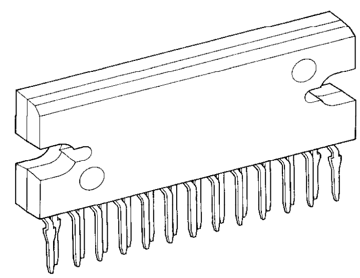
TOSHIBA BIPOLAR LINEAR INTEGRATED CIRCUIT SILICON MONOLITHIC

TA8435H

PWM CHOPPER TYPE BIPOLAR STEPPING MOTOR DRIVER.

The TA8435H 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.



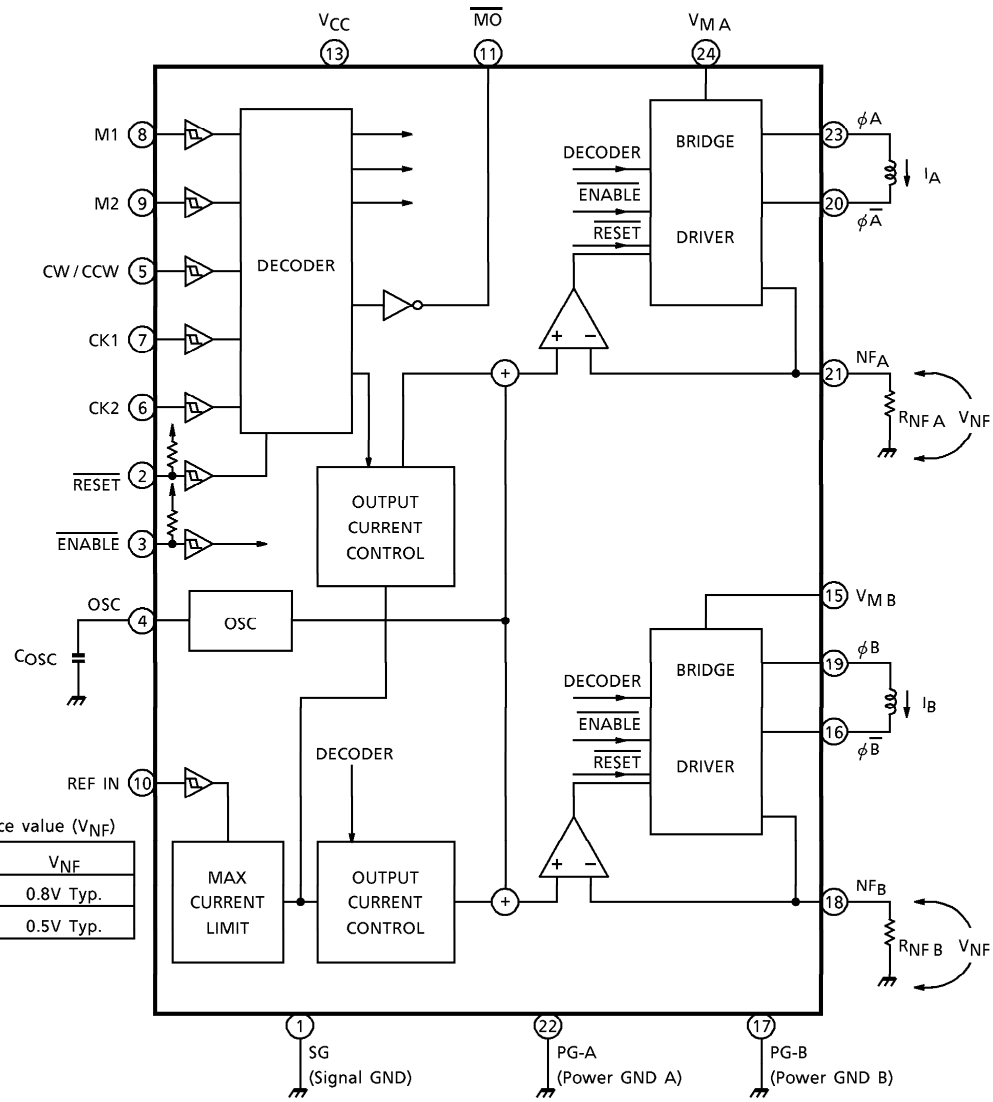
HZIP25-P-1.27

Weight : 9.86g (Typ.)

FEATURES

- 1 chip bipolar sinusoidal micro step stepping motor driver.
- Output current up to 1.5A (AVE.) and 2.5A (PEAK).
- PWM chopper type.
- Structured by high voltage Bi-CMOS process technology.
- Forward and reverse rotation are available.
- 2, 1-2, W1-2, 2W1-2 phase 1 or 2 clock drives are selectable.
- Package : HZIP25-P
- Input Pull-up Resistor equipped with $\overline{\text{RESET}}$ Terminal : R = 100kΩ (Typ.)
- Output Monitor available with $\overline{\text{MO}}$. $I_{O\,(\overline{MO})} = \pm 2\text{mA}$ (MAX.)
- Reset and Enable are available with $\overline{\text{RESET}}$ and $\overline{\text{ENABLE}}$.

BLOCK DIAGRAM

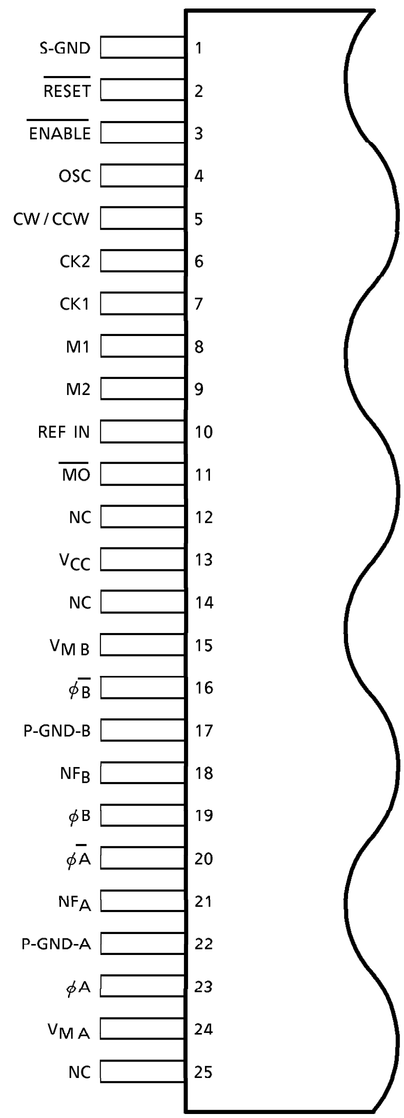


Output reference value (V_{NF})

REF IN	V_{NF}
H	0.8V Typ.
L	0.5V Typ.

Pull-up resistance : 100kΩ (Typ.)
Pin⑫、⑭、㉕ : Non connection

PIN CONNECTION (Top view)

