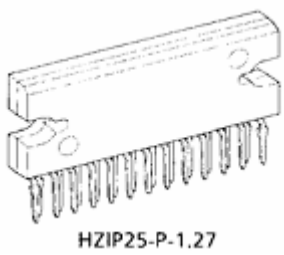
THB6016H

PWM Chopper-Type bipolar Stepping Motor Driver IC

THB6016H

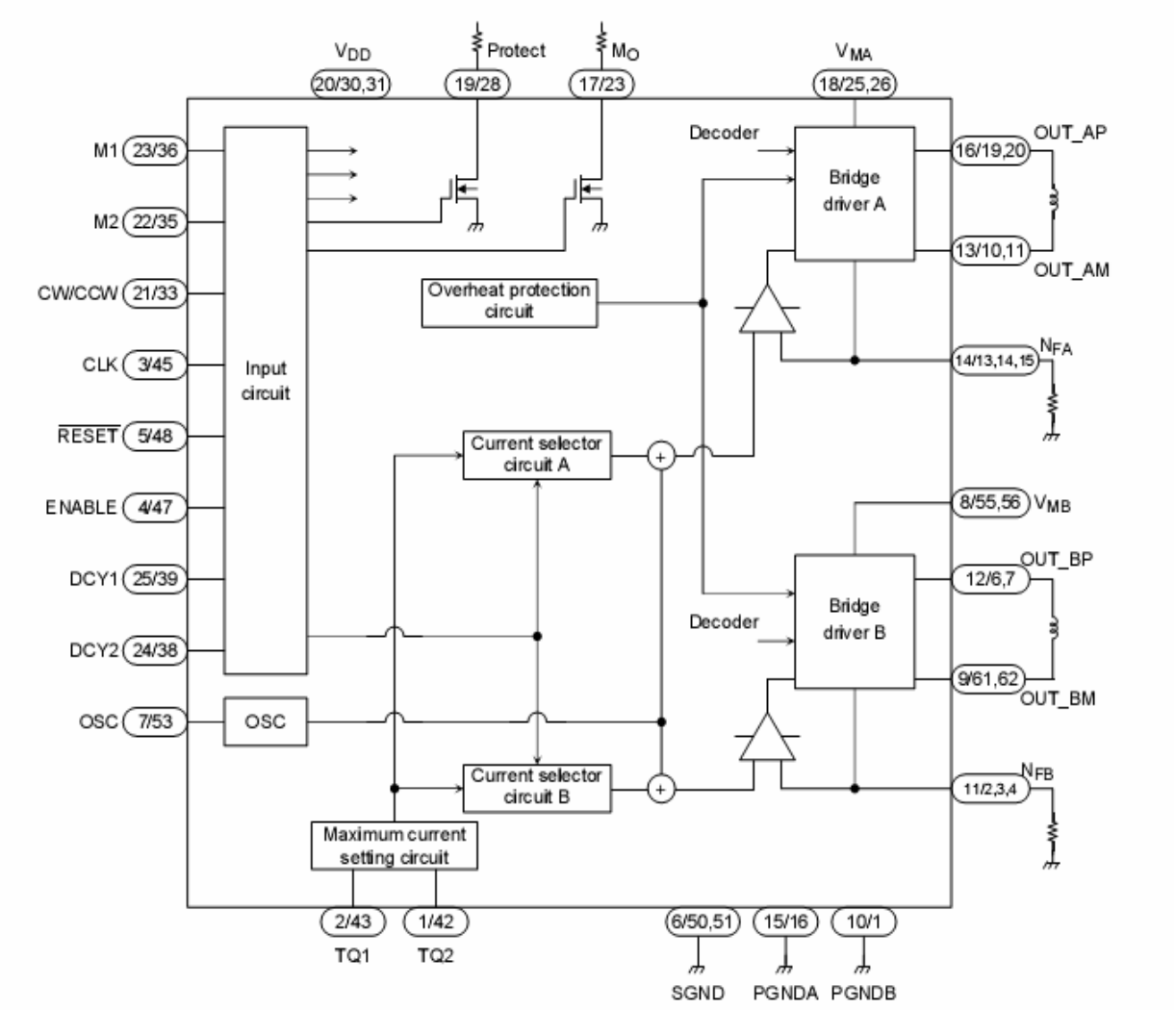


The THB6016H is a PWM chopper-type sinusoidal micro-step ipolar stepping motor driver IC.
It supports both 2-phase/1-2-phase/2W1-2-phase /4W1-2-phase xcitation mode and forward/reverse mode and is capable of ow-vibration, high-performance drive of 2-phase bipolar type tepping motors using only a clock signal.

Features

Single-chip bipolar sinusoidal micro-step stepping motor driver
Uses high withstand voltage BiCD process:
Ron (upper + lower) = 0.60 (typ.)
Forward and reverse rotation control available
Selectable phase drive (2, 1-2, W1-2, and 2W1-2)
High output withstand voltage: VCEO = 40 V
High output current: IOUT = HQ: 3.5 A (peak)
Packages: HZIP25-P-1.27
Built-in input pull-down resistor: 100k (typ.)
Output monitor pin equipped: MO current (IMO (max) = 1 mA)
Equipped with reset and enable pins
Built-in overheat protection circuit

Block Diagram



THB6016H

Pin Functions

Pin No.		I/O	Symbol	Functional Description
HQ	FG			
1	42	Input	TQ2	Torque setting input (current setting) (built-in pull-down resistor)
2	43	Input	TQ1	Torque setting input (current setting) (built-in pull-down resistor)
3	45	Input	CLK	Step transition, clock input (built-in pull-down resistor)
4	47	Input	ENABLE	H: Enable; L: All output OFF (built-in pull-down resistor)
5	48	Input	$\overline{\text{RESET}}$	L: Reset (output is reset to its initial state) (built-in pull-down resistor)
6	50/51	—	SGND	Signal ground (control side) (note:1)
7	53	—	OSC	Connects to and oscillates CR. Output chopping.
8	55/56	Input	V_{MB}	Motor side power pin (B phase side) (note:1)
9	61/62	Output	OUT_BM	OUTB output (note:1)
10	1	—	PGNDB	Power ground (note:1)
11	2/3/4	—	N_{FB}	B channel output current detection pin (resistor connection). Short the two pins for FG. (note:1)
12	6/7	Output	OUT_BP	OUT_B output (note:1)
13	10/11	Output	OUT_AM	OUT_A output (note:1)
14	13/14/15	—	N_{FA}	A channel output current detection pin (resistor connection). Short the two pins for FG. (note:1)
15	16	—	PGNDA	Power ground
16	19/20	Output	OUT_AP	OUT_A output (note:1)
17	23	Output	M_O	Initial state detection output. ON when in initial state (open drain).
18	25/26	Input	V_{MA}	Motor side power pin (A phase side) (note:1)
19	28	Output	Protect	When TSD, ON (open drain). Normal Z.
20	30/31	Input	V_{DD}	Control side power pin. (note:1)
21	33	Input	CW/CCW	Forward/Reverse toggle pin. L: Forward; H: Reverse (built-in pull-down resistor)
22	35	Input	M2	Excitation mode setting input (built-in pull-down resistor)
23	36	Input	M1	Excitation mode setting input (built-in pull-down resistor)
24	38	Input	DCY2	Current Decay mode setting input (built-in pull-down resistor)
25	39	Input	DCY1	Current Decay mode setting input (built-in pull-down resistor)

