

TOSHIBA Bi-CMOS INTEGRATED CIRCUIT MULTICHIP

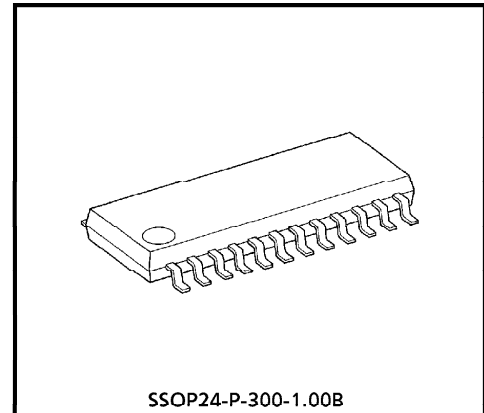
**T B 6 5 1 2 A F****PWM CHOPPER TYPE BIPOLAR STEPPING MOTOR DRIVER**

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  $\overline{MO}$ .  $I_O(\overline{MO}) = \pm 2\text{mA MAX.}$
- Reset and Enable are available with  $\overline{\text{RESET}}$  and  $\overline{\text{ENABLE}}$ .



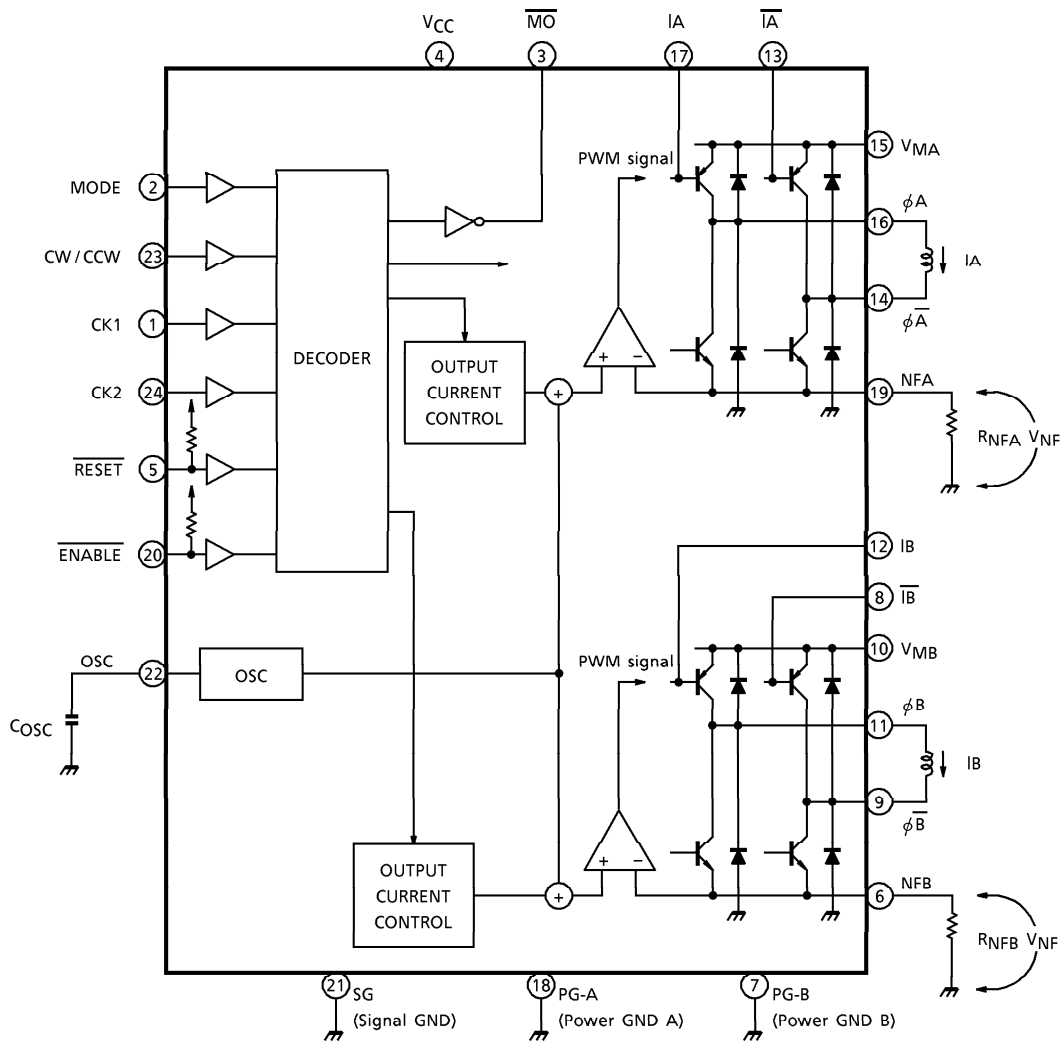
SSOP24-P-300-1.00B

Weight : 0.27g (Typ.)

961001EBA2

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BLOCK DIAGRAM

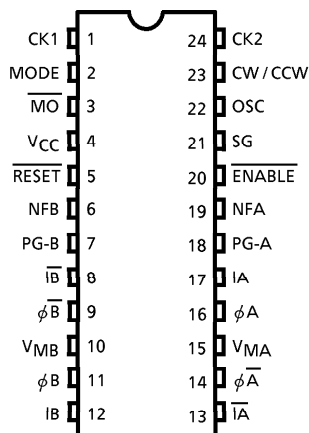


⑤, ⑳ : Pull-up Resistor 500kΩ (Typ.)

