chopper type.
- Structured by high voltage Bi-CMOS process technology.
- Forward and reverse rotation are available.
- 1-2, 2W1-2 phase 1 or 2 clock drives are selectable.
- Package : SSOP24-P-300B
- Input Pull-Up Resistor equipped with RESET and ENABLE Terminal : $R = 500k\Omega$ (Typ.)
- Output Monitor available with $\overline{MO}$. $I_O(\overline{MO}) = \pm 2mA$ MAX.
- Reset and Enable are available with $\overline{RESET}$ and $\overline{ENABLE}$.

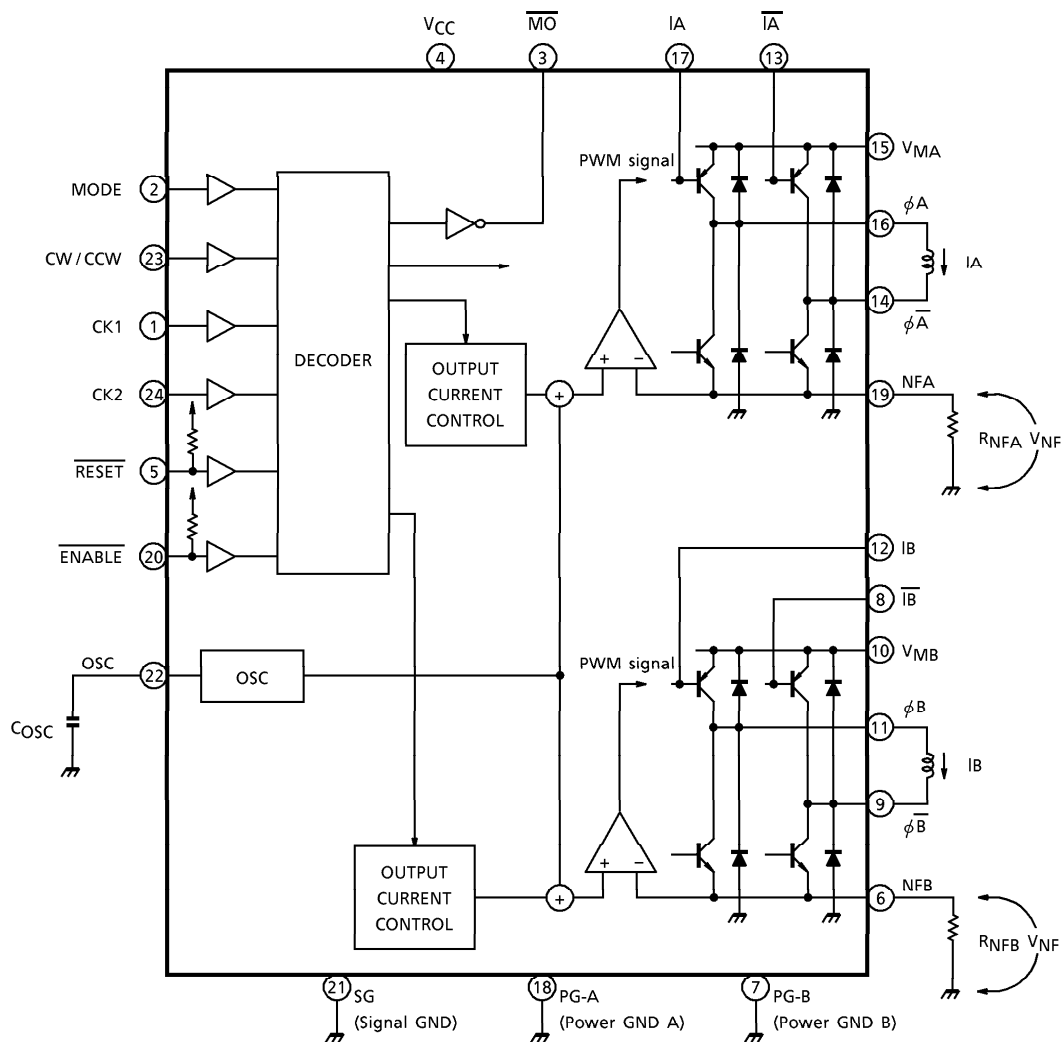


SSOP24-P-300-1.00B
Weight : 0.27g (Typ.)

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BLOCK DIAGRAM

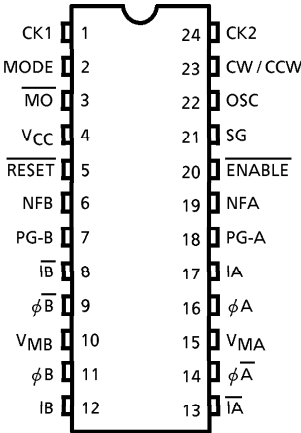


⑤, ⑳ : Pull-up Resistor 500k Ω (Typ.)

PIN FUNCTION

PIN No.	SYMBOL	FUNCTIONAL DESCRIPTION	
1	CK1	CLOCK Signal Input terminal	Truth table A
2	MODE	Excitation Mode Setting terminal	Truth table B
3	$\overline{\text{MO}}$	Monitor Output terminal	
4	V_{CC}	Power voltage supply terminal for Logic	
5	$\overline{\text{RESET}}$	Reset Signal Input terminal	Truth table A
6	NFB	B Channel current detective terminal	
7	PG-B	Power GND B terminal	
8	$\overline{\text{IB}}$	Upper PNP Transistor Base terminal	
9	$\phi\overline{\text{B}}$	Output B terminal	
10	V_{MB}	Power voltage supply terminal for Motor B	
11	ϕB	Output B terminal	
12	IB	Upper PNP Transistor Base terminal	
13	$\overline{\text{IA}}$	Upper PNP Transistor Base terminal	
14	$\phi\overline{\text{A}}$	Output A terminal	
15	V_{MA}	Power voltage supply terminal for Motor A	
16	ϕA	Output A terminal	
17	IA	Upper side PNP Transistor Base terminal	
18	PG-A	Power GND A terminal	
19	NFA	A Channel current detective terminal	
20	$\overline{\text{ENABLE}}$	ENABLE Signal Input terminal	Truth table A
21	SG	Signal GND terminal	
22	OSC	Internal Oscillation frequency detective terminal	
23	CW / CCW	Forward rotation / Reverse rotation signal Input	Truth table A
24	CK2	Clock signal Input terminal	