H: No NC

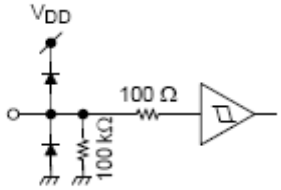
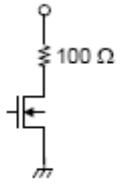
F: Other than the above pins, all are NC

Pull-down resistor 100 k (typ.): [all control input pins]

Note:1--- - If the F pin number column indicates more than one pin, the indicated pins should be tied to each other at a position as close to the pins as possible.

(The electrical characteristics of the relevant pins in this document refer to those when they are handled in that way.)

<Terminal circuits>

Input pins (M1, M2, CLK, CW/CCW, ENABLE and RESET)	Output ins (MO, PROTECT)
	

Absolute Maximum Ratings (Ta = 25°C)

Characteristic			Symbol	Rating	Unit
Power supply voltage			V_{DD}	6	V
			$V_{MA/B}$	40	
Output current	Peak	HQ	$I_{O\ (PEAK)}$	3.5	A/phase
		FG		2.5	
MO drain current			$I_{(MO)}$	1	mA
Input voltage			V_{IN}	5.5	V
Power dissipation		HQ	P_D	5 (Note 1)	W
				43 (Note 2)	
		FG		1.7 (Note 3)	
				4.2 (Note 4)	
Operating temperature			T_{opr}	−30 to 85	°C
Storage temperature			T_{stg}	−55 to 150	°C

Note 1: Ta = 25°C, No heat sink.

Note 2: Ta = 25°C, with infinite heat sink (HZIP25).

Note 3: Ta = 25°C, with soldered leads.

Note 4: Ta = 25°C, when mounted on the board (4-layer board).
Susceptible to the board layout and the mounting conditions.

Operating Range (Ta = −30 to 85°C)

Characteristic		Symbol	Test Condition	Min	Typ.	Max	Unit
Power supply voltage		V_{DD}	—	4.5	5.0	5.5	V
		$V_{MA/B}$	$V_{MA/B} \geq V_{DD}$	4.5	—	(34)	V
Output current	HQ	I_{OUT}	—	—	—	3	A
	FG			—	—	1.5	
Input voltage		V_{IN}	—	0	—	5.5	V
Clock frequency		f_{CLK}	—	—	—	15	kHz
OSC frequency		f_{OSC}	—	—	—	600	kHz

Electrical Characteristics (Ta = 25°C, V_{DD} = 5 V, V_M = 24 V)

Characteristic		Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input voltage	High	$V_{IN\ (H)}$	1	M1, M2, CW/CCW, CLK, $\overline{\text{RESET}}$, ENABLE, DECAY, TQ1, TQ2, ISD	2.0	—	V_{DD}	V
	Low	$V_{IN\ (L)}$			−0.2	—	0.8	
Input hysteresis voltage		V_H	1		—	400	—	mV
Input current		$I_{IN\ (H)}$	1	M1, M2, CW/CCW, CLK, $\overline{\text{RESET}}$, ENABLE, DECAY, TQ1, TQ2, ISD V_{IN} = 5.0 V Built-in pull-down resistor	30	55	80	μA
		$I_{IN\ (L)}$		V_{IN} = 0 V	—	—	1	
Consumption current V_{DD} pin		I_{DD1}	1	Output open, $\overline{\text{RESET}}$: H, ENABLE: H (2, 1-2 phase excitation)	—	3	5	mA
		I_{DD2}		Output open, $\overline{\text{RESET}}$: H, ENABLE: H (W1−2, 2W1-2 phase excitation)	—	3	5	
		I_{DD3}		$\overline{\text{RESET}}$: L, ENABLE: L	—	2	5	
		I_{DD4}		$\overline{\text{RESET}}$: H, ENABLE: L	—	2	5	
Consumption current V_M pin		I_{M1}	1	$\overline{\text{RESET}}$: H/L, ENABLE: L	—	0.5	1	mA
		I_{M2}		$\overline{\text{RESET}}$: H/L, ENABLE: H	—	0.7	2	
Output channel margin of error		ΔV_O	—	B/A, C_{OSC} = 0.0033 μF	−5	—	5	%
VNF level Level differential		V_{NFHH}	—	TQ1 = H, TQ2 = H	10	20	30	%
		V_{NFHL}		TQ1 = L, TQ2 = H	47	50	55	
		V_{NFLH}		TQ1 = H, TQ2 = L	70	75	80	
		V_{NFLL}		TQ1 = L, TQ2 = L			100	
Minimum clock pulse width		$t_{W\ (CLK)}$	—	C = 330 pF	—	7.7	—	μs
MO output residual voltage		V_{OL} MO	—	I_{OL} = 1 mA	—	—	0.5	V
TSD		TSD	—	(Design target value)	—	170	—	°C
TSD hysteresis		TSDhys	—	(Design target value)	—	20	—	°C
Oscillating frequency		f_{OSC}	—	C = 330 pF	60	130	200	kHz

Electrical Characteristics (Ta = 25°C, V_{DD} = 5 V, V_M = 24 V)