**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	$\overline{MO}$	Monitor Output terminal	
4	$V_{CC}$	Power voltage supply terminal for Logic	
5	$\overline{RESET}$	Reset Signal Input terminal	Truth table A
6	NFB	B Channel current detective terminal	
7	PG-B	Power GND B terminal	
8	$\overline{IB}$	Upper PNP Transistor Base terminal	
9	$\phi\overline{B}$	Output B terminal	
10	$V_{MB}$	Power voltage supply terminal for Motor B	
11	$\phi B$	Output B terminal	
12	IB	Upper PNP Transistor Base terminal	
13	$\overline{IA}$	Upper PNP Transistor Base terminal	
14	$\phi\overline{A}$	Output A terminal	
15	$V_{MA}$	Power voltage supply terminal for Motor A	
16	$\phi A$	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	$\overline{ENABLE}$	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

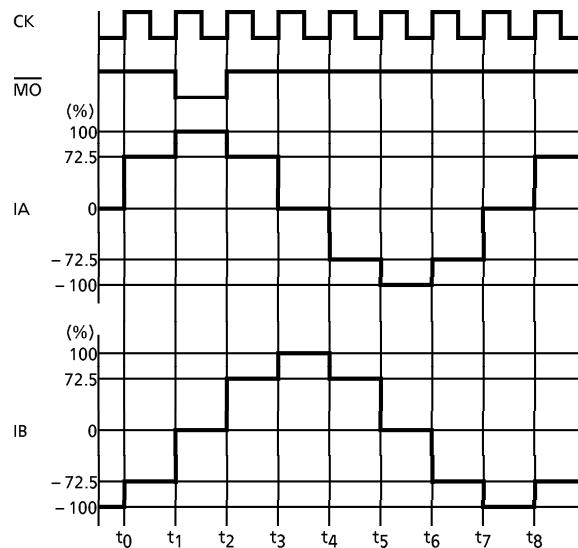
**TRUTH TABLE B**

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

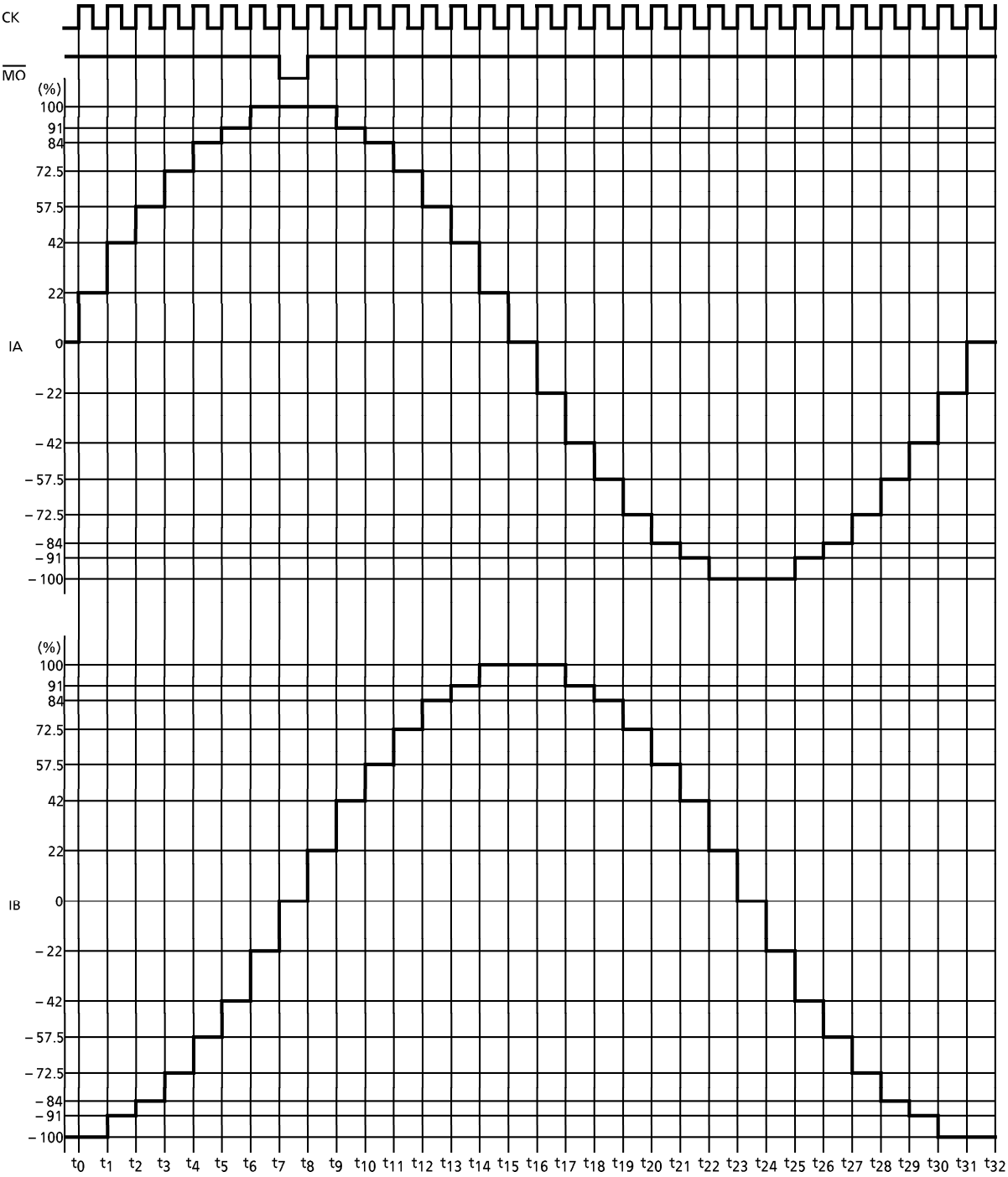
**INITIAL MODE**

EXCITATION MODE	I <sub>OUT</sub> (A)	I <sub>OUT</sub> (B)
1-2 phase	100%	0%
2W1-2 phase	100%	0%