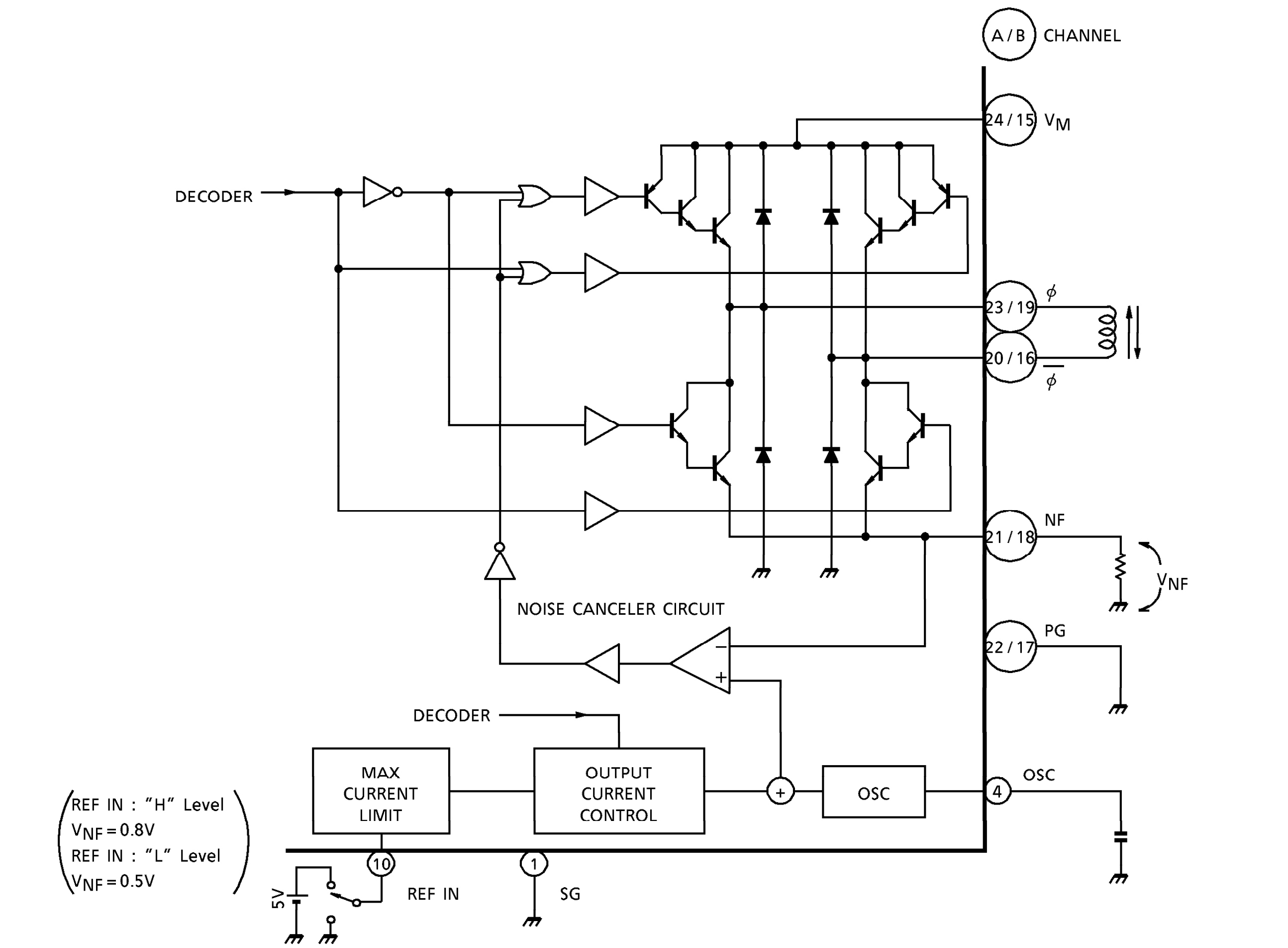


(Note) NC : No connection

PIN FUNCTION

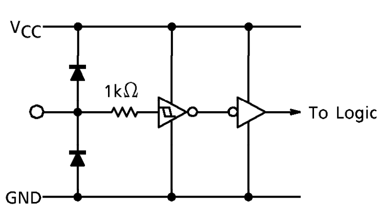
PIN No.	SYMBOL	FUNCTIONAL DESCRIPTION
1	SG	Signal GND.
2	$\overline{\text{RESET}}$	L : RESET.
3	$\overline{\text{ENABLE}}$	L : ENABLE, H : OFF.
4	OSC	Chopping oscillation is determined by the external capacitor.
5	CW / CCW	Forward / Reverse switching terminal.
6	CK2	Clock input terminal.
7	CK1	Clock input terminal.
8	M1	Excitation control input
9	M2	Excitation control input
10	REF IN	V_{NF} control input
11	$\overline{\text{MO}}$	Monitor output
12	NC	No connection.
13	V_{CC}	Voltage supply for logic.
14	NC	No connection.
15	$V_{M B}$	Output power supply terminal.
16	$\phi\overline{B}$	Output $\phi\overline{B}$
17	PG-B	Power GND.
18	NF_B	B-ch output current detection terminal.
19	ϕB	Output ϕB
20	$\phi\overline{A}$	Output $\phi\overline{A}$
21	NF_A	A-ch output current detection terminal.
22	PG-A	Power GND
23	ϕA	Output ϕA
24	V_{MA}	Output power supply terminal.
25	NC	No connection.

OUTPUT CIRCUIT

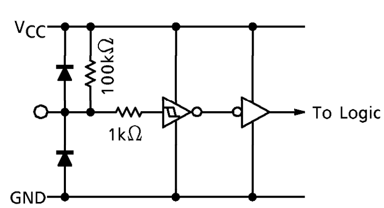


INPUT CIRCUIT

- CK1, CK2, CW / CCW, M1, M2, REF IN : Terminals

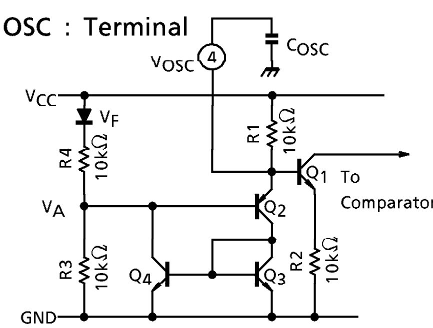


- $\overline{\text{RESET}}$, $\overline{\text{ENABLE}}$: Terminals



100kΩ of Pull-up Resister is equipped.

- OSC : Terminal



$$V_A = (V_{CC} - V_F)\frac{R3}{R3 + R4} \fallingdotseq 2.15\text{V}$$

OSC FREQUENCY CALCULATION

Sawtooth OSC circuit consists of Q_1 through Q_4 and R1 through R4.

Q_2 is turned "off" when V_{OSC} is less than the voltage of $2.5V + V_{BE}\ Q_2$ approximately equal to 2.85V.

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

Q_3 and Q_4 are turned "on" when V_{OSC} becomes 2.85V (Higher level.)

Lower level of V ④ pin is equal to $V_{BE}\ Q_2 + V_{SAT}\ Q_4$ approximately equal to 1.4V.

V_{OSC} is calculated by following equation.

$$V_{OSC} = 5 \cdot \left[1 - \exp\left(- \frac{t}{C_{OSC} \cdot R1} \right) \right] \quad \text{.............} \quad ①$$

Assuming that $V_{OSC} = 1.4V$ $(t = t_1)$ and $= 2.85V$ $(t = t_2)$

C_{OSC} is external capacitance connected to pin④ and R1 is on-chip 10kΩ resistor.

Therefore, OSC frequency is calculated as follows.

$$t_1 = -C_{OSC} \cdot R1 \cdot \ell n \left(1 - \frac{1.4}{5}\right) \quad \text{...................} \quad ②$$

$$t_2 = -C_{OSC} \cdot R1 \cdot \ell n \left(1 - \frac{2.85}{5}\right) \quad \text{..................} \quad ③$$

$$f_{OSC} = \frac{1}{t_2 - t_1} = \frac{1}{C_{OSC}\left(R1 \cdot \ell n \left(1 - \frac{1.4}{5}\right) - R1 \cdot \ell n \left(1 - \frac{2.85}{5}\right)\right)}$$

$$= \frac{1}{5.15 \cdot C_{OSC}} \ (\text{kHz}) \ (C_{OSC} : \mu F)$$

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

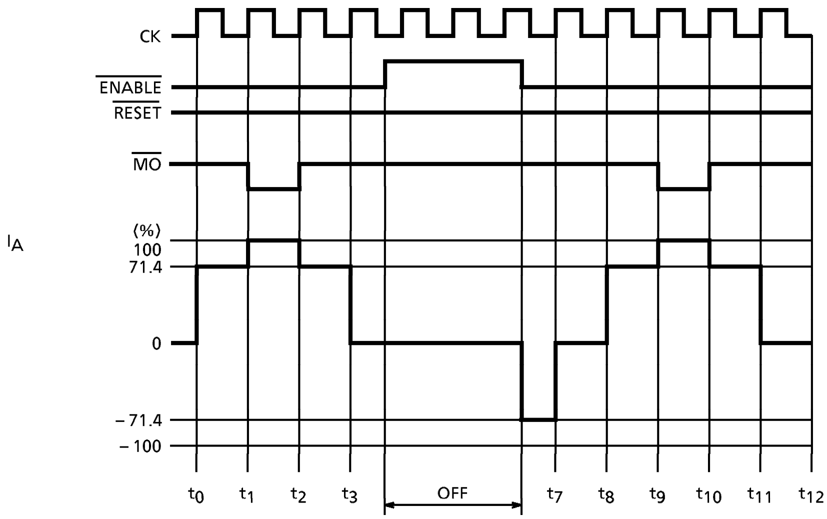


Fig.1 1-2 Phase drive mode (M1 : H, M2 : L)