Output Block

Characteristic				Symbol	Test Circuit	Test Condition		Min	Typ.	Max	Unit
Output ON resistor			AHQ	Ron_{U1H}	4	I_{OUT} = 1.5 A		—	0.3	0.4	Ω
				Ron_{L1H}				—	0.3	0.4	
			AFG	Ron_{U1F}		I_{OUT} = 1.5 A		—	0.35	0.5	
				Ron_{L1F}				—	0.35	0.5	
A-B chopping current (Note)	4W1-2-phase excitation	2W1-2-phase excitation	1-2-phase excitation	Vector	—	θ = 0	TQ1 = L, TQ2 = L	—	100	—	%
		—	—			θ = 1/16		—	100	—	
		2W1-2-phase excitation	—			θ = 2/16		93	98	100	
		—	—			θ = 3/16		91	96	100	
		2W1-2-phase excitation	—			θ = 4/16		87	92	97	
		—	—			θ = 5/16		83	88	93	
		2W1-2-phase excitation	—			θ = 6/16		78	83	88	
		—	—			θ = 7/16		72	77	82	
		2W1-2-phase excitation	1-2-phase excitation			θ = 8/16		66	71	76	
		—	—			θ = 9/16		58	63	68	
		2W1-2-phase excitation	—			θ = 10/16		51	56	61	
		—	—			θ = 11/16		42	47	52	
		2W1-2-phase excitation	—			θ = 12/16		33	38	43	
		—	—			θ = 13/16		24	29	34	
		2W1-2-phase excitation	—			θ = 14/16		15	20	25	
		—	—			θ= 15/16		5	10	15	
	2-phase excitation					—		—	100	—	
Reference voltage				V_{NF}	—	TQ1, TQ2 = L (100%) OSC = 100 kHz		450	500	550	mV
Output transistor switching characteristics				t_r	7	R_L = 2 Ω, V_{NF} = 0 V, C_L = 15 pF		—	0.1	—	µs
				t_f				—	0.1	—	
Delay time				t_{pLH}		$\overline{RESET}$ to output		—	0.1	—	
				t_{pLH}		ENABLE to output		—	0.3	—	
				t_{pHL}				—	0.2	—	
Output leakage current			Upper side	I_{LH}	6	V_M = 40 V		—	—	1	µA
			Lower side	I_{LL}				—	—	1	

Note: Maximum current (θ = 0): 100%

Description of Functions

1. Excitation Settings

You can use the M1 and M2 pin settings to configure four different excitation settings. (The default is 2-phase excitation using the internal pull-down.)

Input		Mode (Excitation)
M2	M1	
L	L	2-phase
L	H	1-2-phase
H	L	4W1-2-phase
H	H	2W1-2-phase

2. Function

You can change the output to OFF and Initial mode by using the ENABLE and $\overline{\text{RESET}}$ pins respectively.

In Initial mode, the CLK and CW/CCW settings don't matter.

Input				Output Mode
CLK	CW/CCW	$\overline{\text{RESET}}$	ENABLE	
↓	L	H	H	CW
↓	H	H	H	CCW
X	X	L	H	Initial mode
X	X	X	L	Z

X: Don't care

3. Initial Mode

When $\overline{\text{RESET}}$ is used, the phase currents are as follows. In this instance, the MO pin is L (connected to open drain).

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%

4. Current Decay Settings

Output is generated by four PWM blasts; 25% decay is created by inducing decay during the last blast in Fast mode; 50% decay is created by inducing decay during the last two blasts in Fast mode; and 100% decay is created by inducing all four blasts in Fast mode.

If there is no input with the pull-down resistor connection then the setting is Normal.

Dcy2	Dcy1	Current Decay Setting
L	L	Normal 0%
L	H	25% Decay
H	L	50% Decay
H	H	100% Decay

5. Torque Settings (Current Value)

The current ratio used in actual operations is determined in regard to the current setting due to resistance. Configure this for extremely low torque scenarios such as when Weak Excitation mode is stopped.

If there is no input with the pull-down resistor connection then the setting is 100% torque.

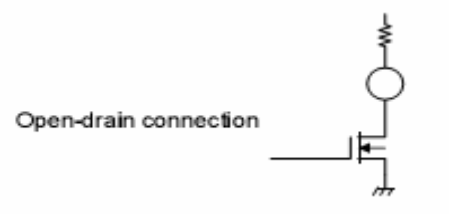
TQ2	TQ1	Current Ratio
L	L	100%
L	H	75%
H	L	50%
H	H	20% (weak excitation)

6. Protect and MO (Output Pins)

You can configure settings from the receiving side by using an open drain connection for the output pins and making the pull-up voltage variable.

When a given pin is in its designated state it will go ON and output at Low level.

Pin State	Protect	MO
Low	Overheat protection operation	Initial state
Z	Normal operation	Other than initial state



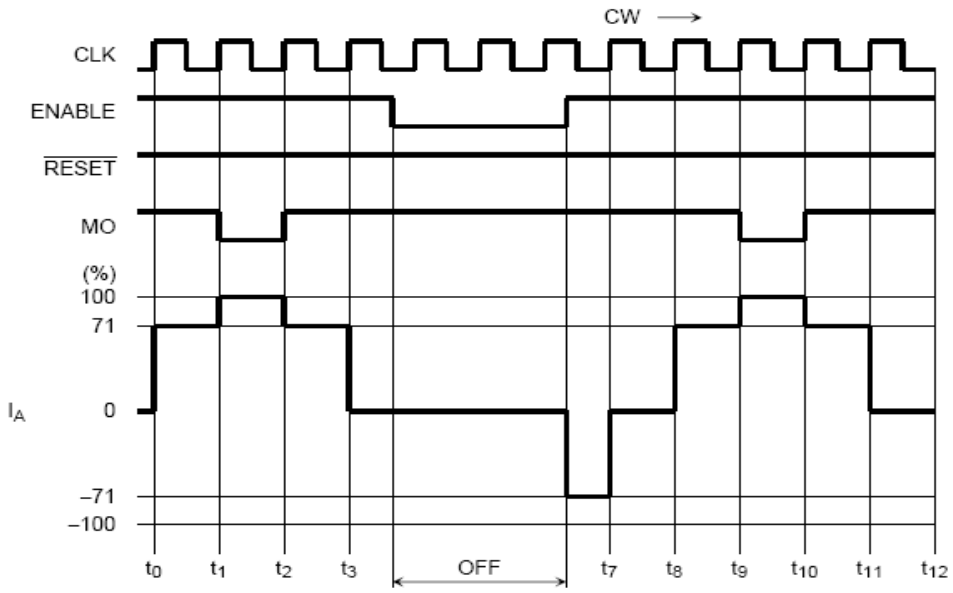
7. OSC

Output chopping waves are generated by connecting the condenser and having the CR oscillate.
The values are as shown below (roughly: ± 30% margin of error).