PIN CONNECTION



TRUTH TABLE A

INPUT					MODE
CK1	CK2	CW / CCW	RESET	ENABLE	
	H	L	H	L	CW
	L	L	H	L	INHIBIT
H		L	H	L	CCW
L		L	H	L	INHIBIT
	H	H	H	L	CCW
	L	H	H	L	INHIBIT
H		H	H	L	CW
L		H	H	L	INHIBIT
X	X	X	L	L	INITIAL
X	X	X	X	H	Z

Z : High Impedance
X : Don't Care

(Note) Do not use INHIBIT MODE

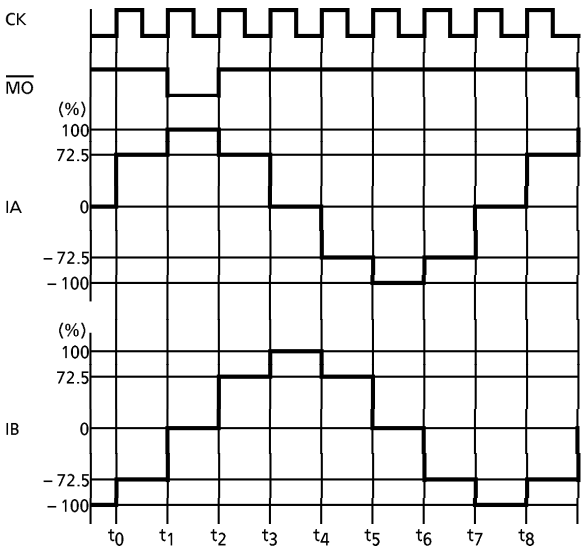
TRUTH TABLE B

INPUT MODE	MODE (EXCITATION)
L	1-2 phase