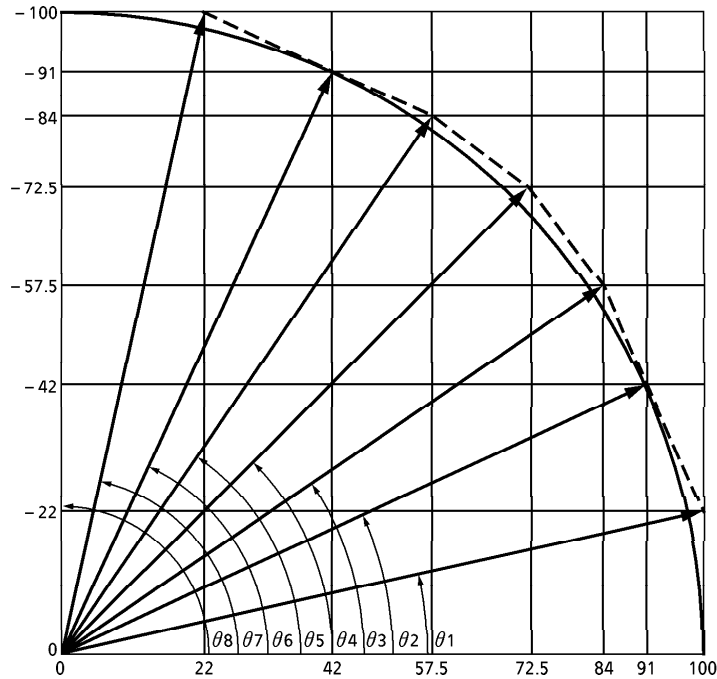
**1-2 PHASE EXCITATION (MODE : L, CW mode)**



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



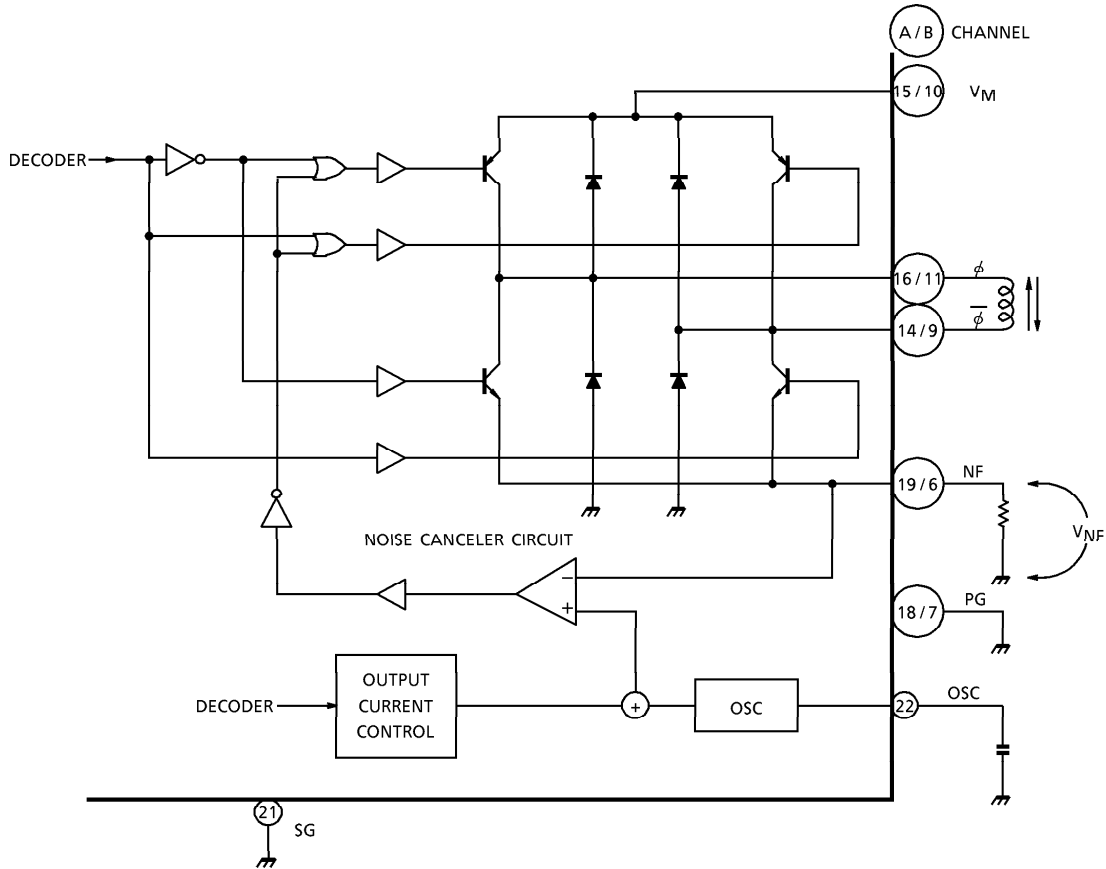
**OUTPUT CURRENT VECTOR OR BIT (Normalize to 90 deg for each one step)**



$\theta$	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

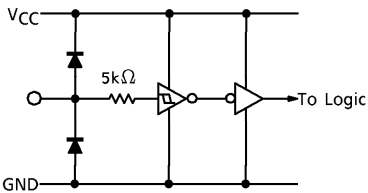
1-2 / 2W1-2 phase

OUTPUT CIRCUIT

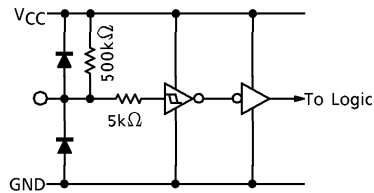


INPUT CIRCUIT

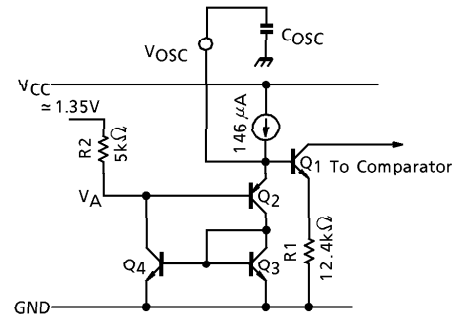
CK1, CK2, CW/CCW,  
MODE Terminals



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



OSC Terminals



- OSC frequency calculation

Sawtooth OSC circuit consists of Q<sub>1</sub> through Q<sub>4</sub> and R<sub>1</sub> through R<sub>4</sub>.