Condenser	Oscillating Frequency
1000 pF	44 kHz
330 pF	130 kHz
100 pF	400 kHz

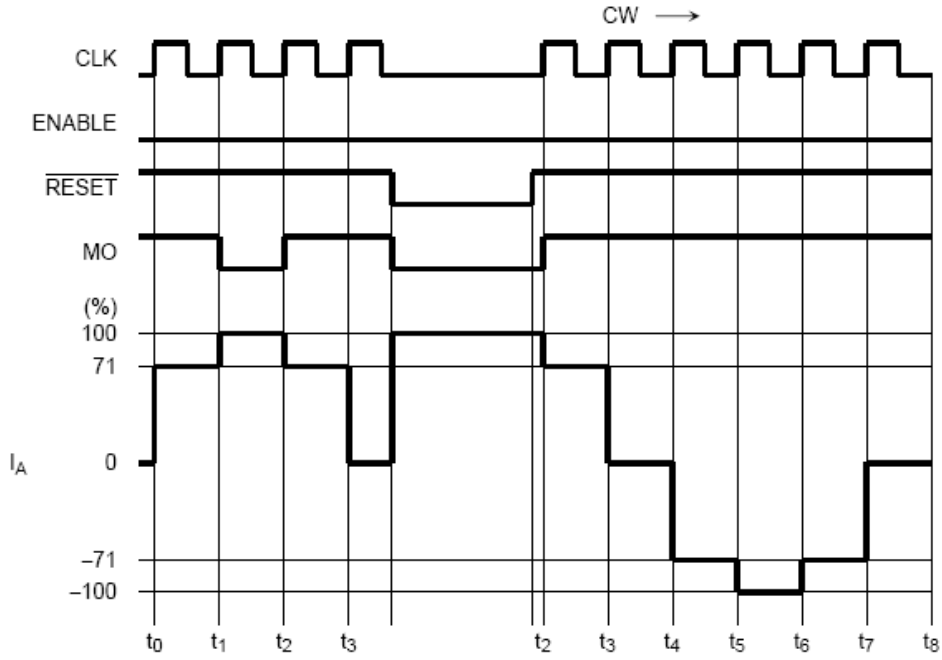
Relationship between Enable, $\overline{\text{RESET}}$ and Output (OUT and MO)

Ex-1: ENABLE 1-2-Phase Excitation (M1: H, M2: L)



The ENABLE signal at Low level disables only the output signals. Internal logic functions proceed in accordance with input clock signals and without regard to the ENABLE signal. Therefore output current is initiated by the timing of the internal logic circuit after release of disable mode.

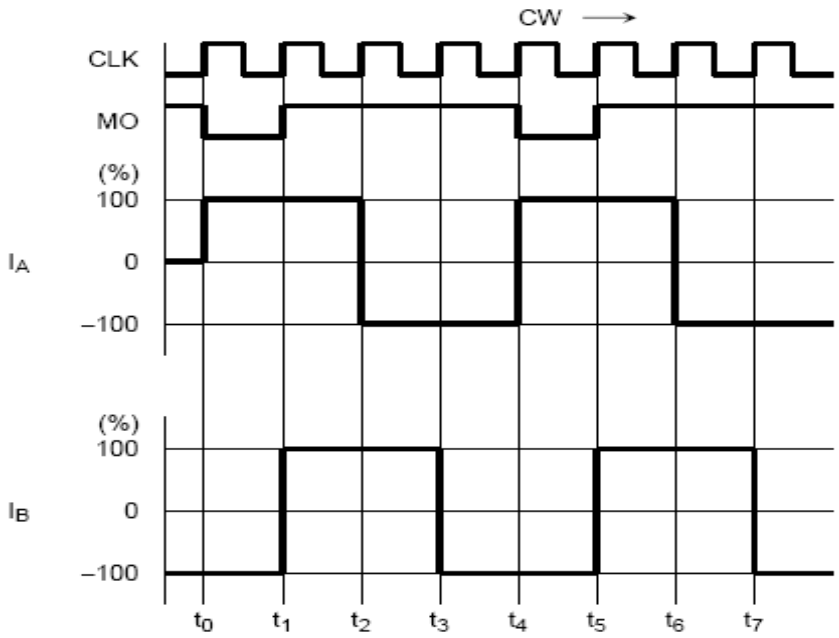
Ex-2: $\overline{\text{RESET}}$ 1-2-Phase Excitation (M1: H, M2: L)



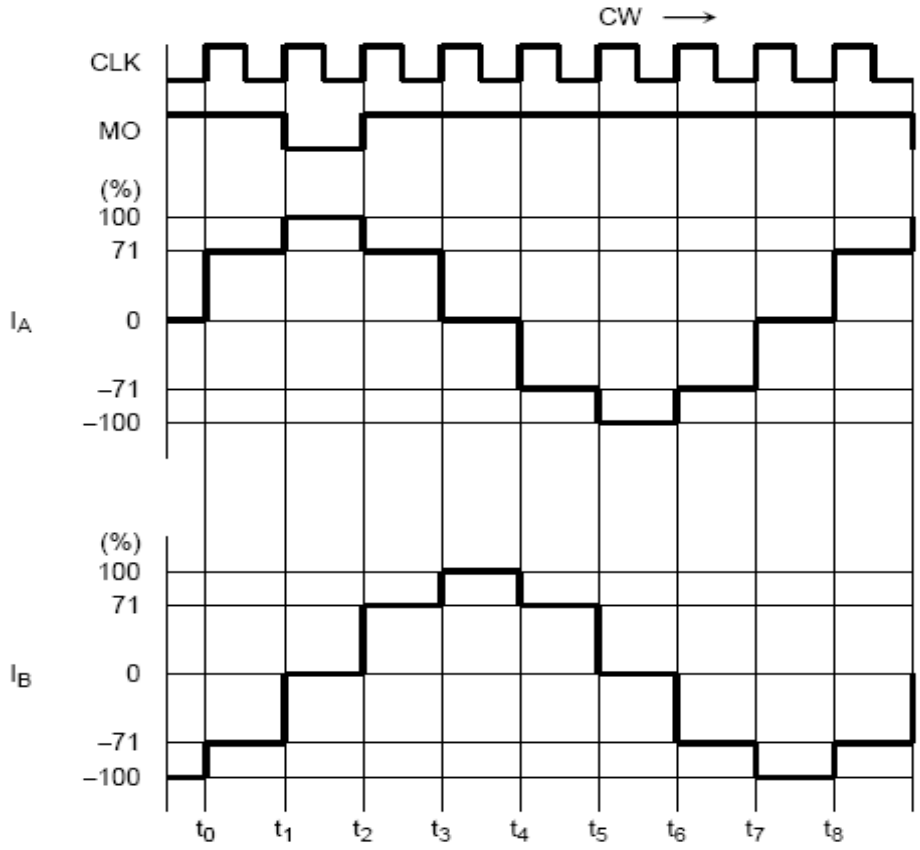
When the $\overline{\text{RESET}}$ signal goes Low level, output goes Initial state and the MO output goes Low level (Initial state: A Channel output current is 100%).