$\overline{\text{ENABLE}}$ Signal disables only Output Signal.
Internal logic functions are proceeded by CK signal without regard to $\overline{\text{ENABLE}}$ signal.
Therefore, Output Current is initiated from the proceeded timing point of internal logic circuit after release of disable mode.
Fig.1 shows the $\overline{\text{ENABLE}}$ functions, when the system is selected in 1-2 Phase drive mode.

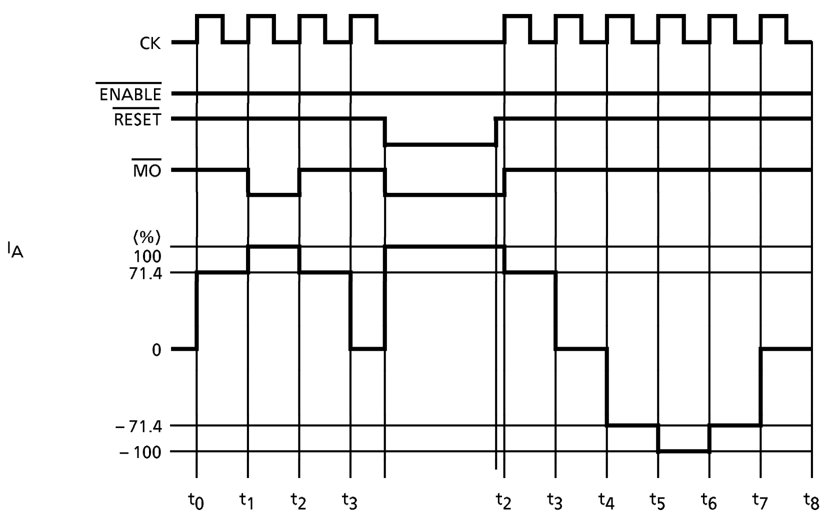


Fig.2 1-2 Phase drive mode (M1 : H, M2 : L)

Low level active of $\overline{\text{RESET}}$ Signal offs not only the Outputs but also stops internal CK functions and $\overline{\text{MO}}$ to low.
Outputs are initiated from the initial point after release of $\overline{\text{RESET}}$ (High) as shown in Fig.2.
$\overline{\text{MO}}$ (Monitor Output) Signals can be used as rotation and initial signal for stable rotation checking.

FUNCTION

INPUT					MODE
CK1	CK2	CW / CCW	$\overline{\text{RESET}}$	$\overline{\text{ENABLE}}$	
↑	H	L	H	L	CW
⎍	L	L	H	L	INHIBIT (Note)
H	↑	L	H	L	CCW
L	⎍	L	H	L	INHIBIT (Note)
↑	H	H	H	L	CCW
⎍	L	H	H	L	INHIBIT (Note)
H	↑	H	H	L	CW
L	⎍	H	H	L	INHIBIT (Note)
X	X	X	L	L	RESET
X	X	X	X	H	Z

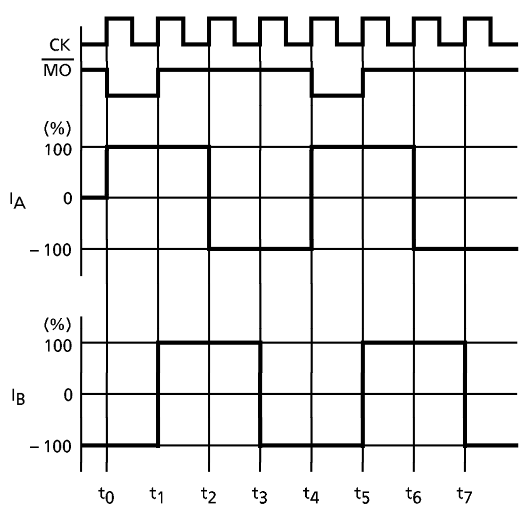
INITIAL MODE

EXCITATION MODE	A PHASE CURRENT	B PHASE CURRENT
2 Phase	100%	− 100%
1-2 Phase	100%	0%
W1-2 Phase	100%	0%
2W1-2 Phase	100%	0%

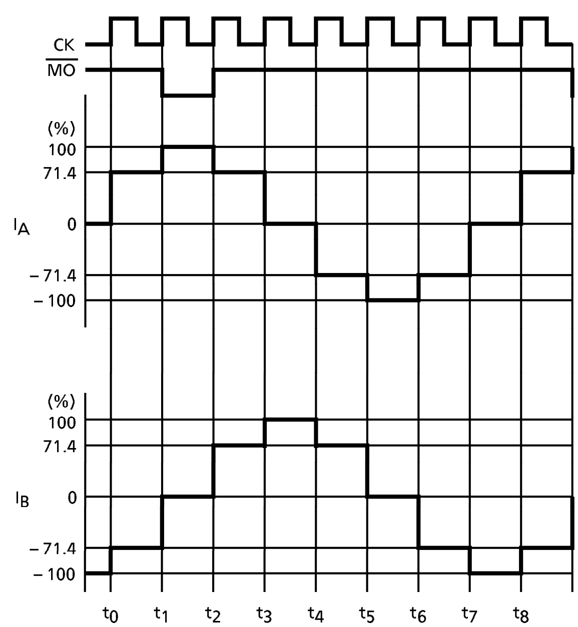
Z : High impedance
X : Don't Care

INPUT		MODE (EXCITATION)
M1	M2	
L	L	2 Phase
H	L	1-2 Phase
L	H	W1-2 Phase
H	H	2W1-2 Phase