H	2W1-2 phase

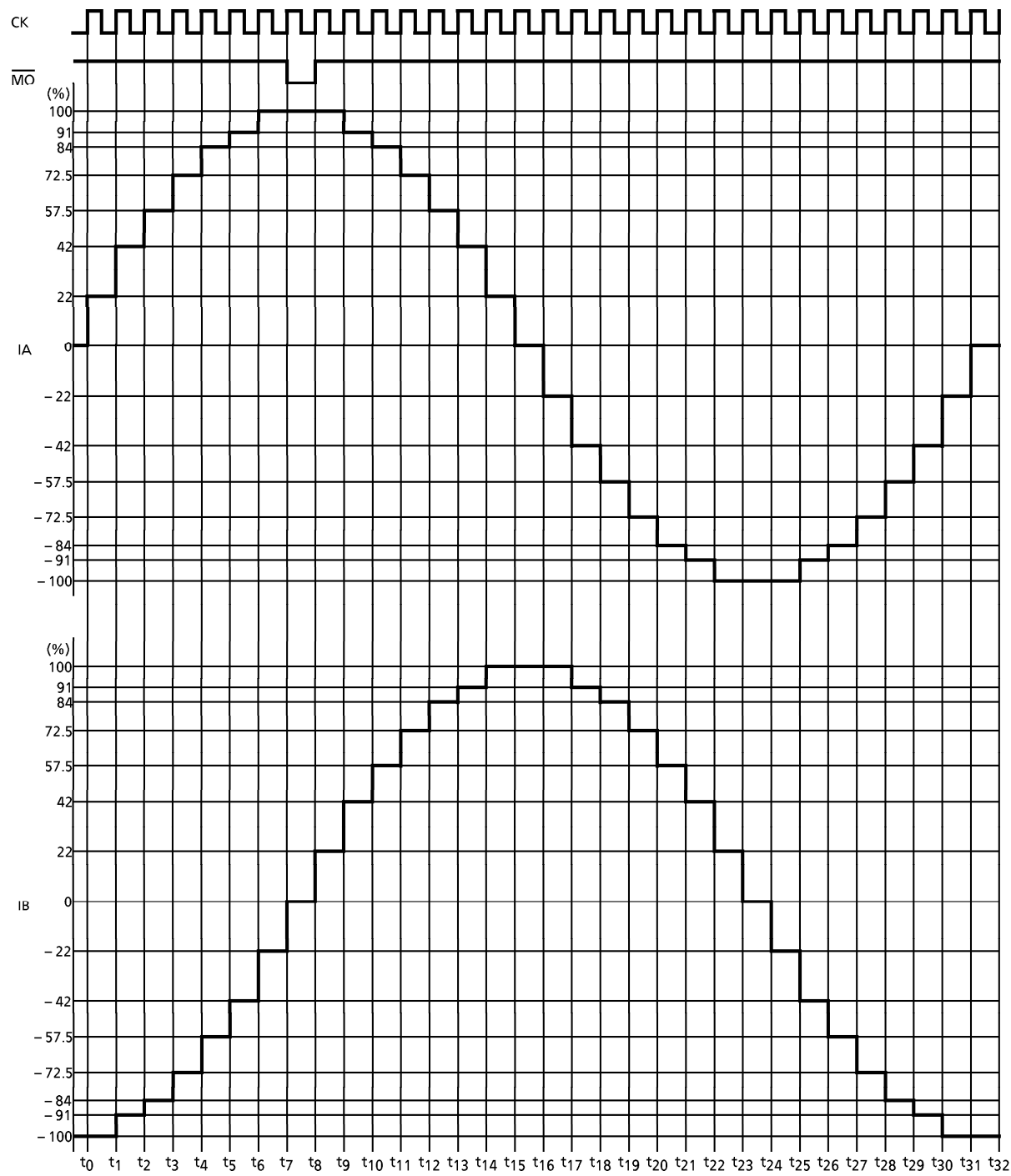
INITIAL MODE

EXCITATION MODE	I _{OUT} (A)	I _{OUT} (B)
1-2 phase	100%	0%
2W1-2 phase	100%	0%

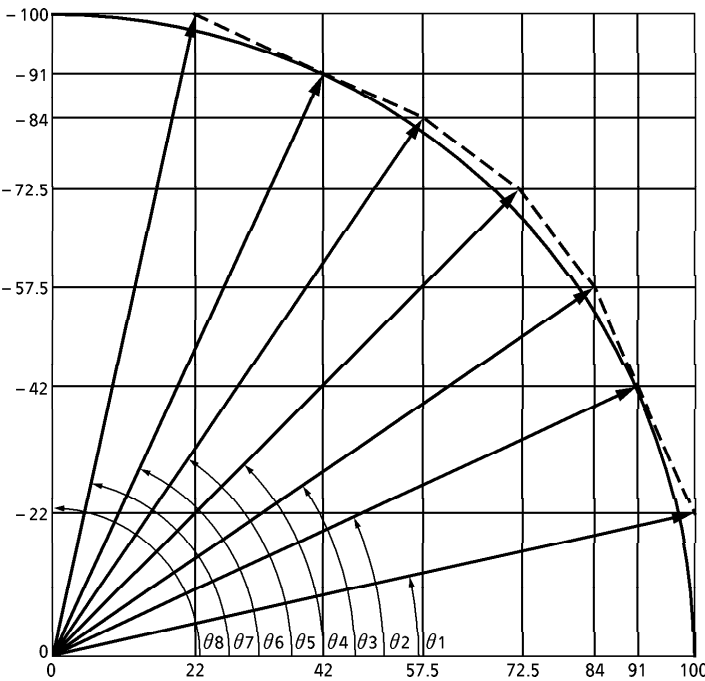
1-2 PHASE EXCITATION (MODE : L, CW mode)



2W1-2 PHASE EXCITATION (MODE : H, CW mode)

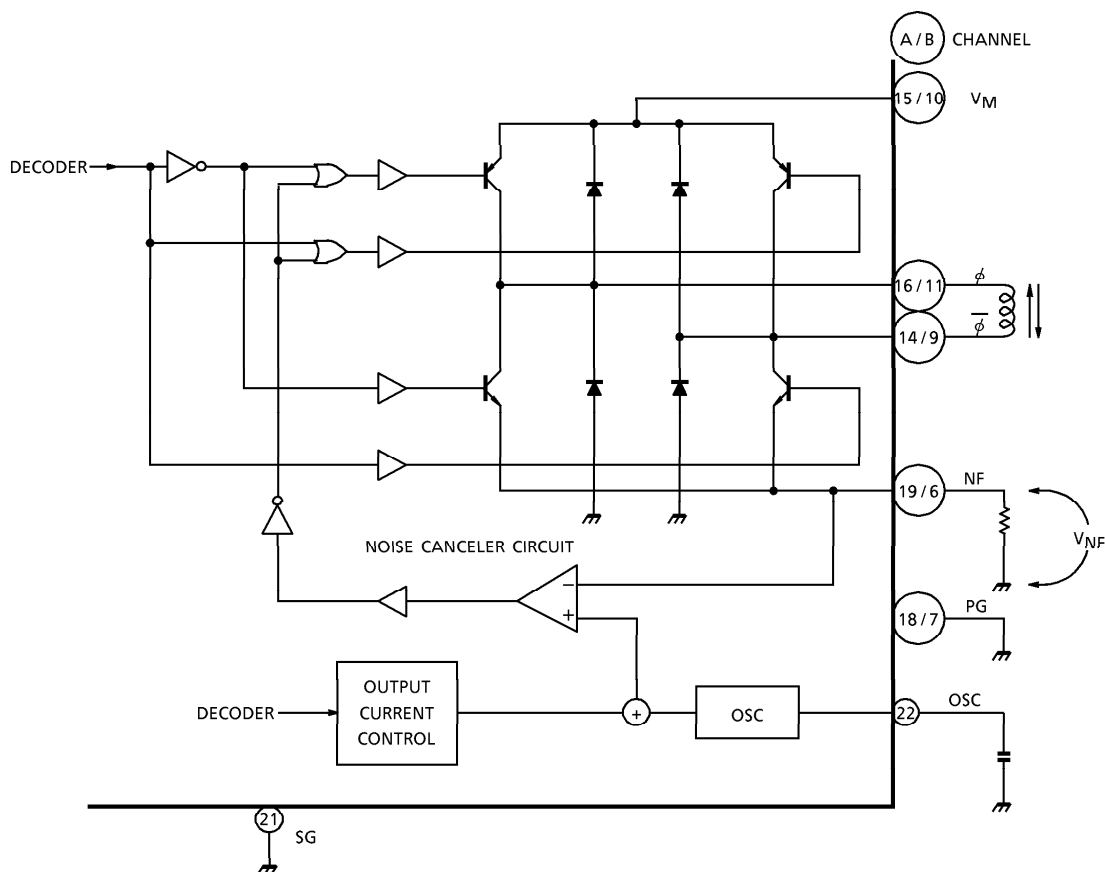


OUTPUT CURRENT VECTOR OR BIT (Normalize to 90 deg for each one step)