Once the $\overline{\text{RESET}}$ signal returns to High level, output continues from the next state after Initial from the next raise in the Clock signal.

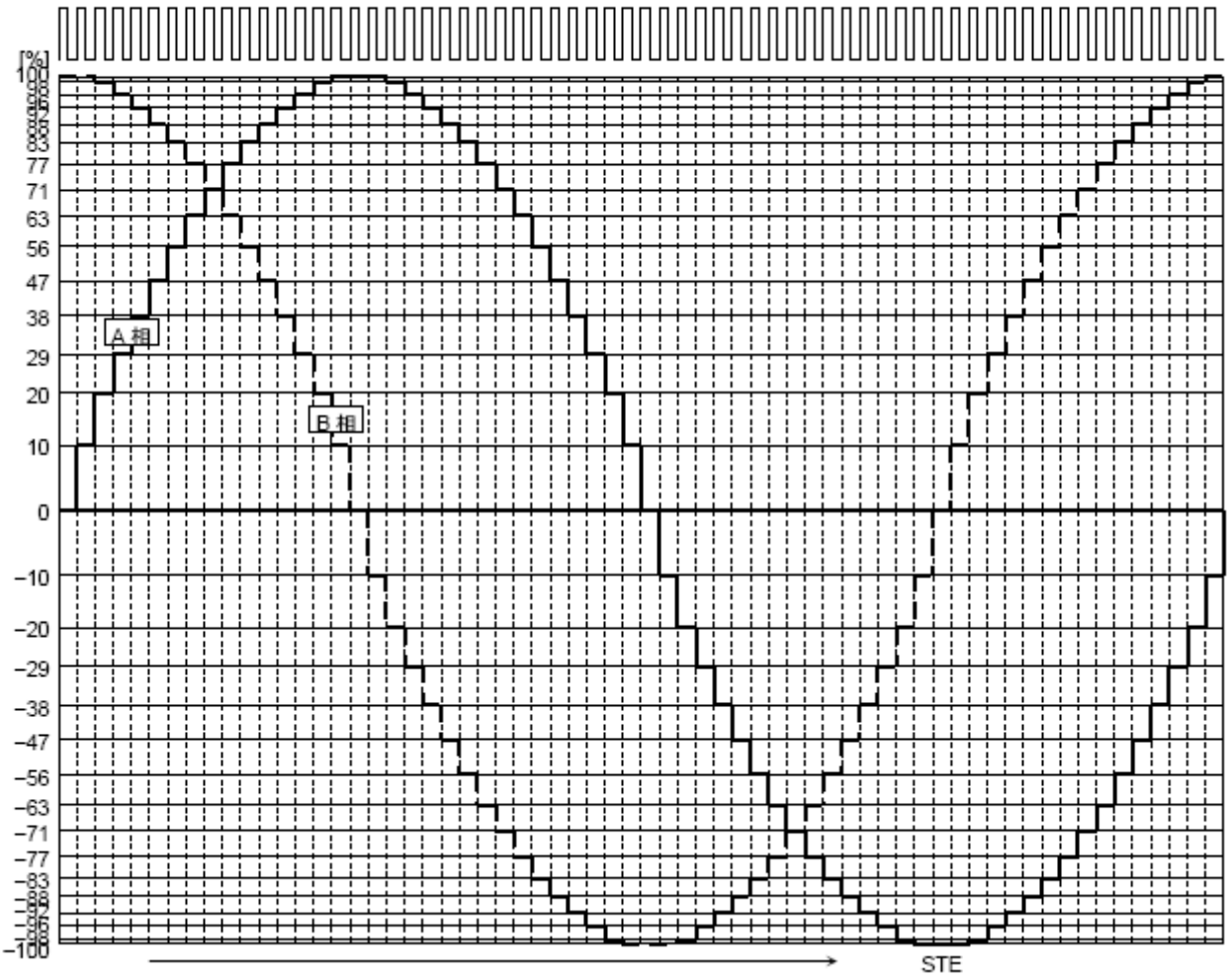
2-Phase Excitation (M1: L, M2: L, CW Mode)