Q<sub>2</sub> is turned "off" when V<sub>OSC</sub> is less than the voltage of 2.5V + V<sub>BE</sub> Q<sub>2</sub> approximately equal to 2.05V.

V<sub>OSC</sub> is increased by C<sub>OSC</sub> charging through R<sub>1</sub>.

Q<sub>3</sub> and Q<sub>4</sub> are turned "on" when V<sub>OSC</sub> becomes 2.05V (Higher level.)

Lower level of V<sub>OSC</sub> pin is equal to V<sub>BE</sub> Q<sub>2</sub> + V<sub>SAT</sub> Q<sub>4</sub> approximately equal to 1.4V.

V<sub>OSC</sub> is calculated by following equation.

Assuming that V<sub>OSC</sub> = 1.4V (t = t<sub>1</sub>) and = 2.05 (t = t<sub>2</sub>)

C<sub>OSC</sub> is external capacitance connected to pin<sup>Ⓜ</sup> and R<sub>1</sub> is on-chip 10kΩ resistor.

Therefore, OSC frequency is calculated as follows.

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

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

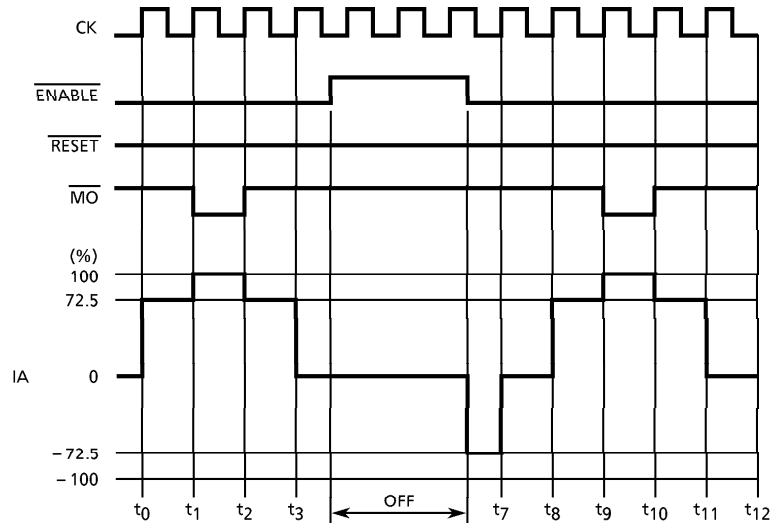
$$f_{OSC} = \frac{1}{t_2 - t_1} = \frac{146 \times 10^{-6}}{C_{OSC} (2.05 - 1.0)}$$

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



**ENABLE AND RESET FUNCTION AND MO SIGNAL**

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

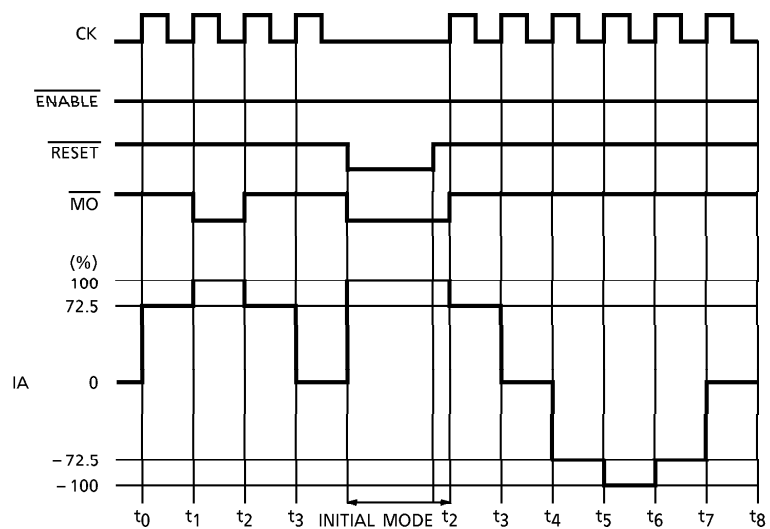


ENABLE signal disables only Output signal. Internal logic functions are proceeded by CK signal without regard to ENABLE signal.

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

Fig.1 shows the ENABLE functions, when the system is selected in 1-2 phase drive mode.

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



As RESET is low, the decoder is initialized and MO is low.

After RESET is high, the motion is resumed from next clock as show in Fig.2.

MO (Monitor Output) signals is used as rotation and initial signal for stable rotation checking.

**MAXIMUM RATINGS** (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V <sub>CC</sub>	5.5	V
Output Voltage	V <sub>M (opr.)</sub>	4.0~10.0	V
	V <sub>M (MAX.)</sub>	12.0	
Output Current	I <sub>O (MAX.)</sub>	120	mA
	AVE. I <sub>O (M<math>\bar{O}</math>)</sub>	±2	
Input Voltage	V <sub>IN</sub>	~V <sub>CC</sub>	V
Power Dissipation	P <sub>D</sub>	0.83 (Note 1)	W
		1.04 (Note 2)	
Operating Temperature	T <sub>opr</sub>	-30~85	°C
Storage Temperature	T <sub>stg</sub>	-55~150	°C
Feed Back Voltage	V <sub>I</sub>	1.0	V

(Note 1) No heat sink

(Note 2) With heat sink (50 × 50 × 1.6mm Cu 10%)

**RECOMMENDED OPERATING CONDITIONS** (Ta = -30~85°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V <sub>CC (opr.)</sub>		2.7	3.0	5.5	V
Output Voltage	V <sub>M (opr.)</sub>		4.0	—	10.0	V
Output Current	I <sub>OUT</sub>		—	—	100	mA
Input Voltage	V <sub>IN</sub>		—	—	V <sub>CC</sub>	V
Clock Frequency	f <sub>CLOCK</sub>		—	—	5	kHz
OSC Frequency	f <sub>OSC</sub>		15	—	80	kHz