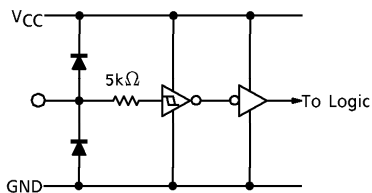
θ	ROTATION ANGLE		VECTOR LENGTH	
	IDEAL	TB6512AF	IDEAL	TB6512AF
$\theta 0$	0°	0°	100	100.00
$\theta 1$	11.25°	12.41°	100	102.39
$\theta 2$	22.5°	27.78°	100	100.22
$\theta 3$	33.75°	34.39°	100	101.80
$\theta 4$	45°	45°	100	102.53
$\theta 5$	56.25°	55.61°	100	101.81
$\theta 6$	67.5°	65.22°	100	100.22
$\theta 7$	78.75°	77.59°	100	102.39
$\theta 8$	90°	90°	100	100.00
1-2 / 2W1-2 phase				

OUTPUT CIRCUIT

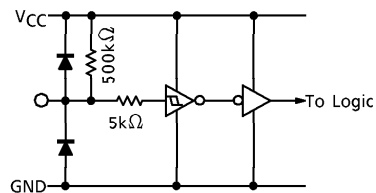


INPUT CIRCUIT

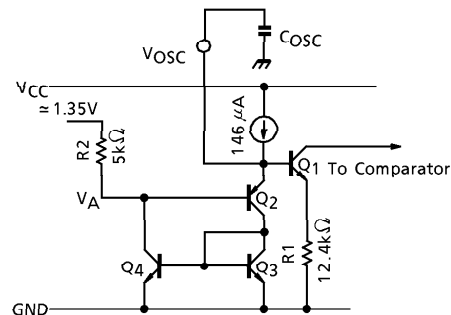
CK1, CK2, CW/CCW,
MODE Terminals



$\overline{\text{RESET}}$, $\overline{\text{ENABLE}}$ Terminals



OSC Terminals



- OSC frequency calculation

Sawtooth OSC circuit consists of Q₁ through Q₄ and R₁ through R₄.

Q₂ is turned "off" when V_{OSC} is less than the voltage of 2.5V + V_{BE} Q₂ approximately equal to 2.05V.

V_{OSC} is increased by C_{OSC} charging through R₁.

Q₃ and Q₄ are turned "on" when V_{OSC} becomes 2.05V (Higher level.)

Lower level of V_{OSC} pin is equal to V_{BE} Q₂ + V_{SAT} Q₄ approximately equal to 1.4V.

V_{OSC} is calculated by following equation.

Assuming that V_{OSC} = 1.4V (t = t₁) and = 2.05 (t = t₂)

C_{OSC} is external capacitance connected to pin^② and R₁ is on-chip 10kΩ resistor.

Therefore, OSC frequency is calculated as follows.

$$t_1 = \frac{1.0 \cdot C_{OSC}}{146 \times 10^{-6}}$$

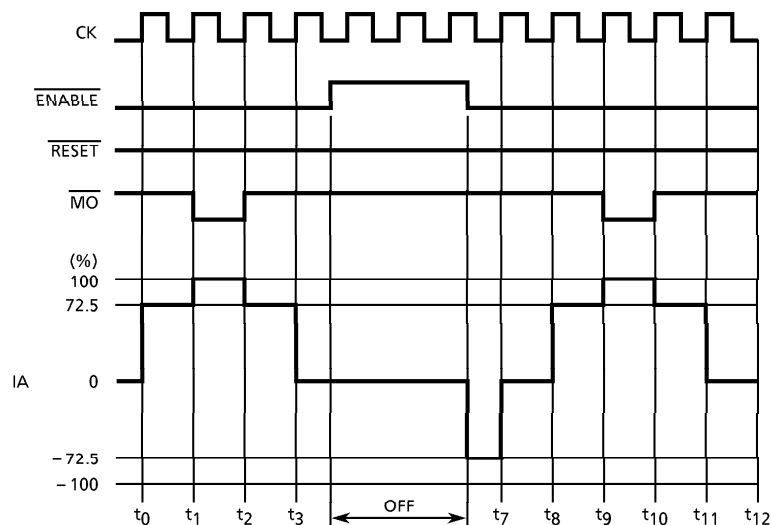
$$t_2 = \frac{2.05 \cdot C_{OSC}}{146 \times 10^{-6}}$$

$$f_{OSC} = \frac{1}{t_2 - t_1} = \frac{146 \times 10^{-6}}{C_{OSC} (2.05 - 1.0)}$$

$$= \frac{0.139}{C_{OSC}} \text{ (kHz) (C}_{OSC} \text{ unit} = \mu\text{F)}$$

ENABLE AND RESET FUNCTION AND $\overline{MO}$ SIGNAL

Fig.1. 1-2 phase drive mode (MODE : L)

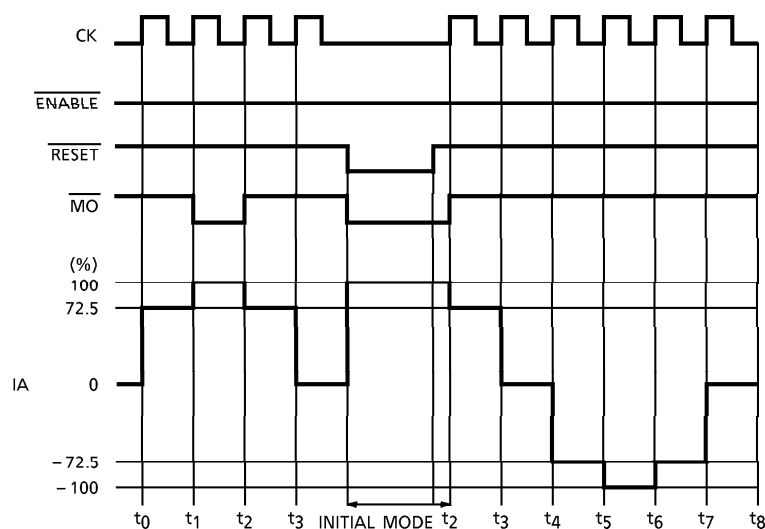


$\overline{ENABLE}$ signal disables only Output signal. Internal logic functions are proceeded by CK signal without regard to $\overline{ENABLE}$ signal.