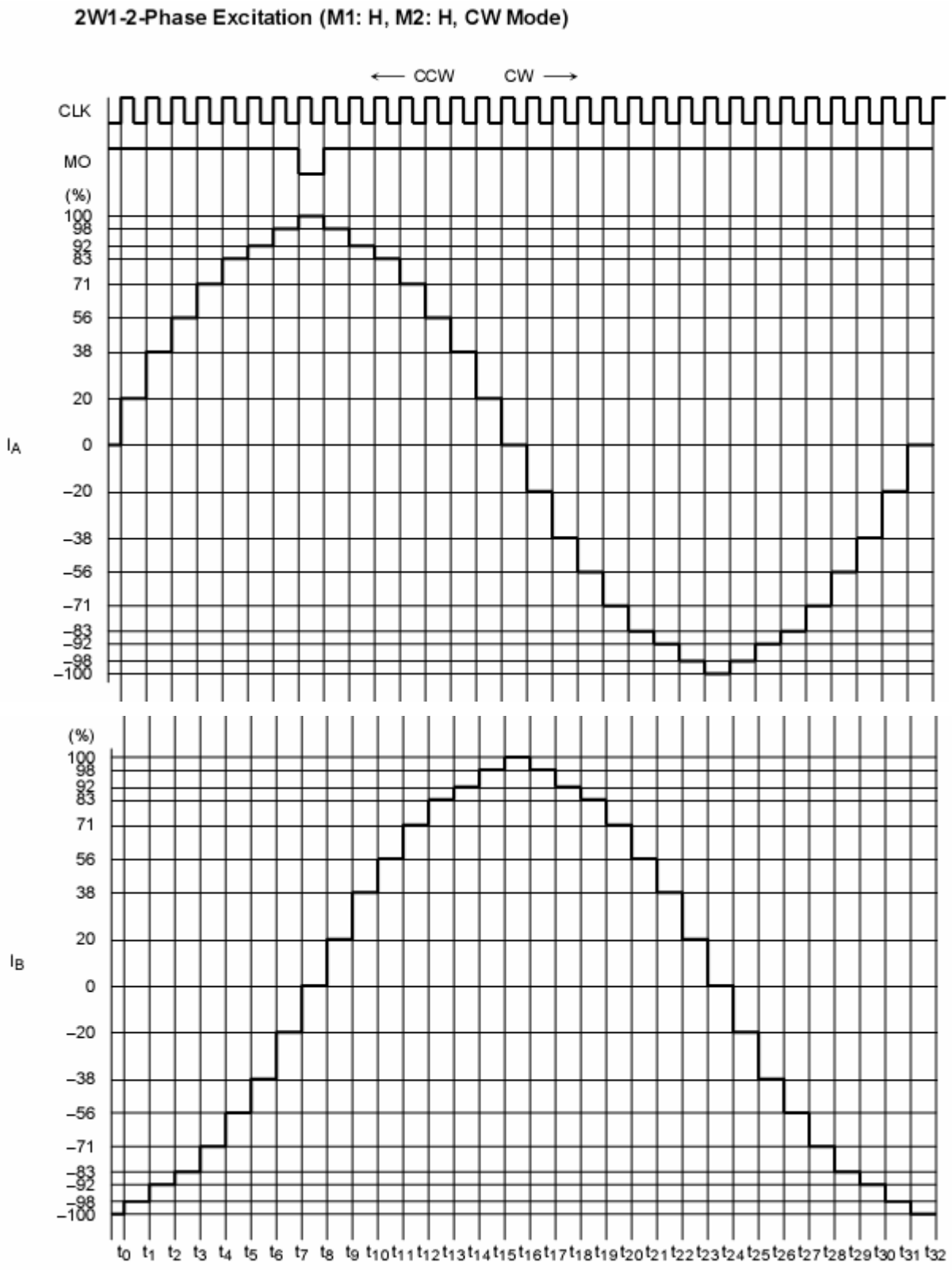


1-2-Phase Excitation (M1: H, M2: L, CW Mode)

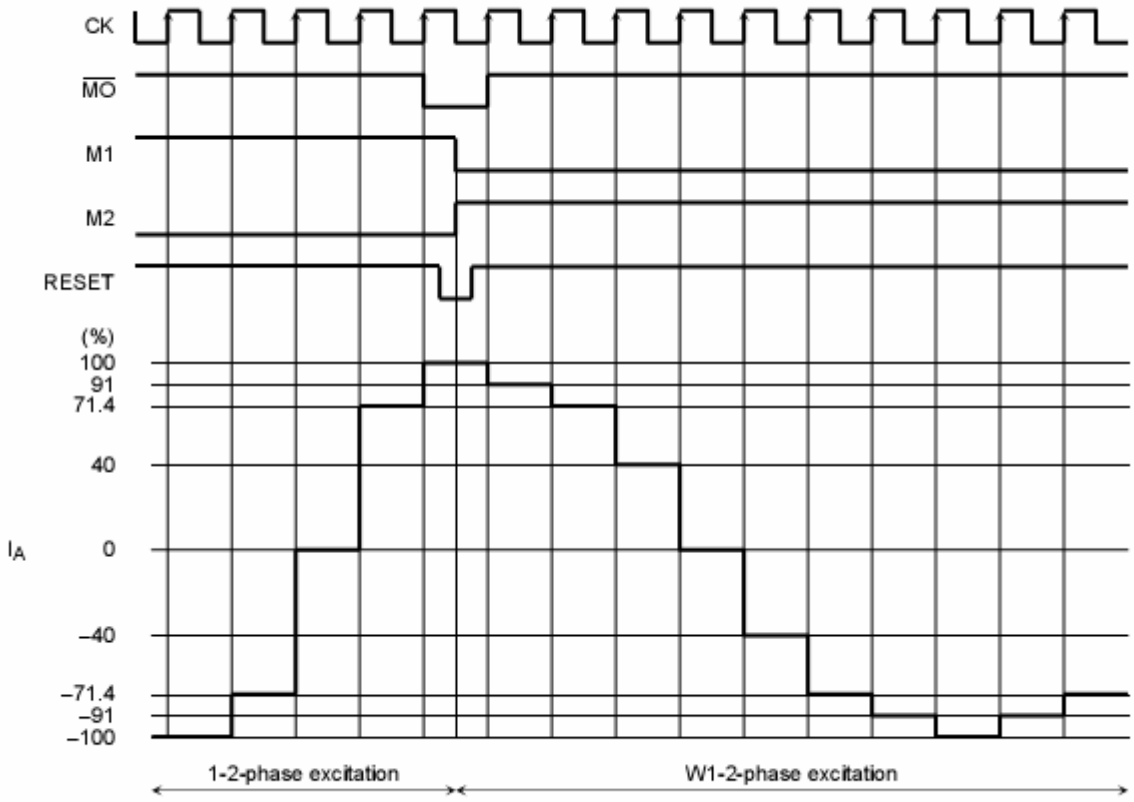


4W1-2-Phase Excitation (M1: L, M2: H, CW Mode)

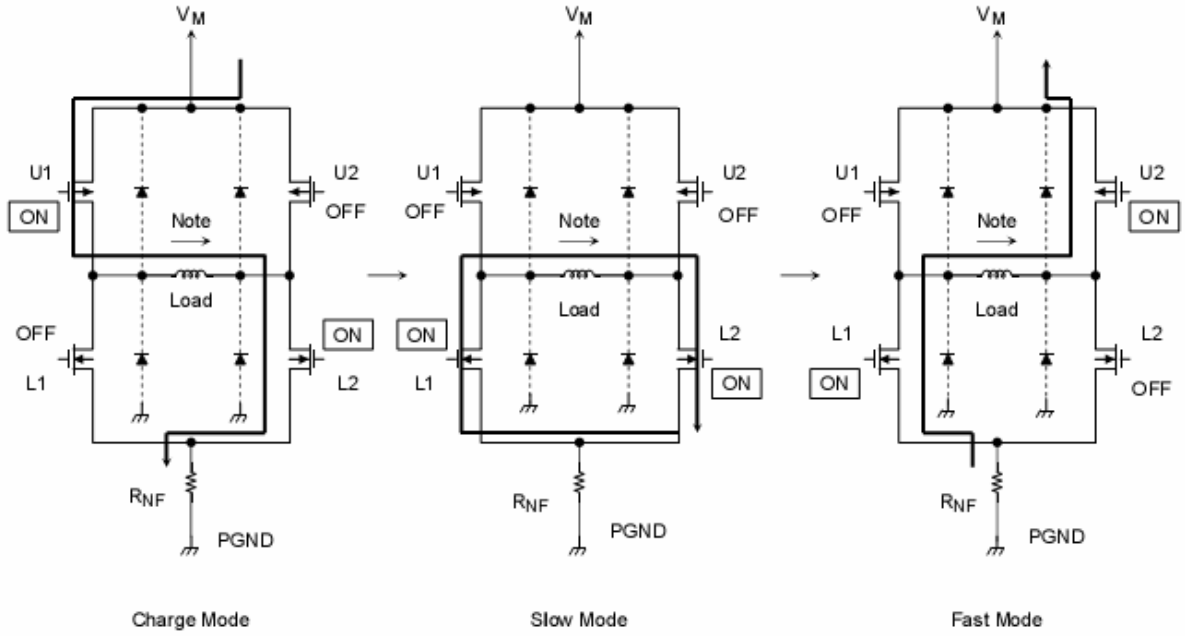



2W1-2-Phase Excitation (M1: H, M2: H, CW Mode)
← CCW CW →
CLK
MO
(%)
100
98
92
83
71
56
38
20
0
–20
–38
–56
–71
–83
–92
–98
–100
I_A
I_B
t_0 t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19} t_{20} t_{21} t_{22} t_{23} t_{24} t_{25} t_{26} t_{27} t_{28} t_{29} t_{30} t_{31} t_{32}