**ELECTRICAL CHARACTERISTICS**

Unless otherwise specified, (Ta = 25°C, VCC = 3V, VM = 5V, L = 20mH / R = 0.5Ω)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Input Voltage	High	V <sub>IN</sub> (H)	1	MODE, CW/CCW, $\overline{\text{ENABLE}}$ CK1, CK2, $\overline{\text{RESET}}$	V <sub>CC</sub> × 0.7	—	V <sub>CC</sub> + 0.4	V
	Low	V <sub>IN</sub> (L)			GND - 0.4	—	GND × 0.3	
Input Hysteresis Voltage		V <sub>H</sub>			—	600	—	mV
Input Current	I <sub>IN-1</sub> (H)		1	M1, M2, REF IN, V <sub>IN</sub> = 5.0V	—	—	100	nA
	I <sub>IN-1</sub> (L)			$\overline{\text{RESET}}$ , V <sub>IN</sub> = 0V, $\overline{\text{ENABLE}}$ Internal pull-up resistor	3	6	12	μA
	I <sub>IN-2</sub> (L)			V <sub>IN</sub> = 0V	—	—	100	nA
Quiescent Current V <sub>CC</sub>	I <sub>CC1</sub>		2	Output open, $\overline{\text{RESET}}$ : H, $\overline{\text{ENABLE}}$ : L, (1-2 phase excitation)	—	5	9	mA
	I <sub>CC2</sub>			Output open, $\overline{\text{RESET}}$ : H, $\overline{\text{ENABLE}}$ : L (2W1-2 phase excitation)	—	5	9	
	I <sub>CC3</sub>			$\overline{\text{RESET}}$ : L, $\overline{\text{ENABLE}}$ : H	—	1.3	—	
	I <sub>CC4</sub>			$\overline{\text{RESET}}$ : H, $\overline{\text{ENABLE}}$ : H	—	1.3	—	
Comparator Reference Voltage		V <sub>NF</sub>	3	R <sub>NF</sub> = 2.5Ω, C <sub>OSC</sub> = 0.0033μF	0.22	0.25	0.28	V
Output Diffirencial		ΔV <sub>O</sub>	—	B / A, C <sub>OSC</sub> = 0.0033μF R <sub>NF</sub> = 2.5Ω	- 10	—	10	%
Maximum OSC Frequency		f <sub>OSC</sub> (MAX.)	—		100	—	—	kHz
Minimum OSC Frequency		f <sub>OSC</sub> (MIN.)	—		—	—	10	kHz
OSC Frequency		f <sub>OSC</sub>	—	C <sub>OSC</sub> = 0.0033μF	31	44	70	kHz
Output Voltage	V <sub>OH</sub> (MO)		—	I <sub>OH</sub> = - 40μA	2.5	—	V <sub>CC</sub>	V
	V <sub>OL</sub> (MO)		—	I <sub>OL</sub> = 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	$\mu A$		
		$I_{M2}$		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 $\phi$	1-2 $\phi$	VECTOR	3	$R_{NF} = 2.5\Omega$ $C_{OSC} = 0.0033\mu F$	$\theta = 0$	—	100	—	%
	2W1-2 $\phi$	—				$\theta = 1/8$	—	100	—	
	2W1-2 $\phi$	—				$\theta = 2/8$	86	91	96	
	2W1-2 $\phi$	—				$\theta = 3/8$	79	84	89	
	2W1-2 $\phi$	1-2 $\phi$				$\theta = 4/8$	67.5	72.5	77.5	
	2W1-2 $\phi$	—				$\theta = 5/8$	52.5	57.5	62.5	
	2W1-2 $\phi$	—				$\theta = 6/8$	37	42	47	
	2W1-2 $\phi$	—				$\theta = 7/8$	17	22	27	

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

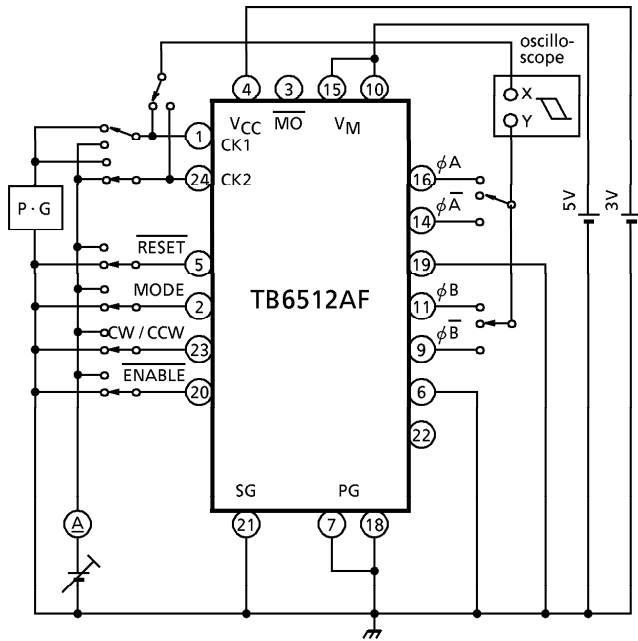
**ELECTRICAL CHARACTERISTICS**

Unless otherwise specified, (Ta = 25°C, VCC = 3V, VM = 5V, L = 20mH / R = 0.5Ω)