Therefore, Output Current is initiated from the proceeded timing point of internal logic circuit, after release of disable mode.

Fig.1 shows the $\overline{ENABLE}$ functions, when the system is selected in 1-2 phase drive mode.

Fig.2. 1-2 phase drive mode (MODE : L)



As $\overline{RESET}$ is low, the decoder is initialized and $\overline{MO}$ is low.

After $\overline{RESET}$ is high, the motion is resumed from next clock as show in Fig.2.

$\overline{MO}$ (Monitor Output) signals is used as rotation and initial signal for stable rotation checking.

MAXIMUM RATINGS ($T_a = 25^\circ\text{C}$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V_{CC}	5.5	V
Output Voltage	V_M (opr.)	4.0~10.0	V
	V_M (MAX.)	12.0	
Output Current	I_O (MAX.)	120	mA
	AVE. I_O ($\overline{MO}$)	± 2	
Input Voltage	V_{IN}	$\sim V_{CC}$	V
Power Dissipation	P_D	0.83 (Note 1)	W
		1.04 (Note 2)	
Operating Temperature	T_{opr}	$-30\sim 85$	$^\circ\text{C}$
Storage Temperature	T_{stg}	$-55\sim 150$	$^\circ\text{C}$
Feed Back Voltage	V_I	1.0	V

(Note 1) No heat sink

(Note 2) With heat sink ($50 \times 50 \times 1.6\text{mm Cu } 10\%$)**RECOMMENDED OPERATING CONDITIONS** ($T_a = -30\sim 85^\circ\text{C}$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V_{CC} (opr.)		2.7	3.0	5.5	V
Output Voltage	V_M (opr.)		4.0	—	10.0	V
Output Current	I_{OUT}		—	—	100	mA
Input Voltage	V_{IN}		—	—	V_{CC}	V
Clock Frequency	f_{CLOCK}		—	—	5	kHz
OSC Frequency	f_{OSC}		15	—	80	kHz

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, (Ta = 25°C, V_{CC} = 3V, V_M = 5V, L = 20mH / R = 0.5Ω)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Input Voltage	High	V _{IN} (H)	1	MODE, CW / CCW, $\overline{\text{ENABLE}}$ CK1, CK2, $\overline{\text{RESET}}$	V _{CC} × 0.7	—	V _{CC} + 0.4	V
	Low	V _{IN} (L)			GND - 0.4	—	GND × 0.3	
Input Hysteresis Voltage		V _H			—	600	—	mV
Input Current		I _{IN-1} (H)	1	M1, M2, REF IN, V _{IN} = 5.0V	—	—	100	nA
		I _{IN-1} (L)		$\overline{\text{RESET}}$, V _{IN} = 0V, $\overline{\text{ENABLE}}$ Internal pull-up resistor	3	6	12	μA
		I _{IN-2} (L)		V _{IN} = 0V	—	—	100	nA
Quiescent Current V _{CC}		I _{CC1}	2	Output open, $\overline{\text{RESET}}$: H, $\overline{\text{ENABLE}}$: L, (1-2 phase excitation)	—	5	9	mA
		I _{CC2}		Output open, $\overline{\text{RESET}}$: H, $\overline{\text{ENABLE}}$: L (2W1-2 phase excitation)	—	5	9	
		I _{CC3}		$\overline{\text{RESET}}$: L, $\overline{\text{ENABLE}}$: H	—	1.3	—	
		I _{CC4}		$\overline{\text{RESET}}$: H, $\overline{\text{ENABLE}}$: H	—	1.3	—	
Comparator Reference Voltage		V _{NF}	3	R _{NF} = 2.5Ω, C _{OSC} = 0.0033μF	0.22	0.25	0.28	V
Output Diffirencial		ΔV _O	—	B / A, C _{OSC} = 0.0033μF R _{NF} = 2.5Ω	- 10	—	10	%
Maximum OSC Frequency		f _{OSC} (MAX.)	—		100	—	—	kHz
Minimum OSC Frequency		f _{OSC} (MIN.)	—		—	—	10	kHz
OSC Frequency		f _{OSC}	—	C _{OSC} = 0.0033μF	31	44	70	kHz
Output Voltage		V _{OH} (MO)	—	I _{OH} = - 40μA	2.5	—	V _{CC}	V
		V _{OL} (MO)	—	I _{OL} = 40μA	GND	0.1	0.5	

Output block

CHARACTERISTIC			SYMBOL	TEST CIR- CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Saturation Voltage	Upper Side		$V_{SAT\ U1}$	4	$I_{OUT} = 0.12A$	—	0.08	0.23	V
	Lower Side		$V_{SAT\ L1}$			—	0.16	0.43	
	Upper Side		$V_{SAT\ U2}$		$I_{OUT} = 0.06A$	—	0.06	—	
	Lower Side		$V_{SAT\ L2}$			—	0.10	—	
Diode Forward Voltage	Upper Side		$V_F\ U1$	5	$I_{OUT} = 0.12A$	—	1.13	1.8	V
	Lower Side		$V_F\ L1$			—	0.95	1.6	
Output Dark Current (A + B Channels)			I_{M1}	2	ENABLE : "H" level RESET : "L" level Output open	—	—	50	μA
			I_{M2}		ENABLE : "L" level RESET : "H" level Output open	—	17	28	mA
NF Dark Current (1 Channels)			I_{NF}		ENABLE : "L" level RESET : "H" level Output open	1	2.5	7	
A-B Chopping Current (Note)	2W1-2 ϕ	1-2 ϕ	VECTOR	3	$\theta = 0$	$R_{NF} = 2.5\Omega$ $C_{OSC} = 0.0033\mu F$	—	100	%
	2W1-2 ϕ	—			$\theta = 1/8$		—	100	
	2W1-2 ϕ	—			$\theta = 2/8$		86	91	
	2W1-2 ϕ	—			$\theta = 3/8$		79	84	
	2W1-2 ϕ	1-2 ϕ			$\theta = 4/8$		67.5	72.5	
	2W1-2 ϕ	—			$\theta = 5/8$		52.5	57.5	
	2W1-2 ϕ	—			$\theta = 6/8$		37	42	
	2W1-2 ϕ	—			$\theta = 7/8$		17	22	