<Input Signal Example>



Output Stage Transistor Operation Mode



Output Stage Transistor Operation Functions

CLK	U1	U2	L1	L2
CHARGE	ON	OFF	OFF	ON
SLOW	OFF	OFF	ON	ON
FAST	OFF	ON	ON	OFF

Note: The above chart shows an example of when the current flows as indicated by the arrows in the above figures. If the current flows in the opposite direction, refer to the following chart:

CLK	U1	U2	L1	L2
CHARGE	OFF	ON	ON	OFF
SLOW	OFF	OFF	ON	ON
FAST	ON	OFF	OFF	ON

1. How to Turn on the Power

Turn on VDD. When the voltage has stabilized, turn on VMA/B.

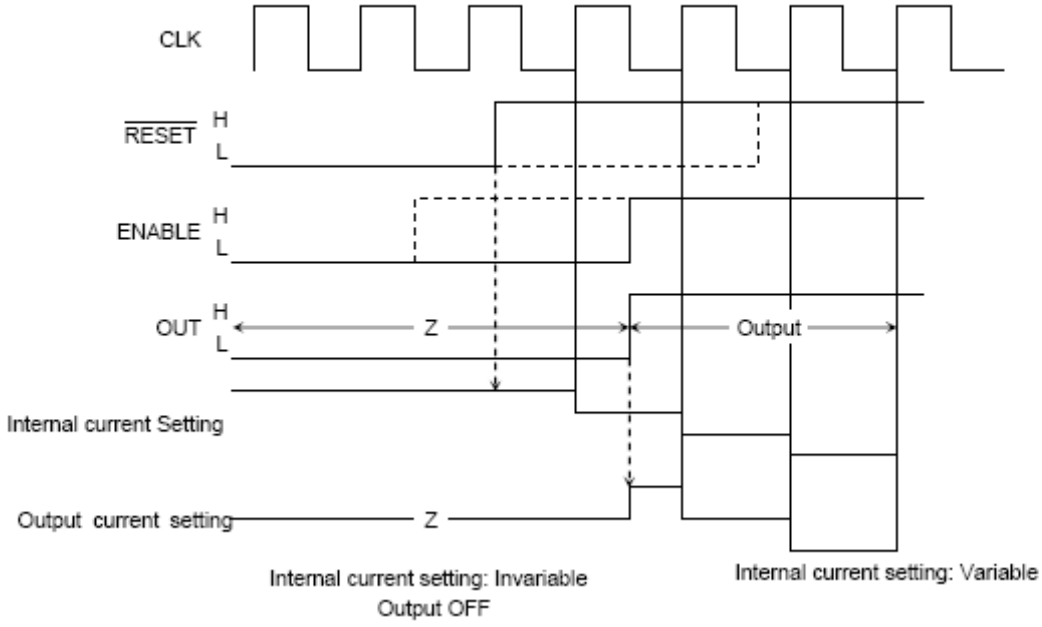
In addition, set the Control Input pins to Low when inputting the power.

(All the Control Input pins are pulled down internally.)

Once the power is on, the CLK signal is received and excitation advances when RESET goes high and excitation is output when ENABLE goes high. If only RESET goes high, excitation won't be output and only the internal counter will advance. Likewise, if only ENABLE goes high, excitation won't advance even if the CLK signal is input and it will remain in the initial state.

The following is an example:

<Recommended Control Input Sequence>



2. Calculating the Setting Current

To perform constant-current operations, it is necessary to configure the base current using an external resistor. If the voltage on the NFA (B) pin is 0.5 V (with a torque of 100%) or greater, it will not charge.

Ex.: If the maximum current value is 1 A, the external resistance will be 0.5 W.

3. PWM Oscillator Frequency (External Condenser Setting)

An external condenser connected to the OSC pin is used to internally generate a saw tooth waveform. PWM is controlled using this frequency. Toshiba recommends 100 to 3300 pF for the capacitance, taking variations between ICs into consideration.

Approximation:fosc=1/(Cosc*1.5*(10/Cosc+1)/66)*1000kHz

4. Power Dissipation

The IC power dissipation is determined by the following equation :

$P=V_{DD}*I_{OUT}*Ron*2drivers$

The higher the ambient temperature, the smaller the power dissipation.