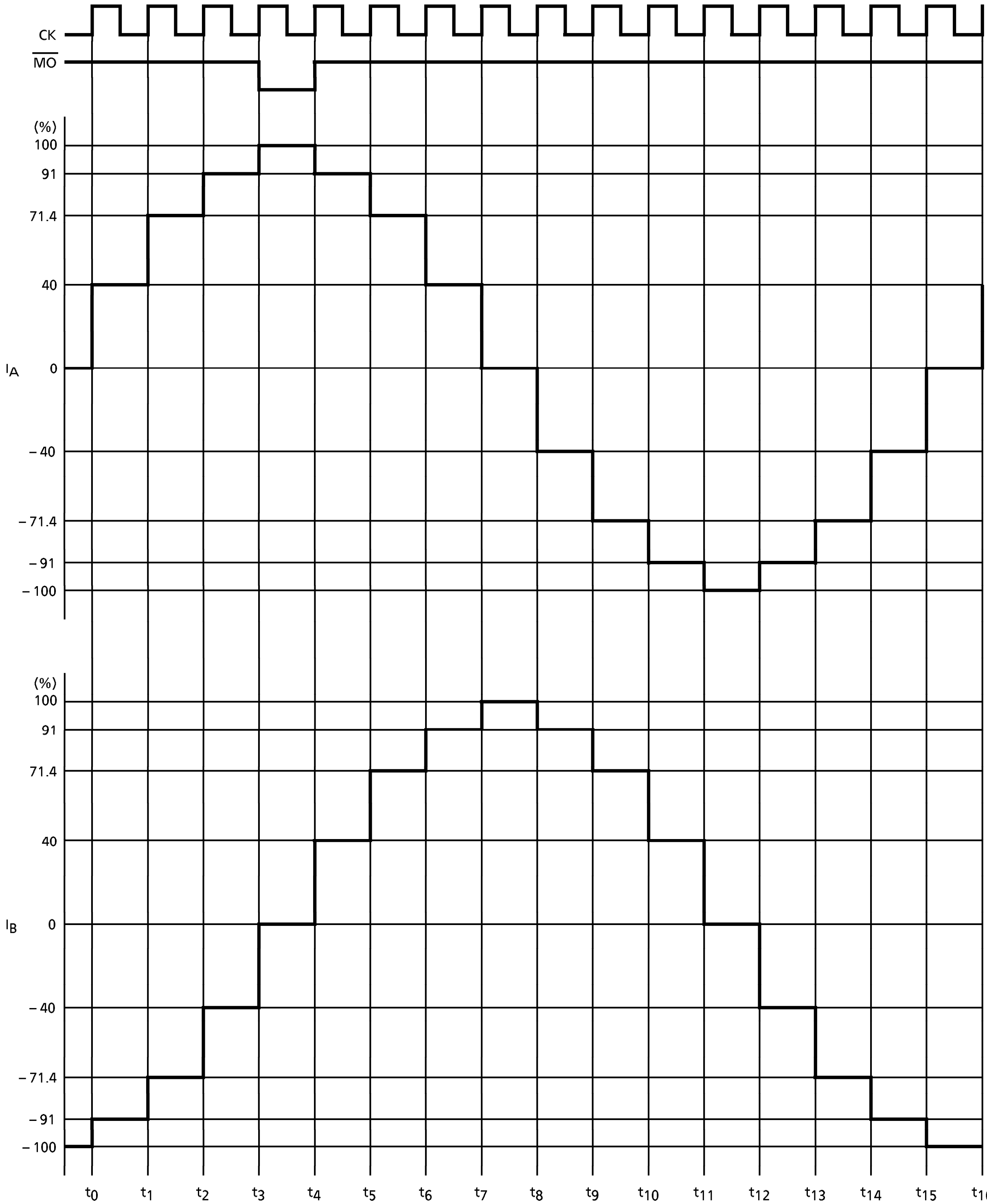
2 PHASE EXCITATION (M1 : L, M2 : L, CW MODE)



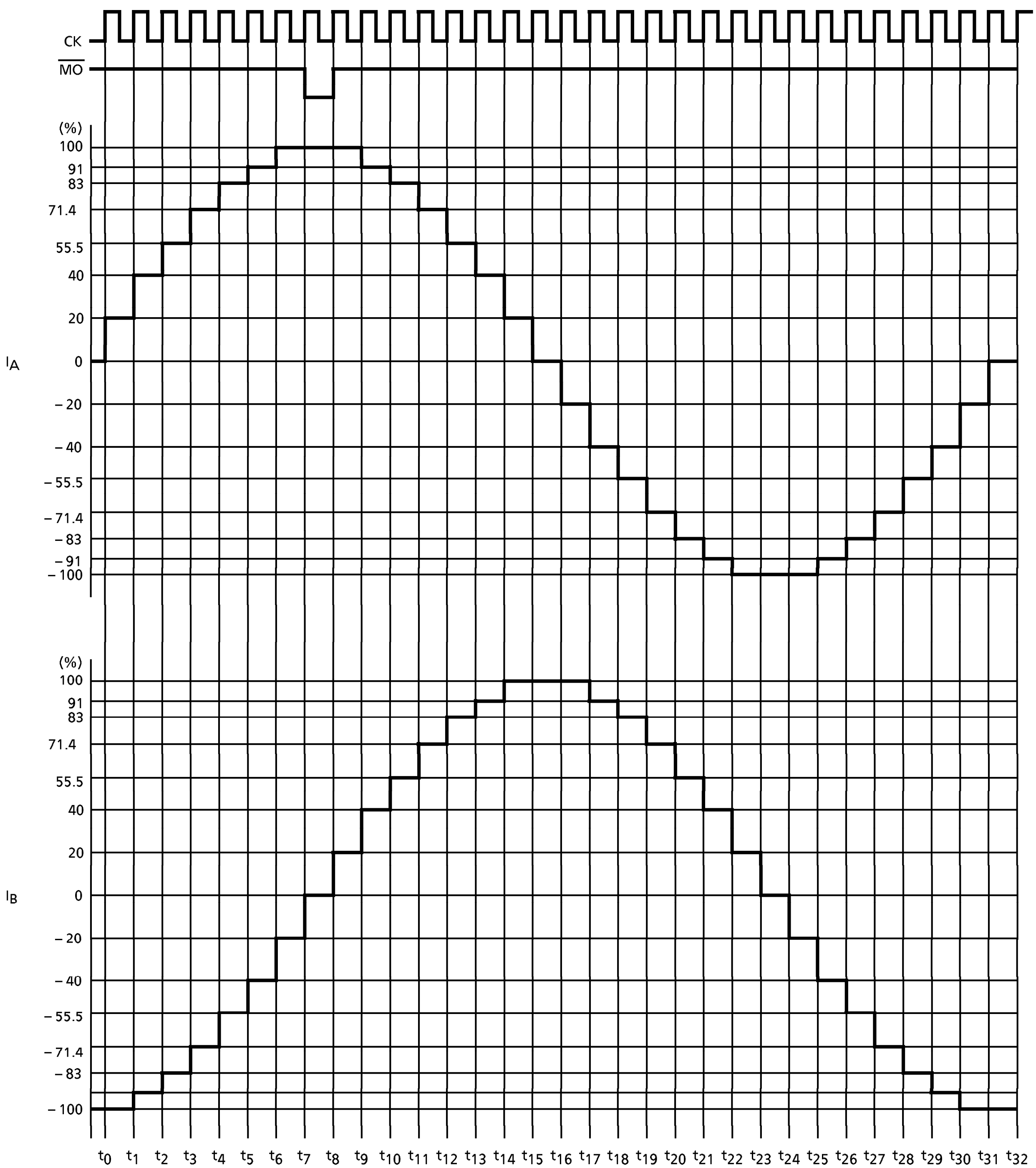
1-2 PHASE EXCITATION (M1 : H, M2 : L, CW MODE)



W1-2 PHASE EXCITATION (M1 : L, M2 : H, CW MODE)



2W1-2 PHASE EXCITATION (M1 : H, M2 : H, CW MODE)



MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Supply Voltage		V_{CC}	5.5	V
Output Voltage		V_M	40	V
Output Current	PEAK	$I_{O\ (PEAK)}$	2.5	A
	AVE.	$I_{O\ (AVE.)}$	1.5	
$\overline{MO}$ Output Current		$I_{O\ (\overline{MO})}$	±2	mA
Input Voltage		V_{IN}	~V_{CC}	V
Power Dissipation		P_D	5 (Note 1)	W
			43 (Note 2)	
Operating Temperature		T_{opr}	−40~85	°C
Storage Temperature		T_{stg}	−55~150	°C
Feed Back Voltage		V_{NF}	1.0	V

(Note 1) No heat sink
(Note 2) Tc = 85°C

RECOMMENDED OPERATING CONDITIONS (Ta = −20~75°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V_{CC}	—	4.5	5.0	5.5	V
Output Voltage	V_M	—	21.6	24	26.4	V
Output Current	I_{OUT}	—	—	—	1.5	A
Input Voltage	V_{IN}	—	—	—	V_{CC}	V
Clock Frequency	f_{CK}	—	—	—	5	kHz
OSC Frequency	f_{OSC}	—	15	—	80	kHz