(Note) Maximum current ($\theta = 0$) : 100%2W1-2 ϕ : 2W1, 2 phase excitation modeW1-2 ϕ : W1, 2 phase excitation mode1-2 ϕ : 1, 2 phase excitation mode

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, (Ta = 25°C, V_{CC} = 3V, V_M = 5V, L = 20mH / R = 0.5Ω)

CHARACTERISTIC			SYMBOL	TEST CIR- CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
A-B Chopping Current (Note)	2W1-2φ	1-2φ	VECTOR	3	θ = 0	—	100	—	%
	2W1-2φ	—			θ = 1 / 8	—	100	—	
	2W1-2φ	—			θ = 2 / 8	—	91.1	—	
	2W1-2φ	—			θ = 3 / 8	—	83.6	—	
	2W1-2φ	1-2φ			θ = 4 / 8	—	72.6	—	
	2W1-2φ	—			θ = 5 / 8	—	60.0	—	
	2W1-2φ	—			θ = 6 / 8	—	44.5	—	
	2W1-2φ	—			θ = 7 / 8	—	24.3	—	
Reference Voltage			ΔV _{NF}	3	Δθ = 0 / 8 - 1 / 8	—	0	—	mV
					Δθ = 1 / 8 - 2 / 8	10	22.5	35	
					Δθ = 2 / 8 - 3 / 8	5	17.5	30	
					Δθ = 3 / 8 - 4 / 8	16.25	28.75	41.25	
					Δθ = 4 / 8 - 5 / 8	25	37.5	50	
					Δθ = 5 / 8 - 6 / 8	26.25	38.75	51.25	
					Δθ = 6 / 8 - 7 / 8	37.5	50	62.5	
Output Tr Switching Characteristics			t _r	7	R _L = 2Ω, V _{NF} = 0V, C _L = 15pF	—	0.3	—	μs
			t _f			—	2.2	—	
			t _{pLH}		CK~Output	—	1.5	—	
			t _{pHL}			—	2.7	—	
			t _{pLH}		OSC~Output	—	5.4	—	
			t _{pHL}			—	6.3	—	
			t _{pLH}		RESET~Output	—	2.0	—	
			t _{pHL}			—	2.5	—	
			t _{pLH}		ENABLE~Output	—	5.0	—	
			t _{pHL}			—	6.0	—	
Output Leakage Current	Upper Side	I _{OH}	6	V _M = 12V		—	—	50	μA
	Lower Side	I _{OL}				—	—	50	