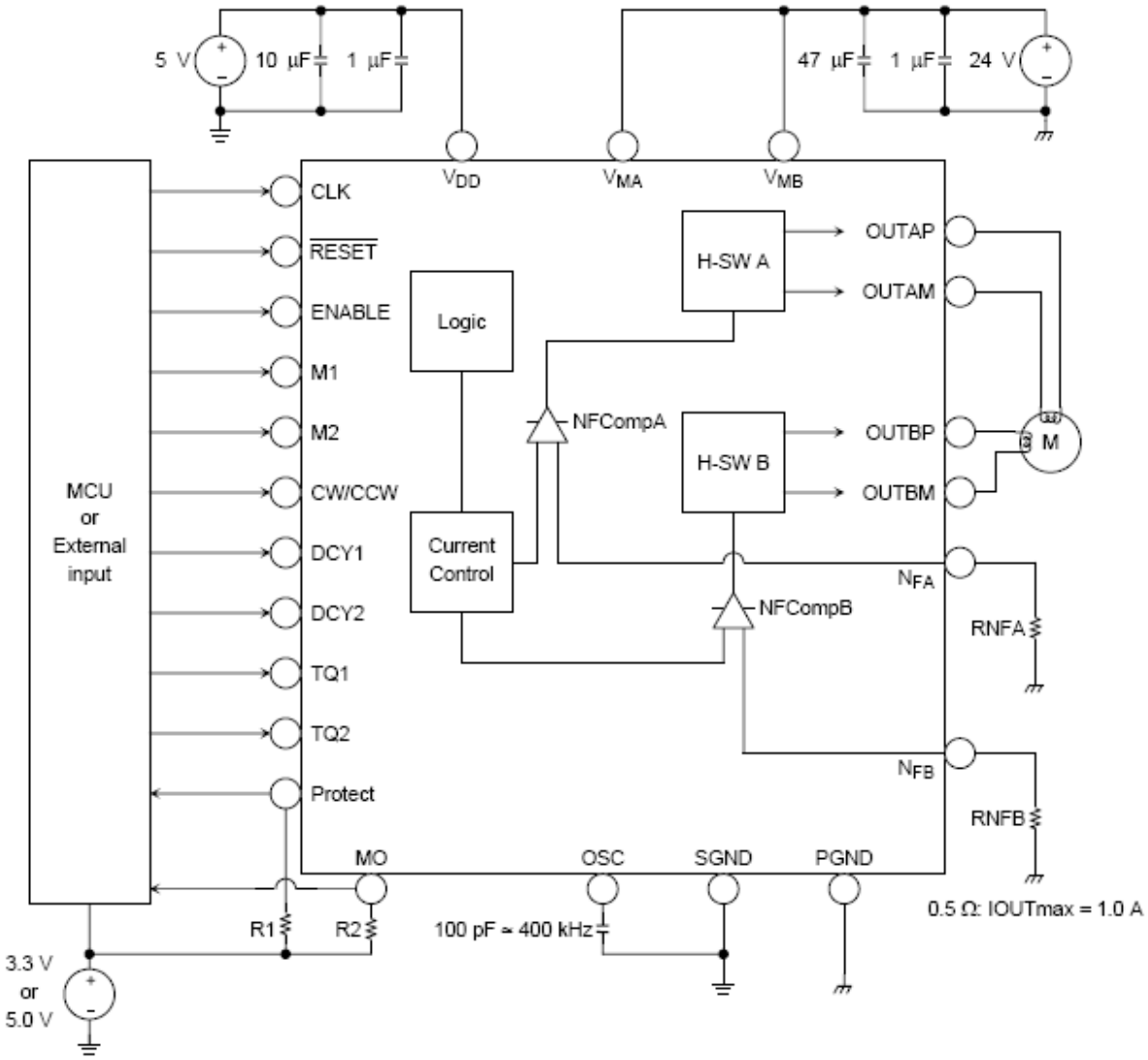
Check the PD-Ta curve, and be sure to design the heat dissipation with a sufficient margin.

5. Heat Sink Fin Processing

The IC fin (rear) is electrically connected to the rear of the chip. If current flows to the fin, the IC will malfunction. If there is any possibility of a voltage being generated between the IC GND and the fin, either ground the fin or insulate it.

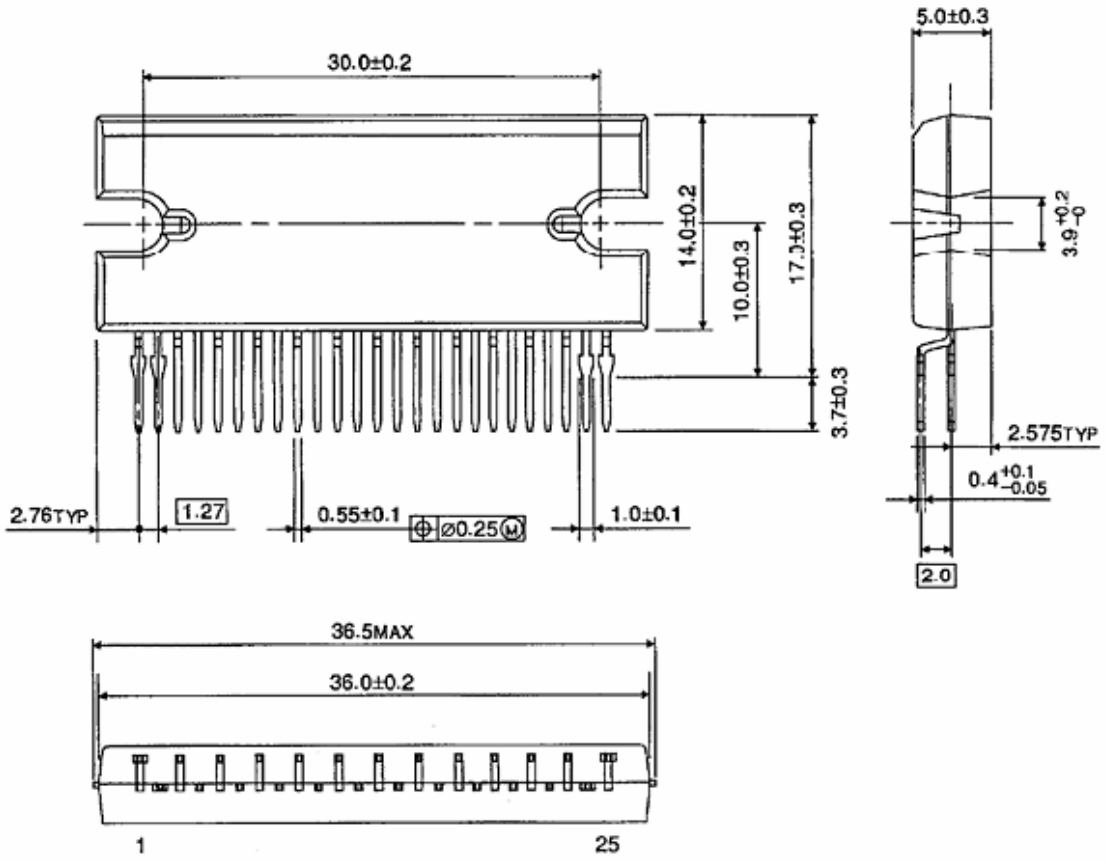
6. Thermal Protection

When the temperature reaches 170ºC(as standard value),the thermal protection circuit is activated Swithing the output to off. There is a variation of plus or minus about 20 C in the temperature that Triggers the circuit operation.


5 V
10 µF
1 µF
47 µF
1 µF
24 V
VDD
VMA
VMB
CLK
RESET
ENABLE
M1
M2
CW/CCW
DCY1
DCY2
TQ1
TQ2
Protect
MO
OSC
SGND
PGND
Logic
Current Control
H-SW A
H-SW B
NFCompA
NFCompB
OUTAP
OUTAM
OUTBP
OUTBM
NFA
NFB
RNFA
RNFB
M
MCU or External input
R1
R2
100 pF ≈ 400 kHz
3.3 V or 5.0 V
0.5 Ω: IOUTmax = 1.0 A

Package Dimensions

HZIP25-P-1.27 Unit : mm



Weight: 9.86 g (typ.)