ELECTRICAL CHARACTERISTICS ($Ta = 25°C$、$V_{CC} = 5V$、$V_M = 24V$)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Input Voltage	High	$V_{IN\,(H)}$	1	M1, M2, CW / CCW, REF IN $\overline{ENABLE}$, CK1, CK2 $\overline{RESET}$	3.5	—	V_{CC} +0.4	V
	Low	$V_{IN\,(L)}$			GND −0.4	—	1.5	
Input Hysteresis Voltage		V_H			—	600	—	mV
Input Current		$I_{IN\text{-}1\,(H)}$	1	M1, M2, REF IN, $V_{IN} = 5.0V$	—	—	100	nA
		$I_{IN\text{-}1\,(L)}$		$\overline{RESET}$, $\overline{ENABLE}$, $V_{IN} = 0V$, INTERNAL PULL-UP RESISTOR	10	50	100	μA
		$I_{IN\text{-}2\,(L)}$		SOURCE TYPE, $V_{IN} = 0V$	—	—	100	nA
Quiescent Current V_{CC} Terminal		I_{CC1}	1	Output Open, $\overline{RESET}$: H, $\overline{ENABLE}$: L (2, 1-2 Phase excitation)	—	10	18	mA
		I_{CC2}		Output Open, $\overline{RESET}$: H, $\overline{ENABLE}$: L (W1-2, 2W1-2 Phase excitation)	—	10	18	
		I_{CC3}		$\overline{RESET}$: L, $\overline{ENABLE}$: H	—	5	—	
		I_{CC4}		$\overline{RESET}$: H, $\overline{ENABLE}$: H	—	5	—	
Comparator Reference Voltage	High	$V_{NF\,(H)}$	3	REF IN H Output Open (Note)	0.72	0.8	0.88	V
	Low	$V_{NF\,(L)}$		REF IN L Output Open (Note)	0.45	0.5	0.55	
Output Differential		ΔV_O	—	B / A, $C_{OSC} = 0.0033\mu F$, $R_{NF} = 0.8\Omega$	−10	—	10	%
$V_{NF\,(H)} - V_{NF\,(L)}$		ΔV_{NF}	—	$V_{NF\,(L)} / V_{NF\,(H)}$ $C_{OSC} = 0.0033\mu F$, $R_{NF} = 0.8\Omega$	56	63	70	%
NF Terminal Current		I_{NF}	—	SOURCE TYPE	—	170	—	μA
Maximum OSC Frequency		$f_{OSC\,(MAX.)}$	—	—	100	—	—	kHz
Minimum OSC Frequency		$f_{OSC\,(MIN.)}$	—	—	—	—	10	kHz
OSC Frequency		f_{OSC}	—	$C_{OSC} = 0.0033\mu F$	25	44	62	kHz
Minimum Clock Pulse Width		$t_{W\,(CK)}$	—	—	—	1.0	—	μs
Output Voltage		V_{OH} ($\overline{MO}$)	—	$I_{OH} = -40\mu A$	4.5	4.9	V_{CC}	V
		V_{OL} ($\overline{MO}$)		$I_{OL} = 40\mu A$	GND	0.1	0.5	

(Note) 2 Phase excitation, $R_{NF} = 0.7\Omega$, $C_{OSC} = 0.0033\mu F$

OUTPUT BLOCK

CHARACTERISTIC				SYMBOL	TEST CIRCUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Output Saturation Voltage	Upper Side			$V_{SAT\ U1}$	4	$I_{OUT} = 1.5A$		—	2.1	2.8	V
	Lower Side			$V_{SAT\ L1}$				—	1.3	2.0	
	Upper Side			$V_{SAT\ U2}$		$I_{OUT} = 0.8A$		—	1.8	2.2	
	Lower Side			$V_{SAT\ L2}$				—	1.1	1.5	
	Upper Side			$V_{SAT\ U3}$		$I_{OUT} = 2.5A$ Pulse width 30ms		—	2.5	3.0	
	Lower Side			$V_{SAT\ L3}$				—	1.8	2.2	
Diode Forward Voltage	Upper Side			$V_{F\ U1}$	5	$I_{OUT} = 1.5A$		—	2.0	3.0	V
	Lower Side			$V_{F\ L1}$				—	1.5	2.1	
	Upper Side			$V_{F\ U2}$		$I_{OUT} = 2.5A$ Pulse width 30ms		—	2.5	3.3	
	Lower Side			$V_{F\ L2}$				—	1.8	2.5	
Output Dark Current (A + B Channels)				I_{M1}	2	$\overline{ENABLE}$: "H" Level, Output Open; $\overline{RESET}$: "L" Level		—	—	50	μA
				I_{M2}		$\overline{ENABLE}$: "L" Level Output Open; $\overline{RESET}$: "H" Level		—	8	15	mA
A-B Chopping Current (Note)	2W1-2ϕ	W1-2ϕ	1-2ϕ	VECTOR	—	$\theta = 0$	REF IN : H, $R_{NF} = 0.8\Omega$, $C_{OSC} = 0.0033\mu F$	—	100	—	%
	2W1-2ϕ	—	—			$\theta = 1/8$		—	100	—	
	2W1-2ϕ	W1-2ϕ	—			$\theta = 2/8$		86	91	96	
	2W1-2ϕ	—	—			$\theta = 3/8$		78	83	88	
	2W1-2ϕ	W1-2ϕ	1-2ϕ			$\theta = 4/8$		66.4	71.4	76.4	
	2W1-2ϕ	—	—			$\theta = 5/8$		50.5	55.5	60.5	
	2W1-2ϕ	W1-2ϕ	—			$\theta = 6/8$		35	40	45	
	2W1-2ϕ	—	—			$\theta = 7/8$		15	20	25	
	2 Phase Excitation Mode VECTOR					—		—	100	—	

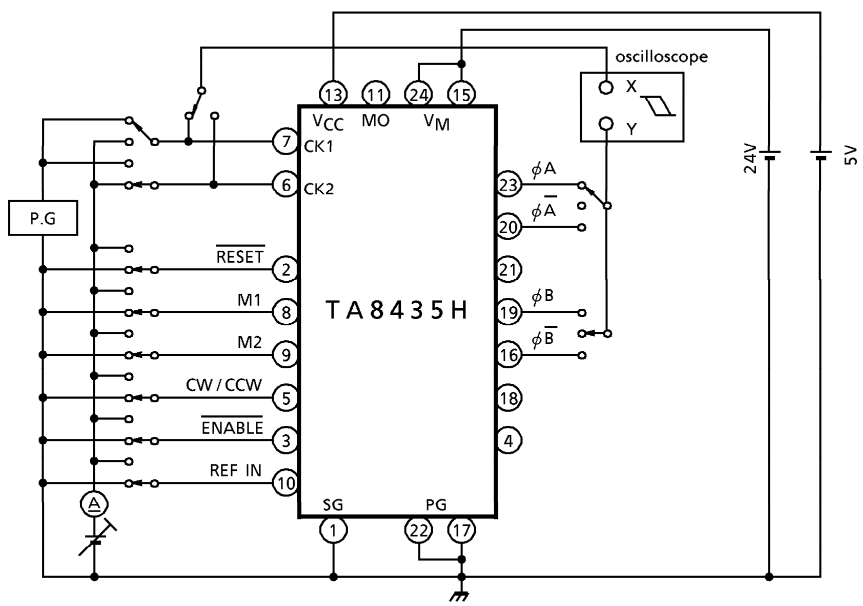
(Note) Maximum current ($\theta = 0$) : 100%
2W1-2ϕ : 2W1, 2 phase excitation mode
W1-2ϕ : W1, 2 phase excitation mode
1-2ϕ : 1, 2 phase excitation mode