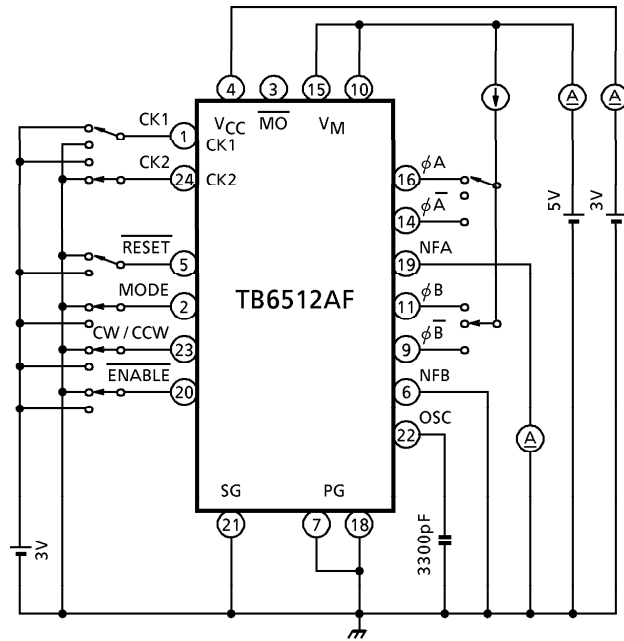
CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT		
A-B Chopping Current (Note)	2W1-2φ	1-2φ	3	θ = 0	RNf = 3.3Ω COSC = 0.0033μF L = 5mH / R = 50Ω	—	100	—	%	
	2W1-2φ	—		θ = 1/8		—	100	—		
	2W1-2φ	—		θ = 2/8		—	91.1	—		
	2W1-2φ	—		θ = 3/8		—	83.6	—		
	2W1-2φ	1-2φ		θ = 4/8		—	72.6	—		
	2W1-2φ	—		θ = 5/8		—	60.0	—		
	2W1-2φ	—		θ = 6/8		—	44.5	—		
	2W1-2φ	—		θ = 7/8		—	24.3	—		
Reference Voltage	ΔVNF		3	Δθ = 0/8 - 1/8	RNf = 2.5Ω COSC = 0.0033μF	—	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			7	RL = 2Ω, VNF = 0V, CL = 15pF		—	0.3	—	μs	
				tf		—	2.2	—		
				tpLH		CK~Output	—	1.5		—
				tpHL		—	—	2.7		—
				tpLH		OSC~Output	—	5.4		—
				tpHL		—	—	6.3		—
				tpLH		RESET~Output	—	2.0		—
				tpHL		—	—	2.5		—
				tpLH		ENABLE~Output	—	5.0		—
				tpHL		—	—	6.0		—
Output Leakage Current	Upper Side	I <sub>OH</sub>	6	VM = 12V	—	—	50	μA		
	Lower Side	I <sub>OL</sub>			—	—	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

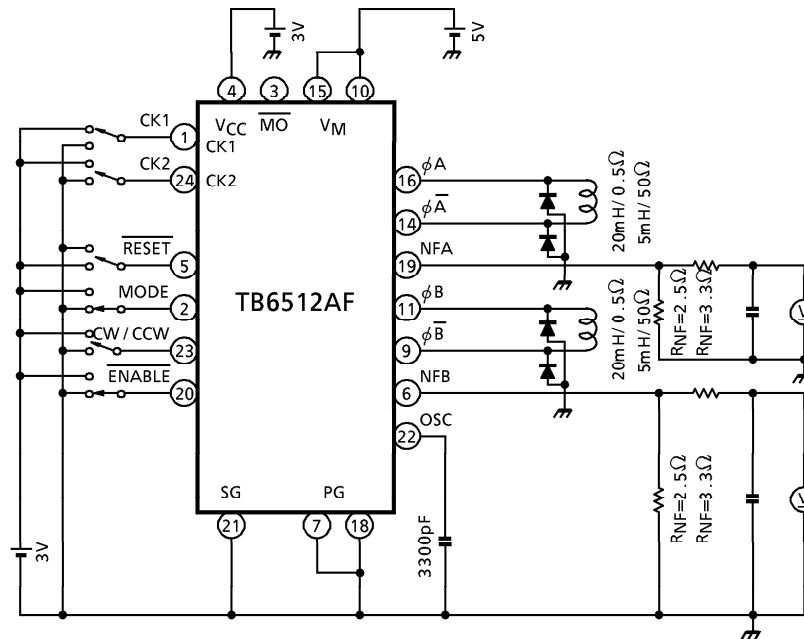
**TEST CIRCUIT 1 :  $V_{IN}$  (H), (L),  $I_{IN}$  (H), (L)**



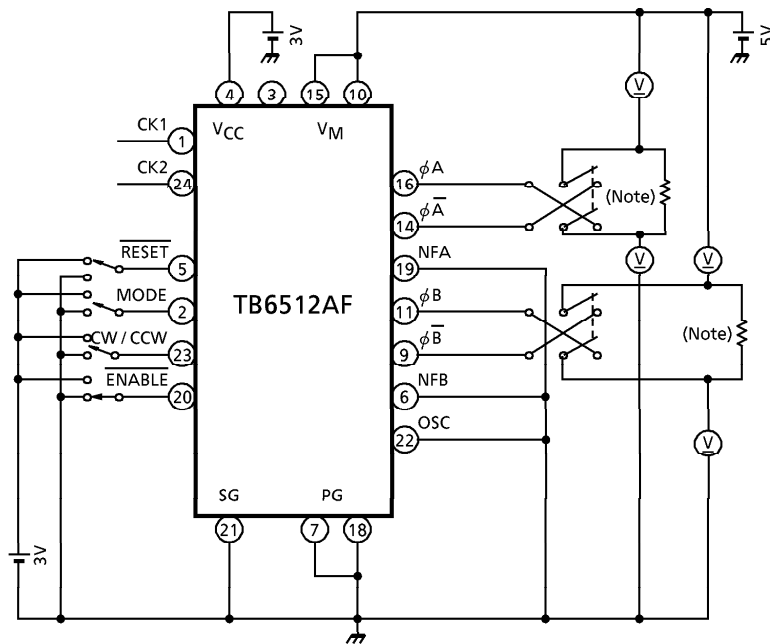
**TEST CIRCUIT 2 :  $I_{CC}$ ,  $I_M$ ,  $I_{NF}$**