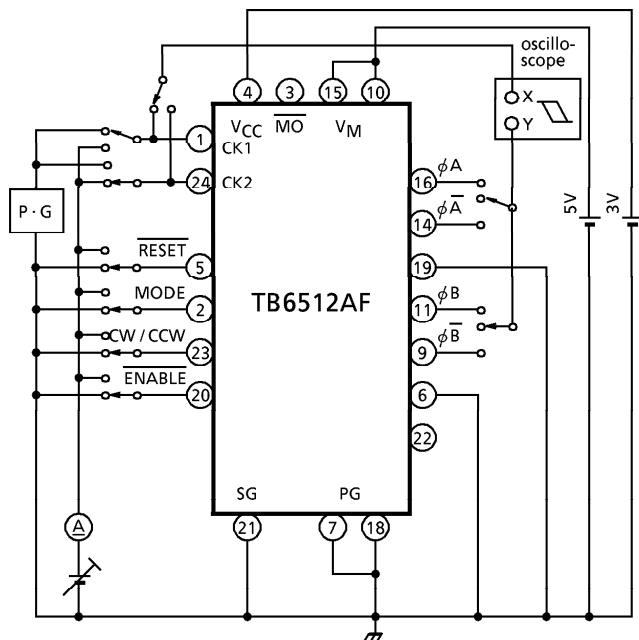
(Note) Maximum current (θ = 0) : 100%

2W1-2φ : 2W1, 2 phase excitation mode

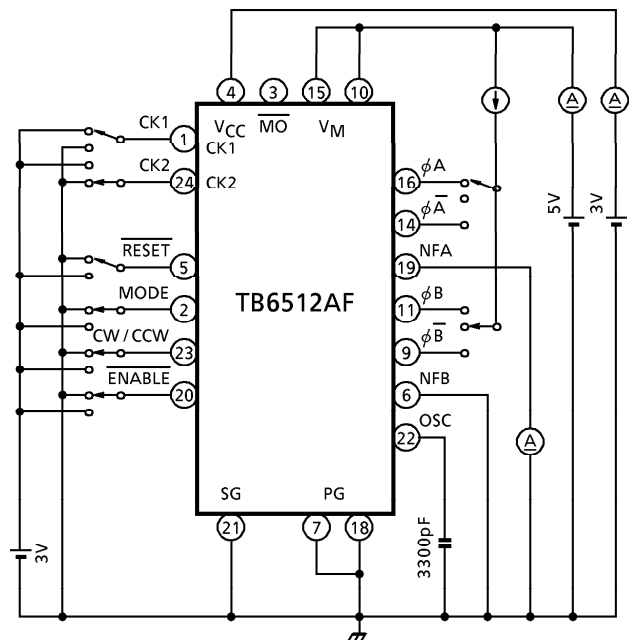
W1-2φ : W1, 2 phase excitation mode

1-2φ : 1,2 phase excitation mode

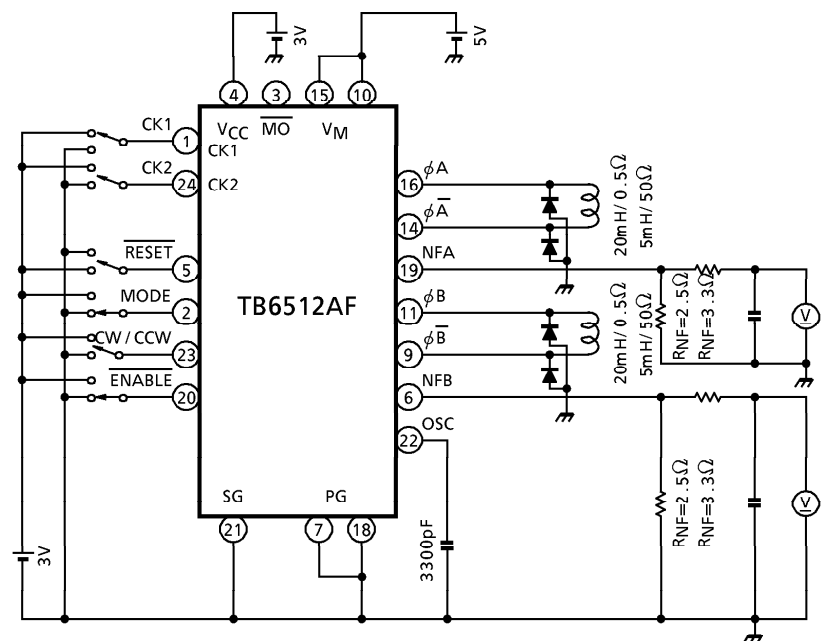
TEST CIRCUIT 1 : V_{IN} (H), (L), I_{IN} (H), (L)

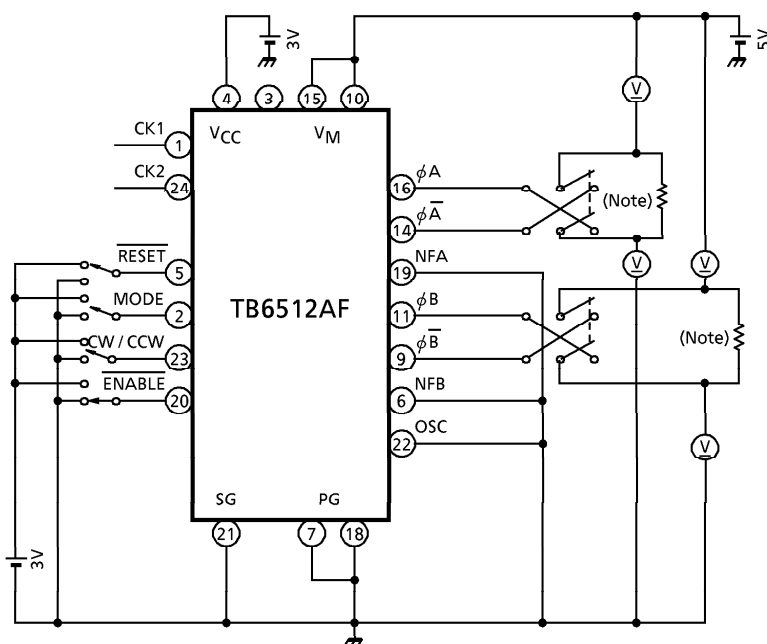


TEST CIRCUIT 2 : I_{CC} , I_M , I_{NF}

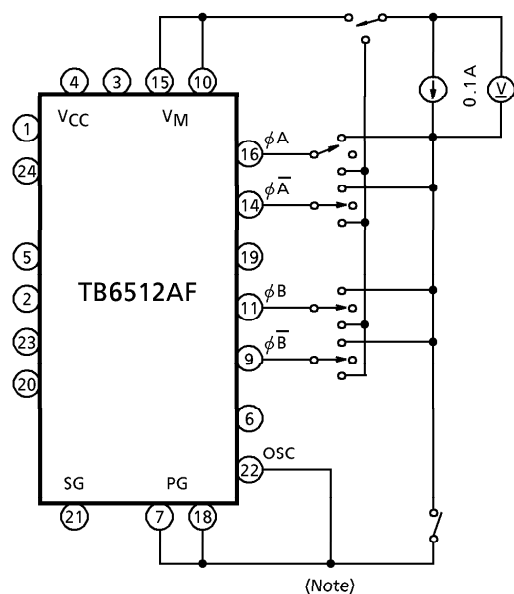
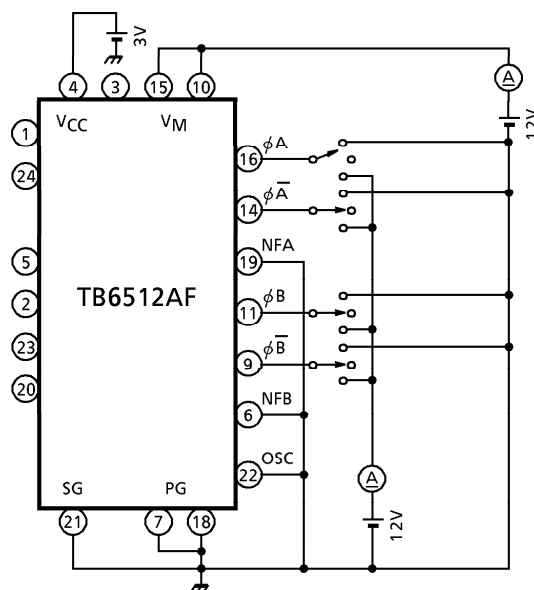