CHARACTERISTIC				SYMBOL	TEST CIRCUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
A-B Chopping Current (Note)	2W1-2ϕ	W1-2ϕ	1-2ϕ	VECTOR	—	$\theta=0$	REF IN : L $R_{NF}=0.8\Omega$ $C_{OSC}=0.0033\mu F$	—	100	—	%
	2W1-2ϕ	—	—			$\theta=1/8$		—	100	—	
	2W1-2ϕ	W1-2ϕ	—			$\theta=2/8$		86	91	96	
	2W1-2ϕ	—	—			$\theta=3/8$		78	83	88	
	2W1-2ϕ	W1-2ϕ	1-2ϕ			$\theta=4/8$		66.4	71.4	76.4	
	2W1-2ϕ	—	—			$\theta=5/8$		50.5	55.5	60.5	
	2W1-2ϕ	W1-2ϕ	—			$\theta=6/8$		35	40	45	
	2W1-2ϕ	—	—			$\theta=7/8$		15	20	25	
	2 Phase Excitation Mode VECTOR					—		—	100	—	
Feed Back Voltage Step				ΔV_{NF}	—	$\Delta\theta=0/8-1/8$	REF IN : H $R_{NF}=0.8\Omega$ $C_{OSC}=0.0033\mu F$	—	0	—	mV
						$\Delta\theta=1/8-2/8$		32	72	112	
						$\Delta\theta=2/8-3/8$		24	64	104	
						$\Delta\theta=3/8-4/8$		53	93	133	
						$\Delta\theta=4/8-5/8$		87	127	167	
						$\Delta\theta=5/8-6/8$		84	124	164	
						$\Delta\theta=6/8-7/8$		120	160	200	
Output T_r Switching Characteristics				t_r	7	$R_L=2\Omega$, $V_{NF}=0V$, $C_L=15pF$		—	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}		$\overline{RESET}$~Output		—	2.0	—	
				t_{pHL}				—	2.5	—	
				t_{pLH}		$\overline{ENABLE}$~Output		—	5.0	—	
				t_{pHL}				—	6.0	—	
Output Leakage Current	Upper Side			I_{OH}	6	$V_M=30V$		—	—	50	μA
	Lower Side			I_{OL}				—	—	50	

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

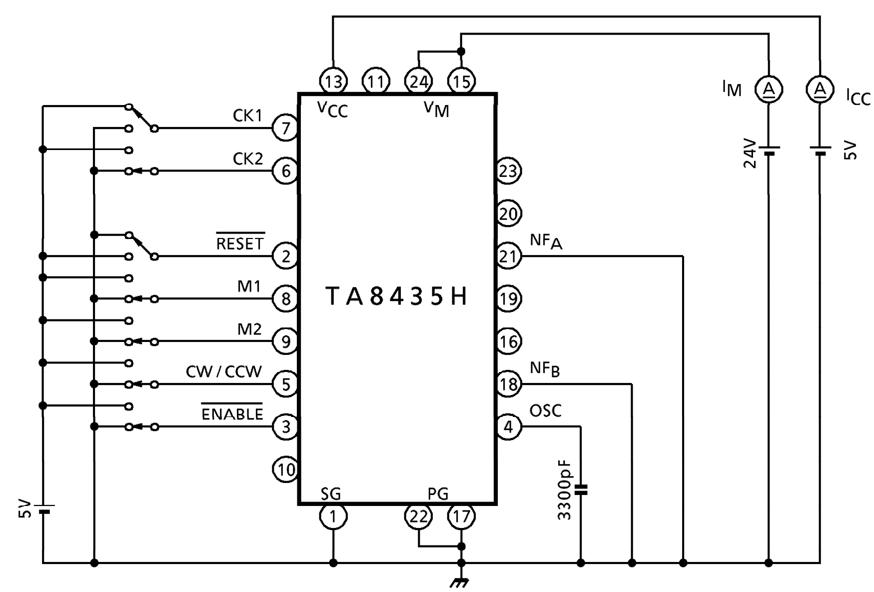
TEST CIRCUIT 1

$V_{IN\ (H)}$, (L), $I_{IN\ (H)}$, (L)



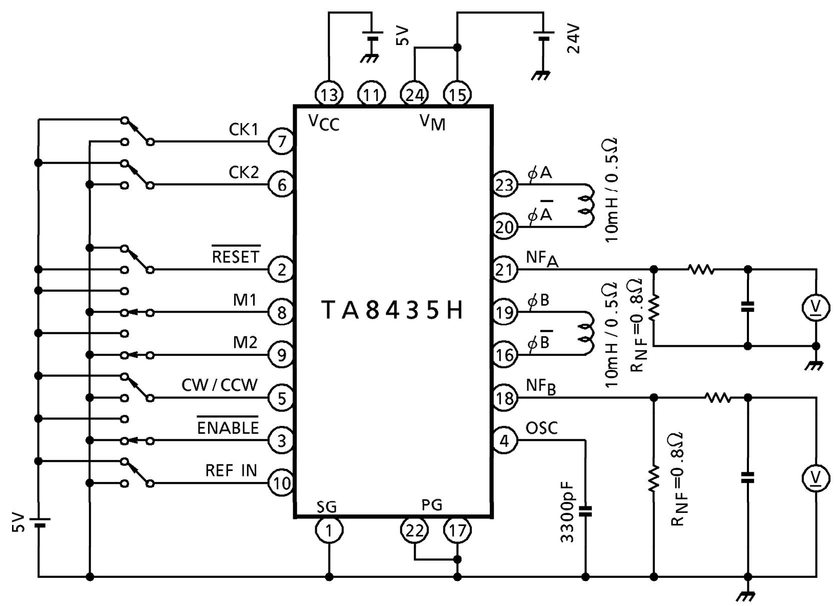
TEST CIRCUIT 2

I_{CC}, I_M



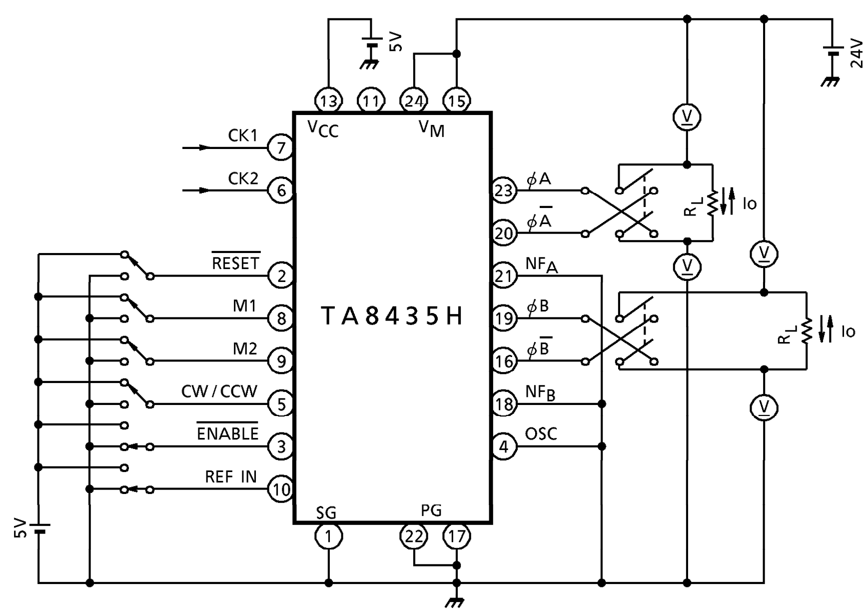
TEST CIRCUIT 3

$V_{NF (H)}$, (L)