**TEST CIRCUIT 3 :  $V_{NF}$**

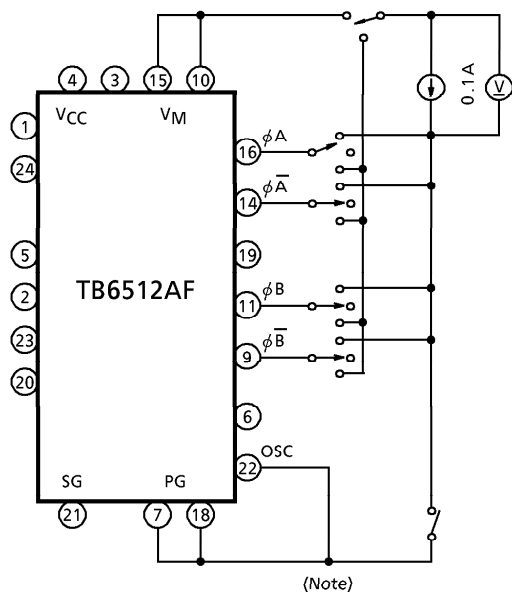


TEST CIRCUIT 4 :  $V_{CE(SAT)}$  Upper, lower

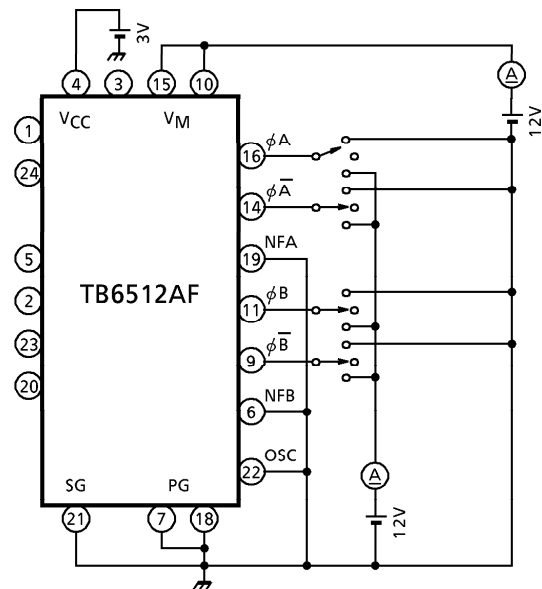


(Note) Calibrate Output Current becomes 0.06A (or 0.10A) with this resistor.

TEST CIRCUIT 5 :  $V_{F-U}$ ,  $V_{F-L}$

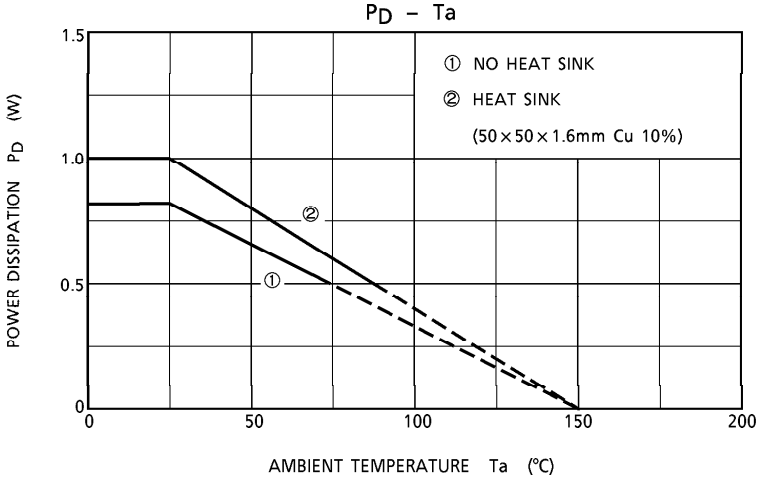
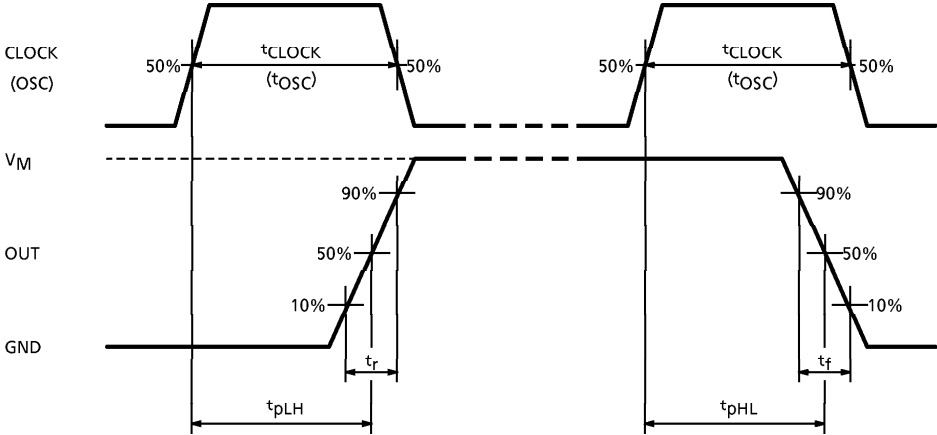