TEST CIRCUIT 3 : V_{NF}



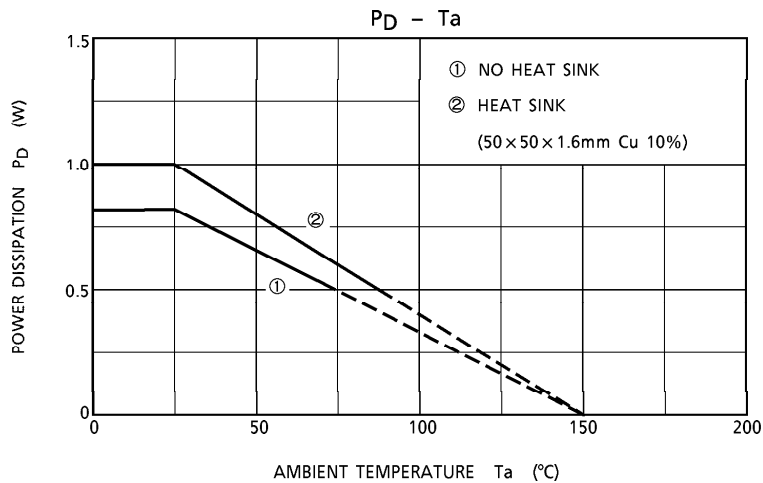
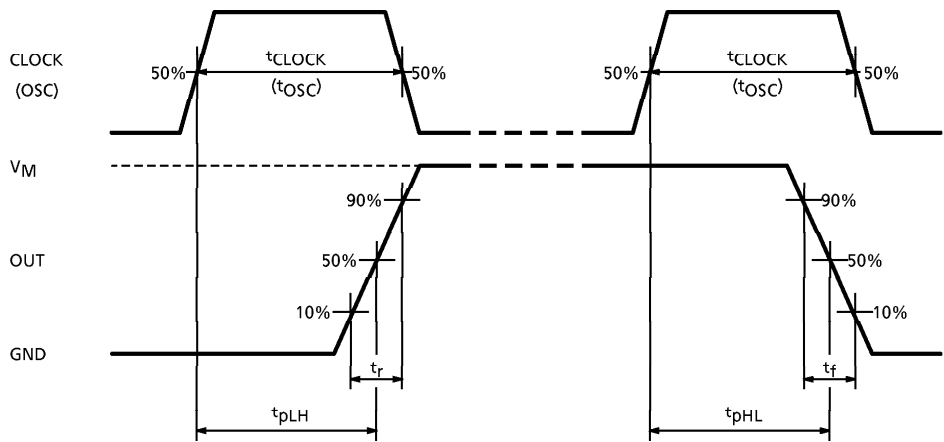
TEST CIRCUIT 4 : $V_{CE(SAT)}$ Upper, lower

(Note) Calibrate Output Current becomes 0.06A (or 0.10A) with this resistor.

TEST CIRCUIT 5 : V_{F-U} , V_{F-L} TEST CIRCUIT 6 : I_{OH} , I_{OL} 

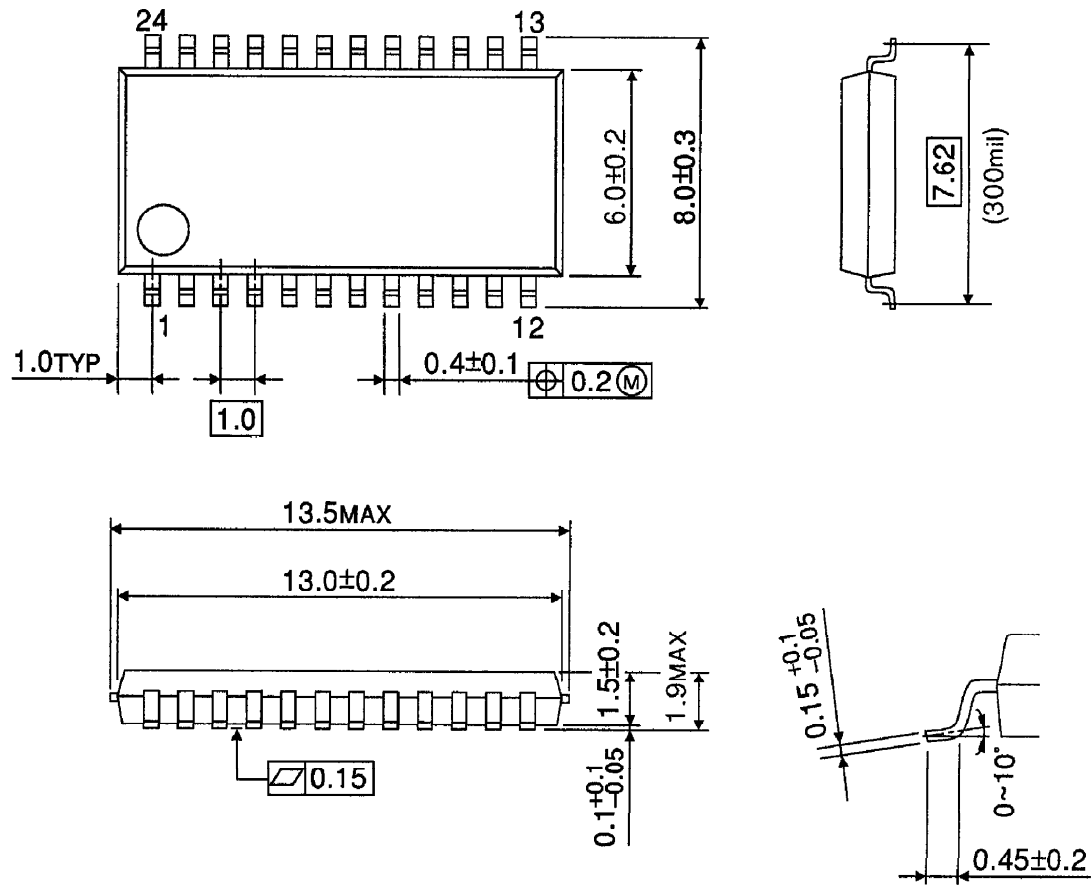
(Note) Not to take a GND with any non-connecting Pins.

AC ELECTRICAL, CHARACTERICAL
CK (OSC) – OUT



OUTLINE DRAWING
SSOP24-P-300-1.00B

Unit : mm



Weight : 0.27g (Typ.)