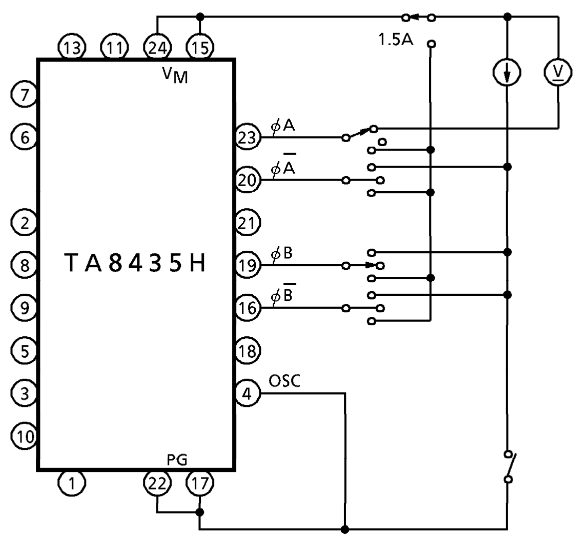
TEST CIRCUIT 4

$V_{CE (SAT)}$ UPPER SIDE, LOWER SIDE

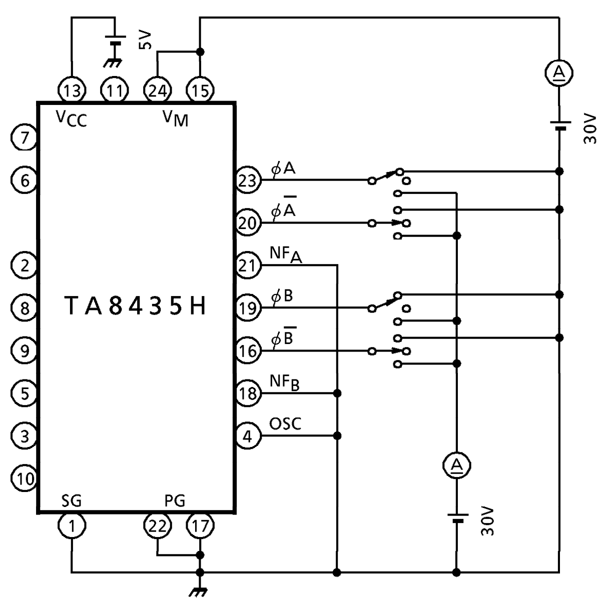


(Note) Calibrate Io to 1.5A / 0.8A by R_L

TEST CIRCUIT 5
V_{FU}, V_{FL}

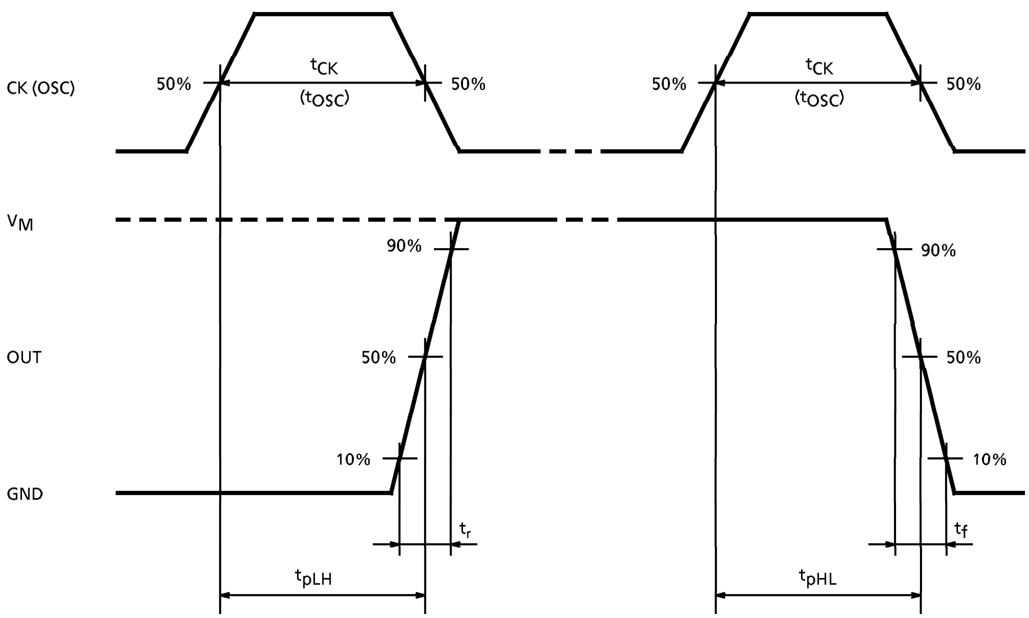


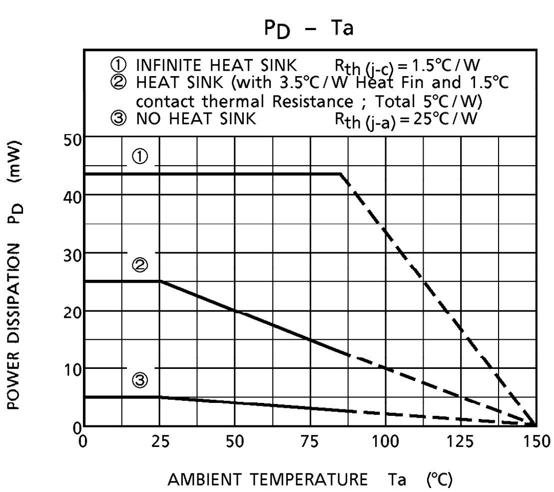
TEST CIRCUIT 6
I_{OH}, I_{OL}

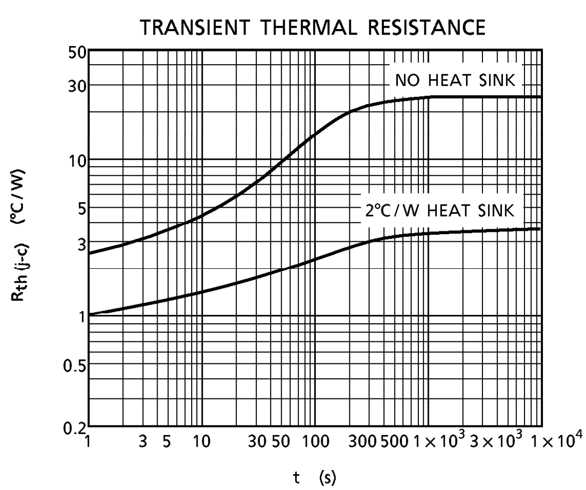


AC ELECTRICAL CHARACTERISTICS, MEASUREMENT WAVE

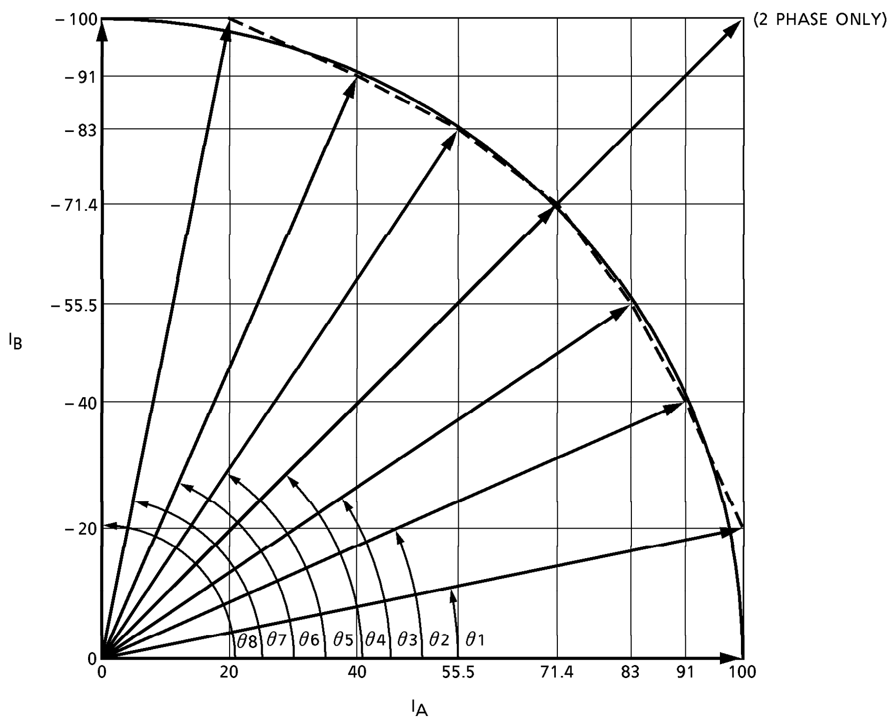
CK (OSC)-OUT





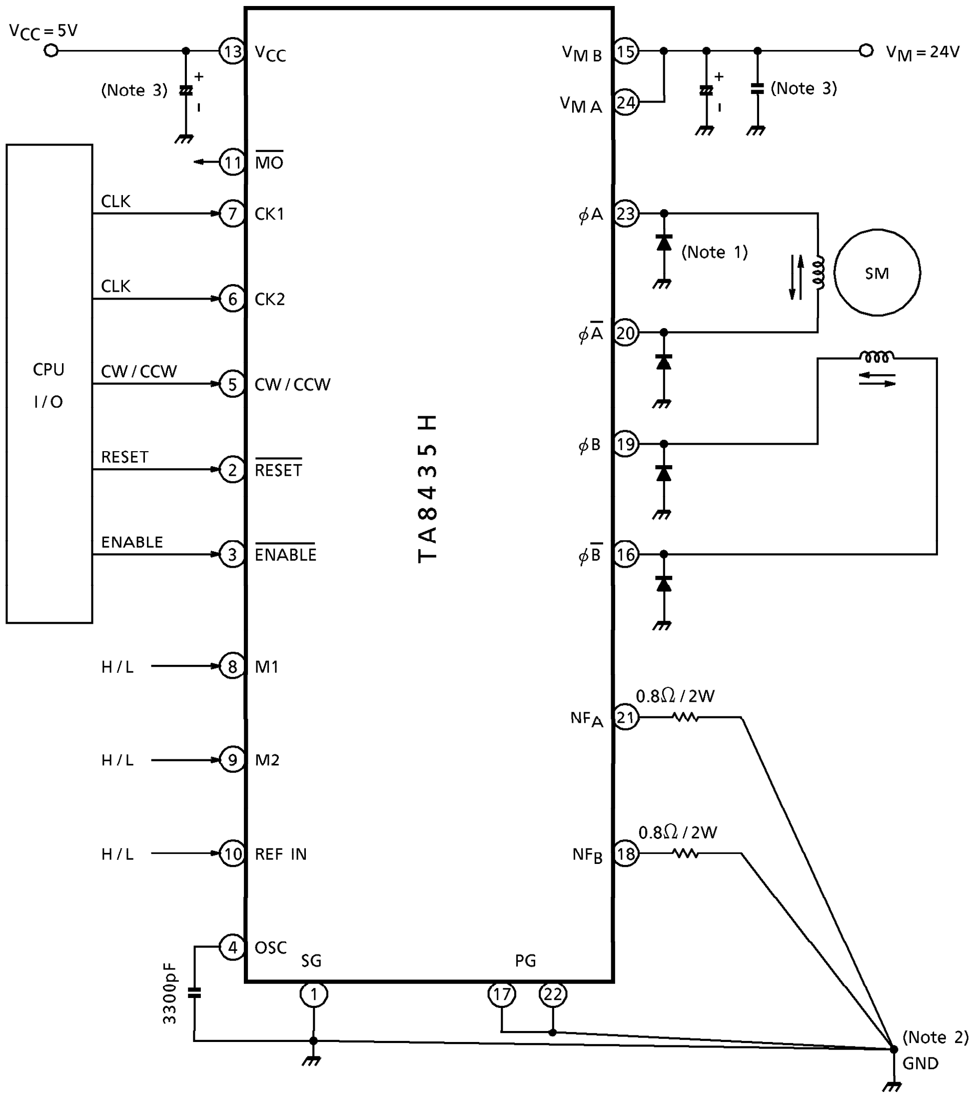


OUTPUT CURRENT VECTOR ORBIT (Normalize to 90° for each one step)



θ	ROTATION ANGLE		VECTOR LENGTH		
	IDEAL	TA8435H	IDEAL	TA8435H	
θ0	0°	0°	100	100.00	—