TEST CIRCUIT 6 :  $I_{OH}$ ,  $I_{OL}$



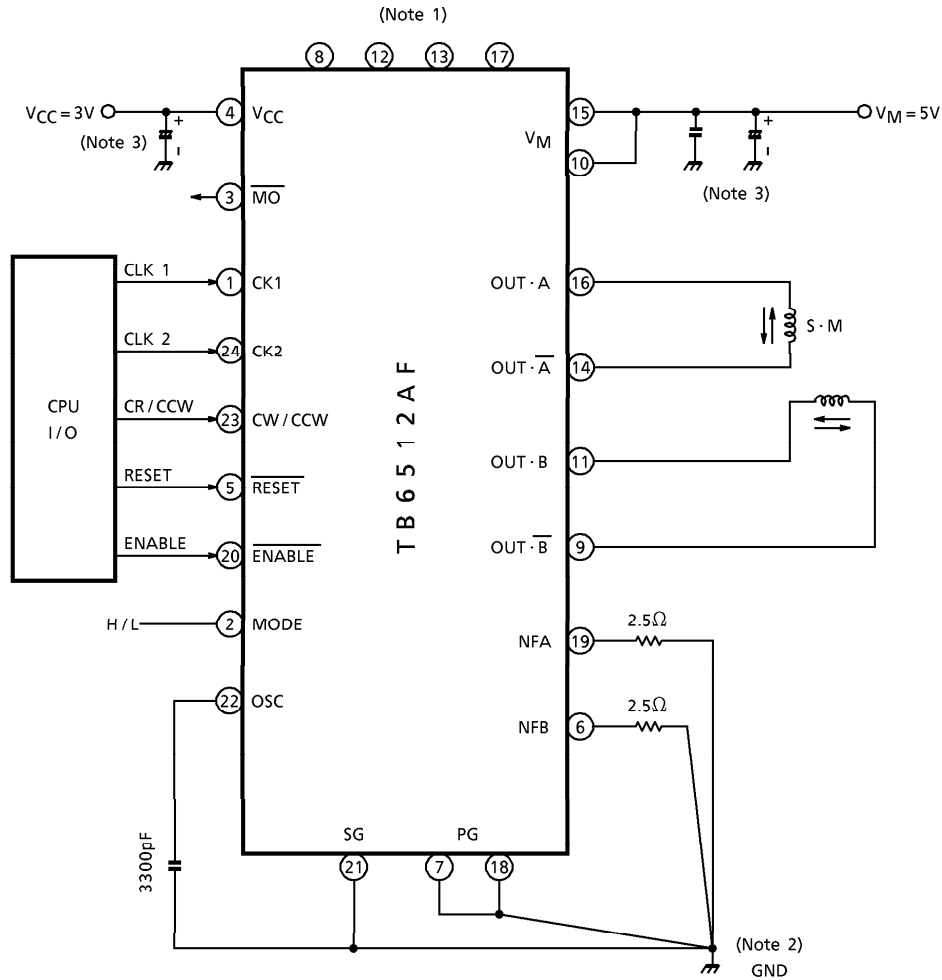
(Note) Not to take a GND with any non-connecting Pins.

AC ELECTRICAL, CHARACTERICAL  
CK (OSC) – OUT





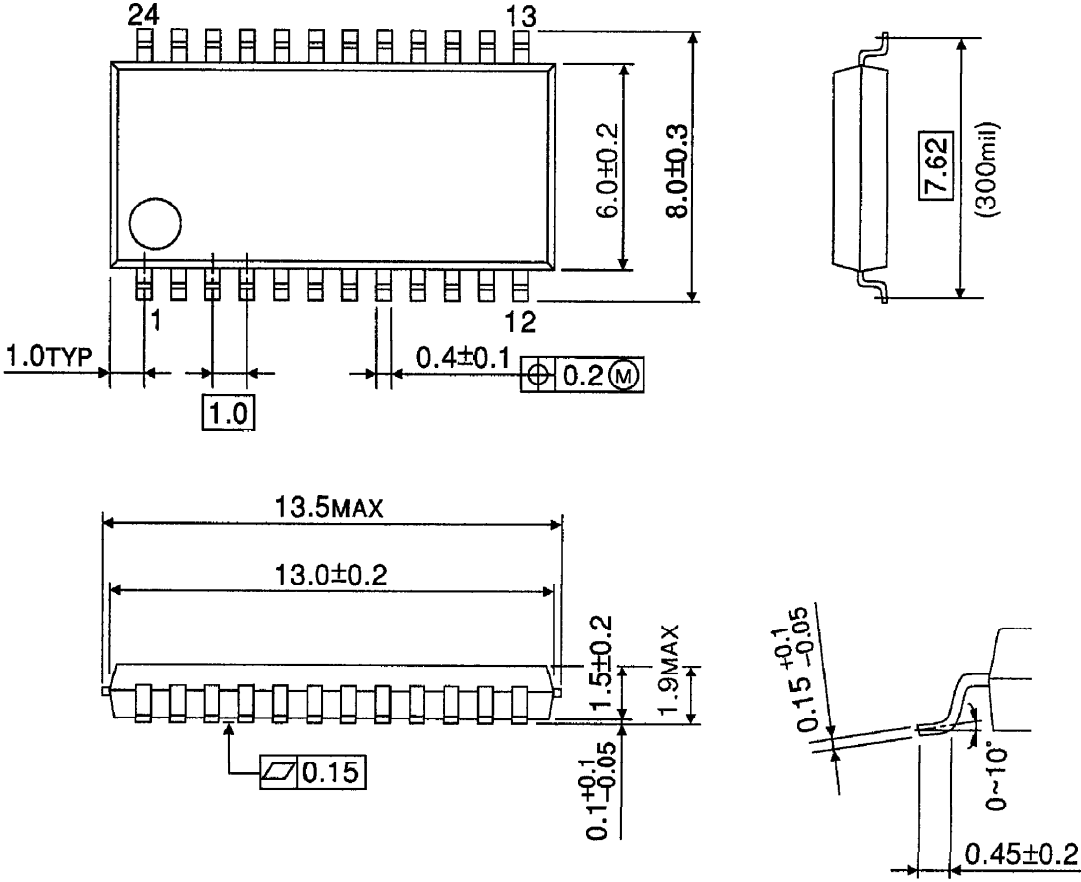
APPLICATION CIRCUIT



- (Note 1) ⑧, ⑫, ⑬, ⑰pin : open
- (Note 2) GND pattern to be laid out at one point in order to prevent common impedance.
- (Note 3) Capacitor for noise suppression to be connected between the Power Supply ( $V_{CC}$ ,  $V_M$ ) and GND to stabilize the operation.
- (Note 4) Utmost care is necessary in the design of the output line,  $V_M$  and GND line since IC may be destroyed due to short-circuit between outputs, air contamination fault, or fault by improper grounding.

OUTLINE DRAWING  
SSOP24-P-300-1.00B

Unit : mm



Weight : 0.27g (Typ.)