θ1	11.25°	11.31°	100	101.98	—
θ2	22.5°	23.73°	100	99.40	—
θ3	33.75°	33.77°	100	99.85	—
θ4	45°	45°	100	100.97	141.42
θ5	56.25°	56.23°	100	99.85	—
θ6	67.5°	66.27°	100	99.40	—
θ7	78.75°	78.69°	100	101.98	—
θ8	90°	90°	100	100.00	—
			1-2 / W1-2 / 2W1-2 Phase		2 Phase

APPLICATION CIRCUIT



(Note 1) Schottky diode (3GWJ42) to be connected additionally between each output (pin 16 / 19 / 20 / 23) and GND for preventing Punch-Through Current

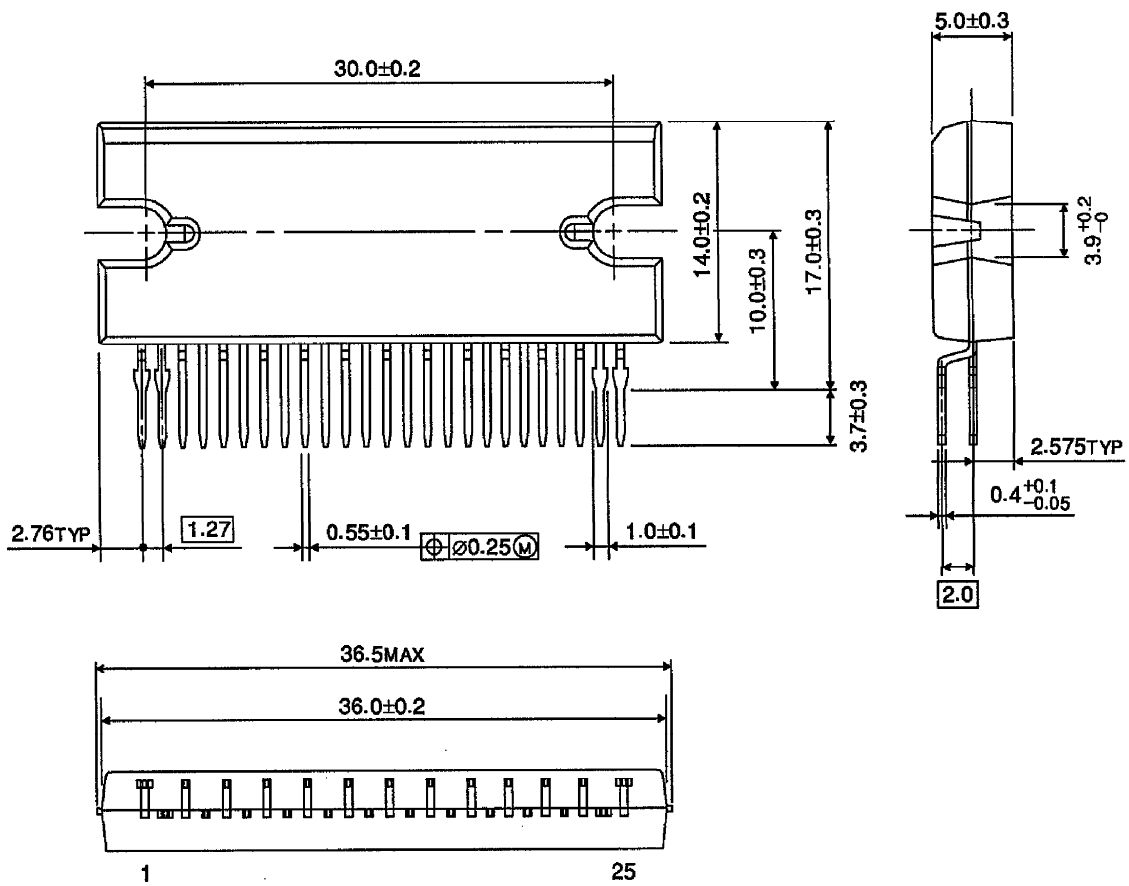
(Note 2) GND pattern to be laid out at one point in order to prevent common impedance.

(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

HZIP25-P-1.27 Unit : mm



Weight : 9.86g (Typ.)