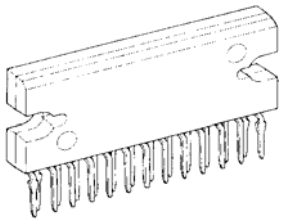
Preliminary TOSHIBA BiCD Integrated Circuit Silicon Monolithic

TB6560AHQ,TB6560AFG

PWM Chopper-Type bipolar
Stepping Motor Driver IC

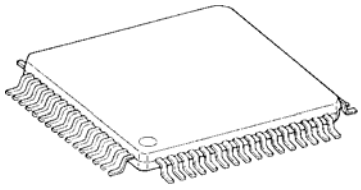
The TB6560AHQ/AFG is a PWM chopper-type sinusoidal micro-step bipolar stepping motor driver IC.
It supports both 2-phase/1-2-phase/2W1-2-phase/4W1-2-phase excitation mode and forward/reverse mode and is capable of low-vibration, high-performance drive of 2-phase bipolar type stepping motors using only a clock signal.

TB6560AHQ



HZIP25-P-1.27

TB6560AFG



HQFP64-P-1010-0.50

Weight:
HZIP25-P-1.27: 9.86 g (typ.)
HQFP64-P-1010-0.50: 0.26 g (typ.)

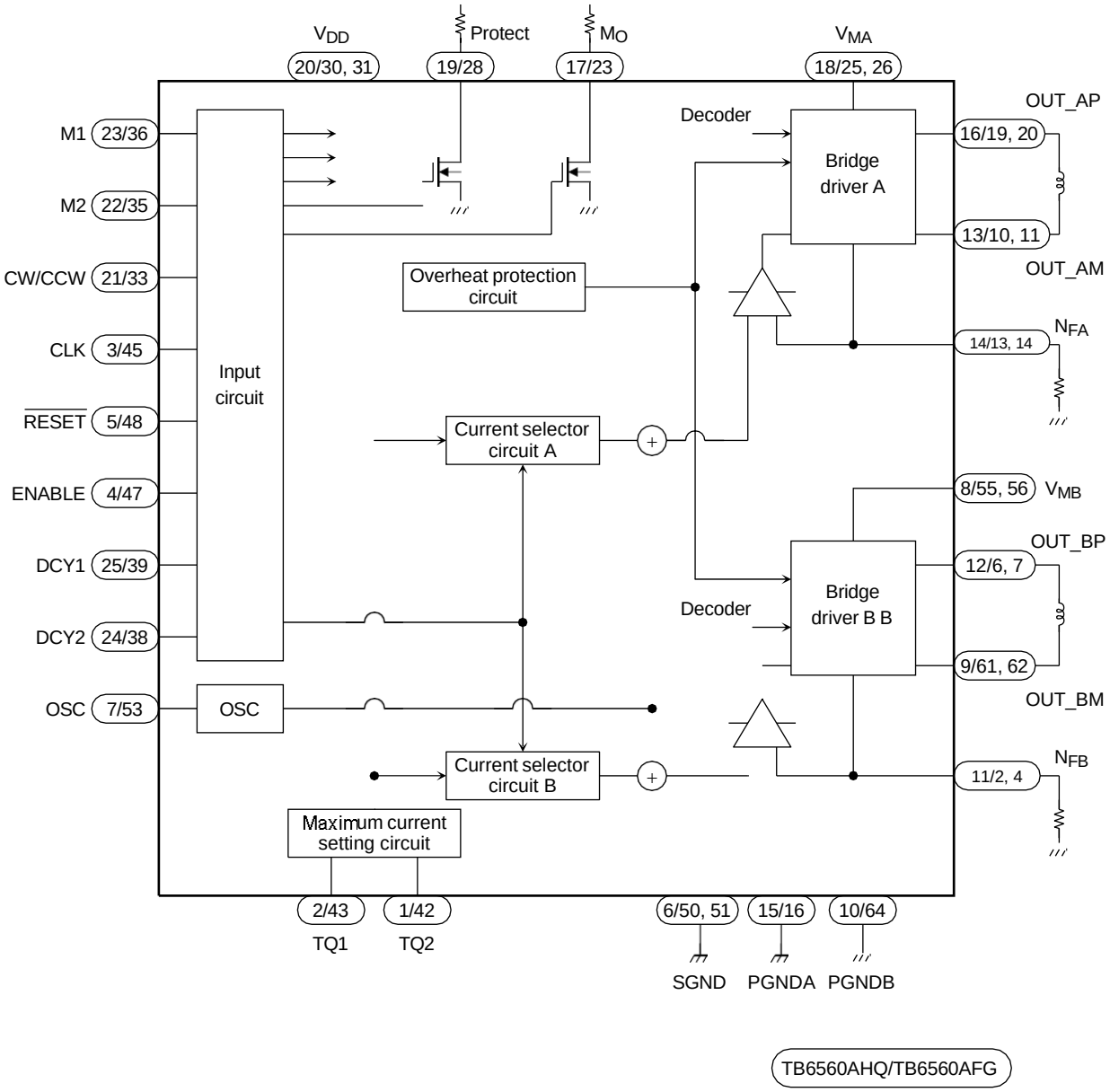
Features

- Single-chip bipolar sinusoidal micro-step stepping motor driver
- Uses high withstand voltage BiCD process:
  Ron (upper lower) = 0.6 Ω (typ.)
- Forward and reverse rotation control available
- Selectable phase drive (2, 1-2, 2W1-2, and 4W1-2)
- High output withstand voltage: VDSS = 40 V
- High output current: I_{OUT} = HQ: 3.5 A (peak)
  FG: 2.5 A (peak)
- Packages: HZIP25-P-1.27/HQFP64-P-1010-0.50
- Built-in input pull-down resistor: 100 kΩ (typ.)
- Output monitor pin equipped: MO current (I_{MO} (max) = 1 mA)
- Equipped with reset and enable pins
- Built-in overheat protection circuit

The TB6560AHQ/AFG is a Pb-free product.
The following conditions apply to solderability:
*Solderability
1. Use of Sn-37Pb solder bath
   *solder bath temperature = 230°C
   *dipping time = 5 seconds
   *number of times = once
   *use of R-type flux
2. Use of Sn-3.0Ag-0.5Cu solder bath
   *solder bath temperature = 245°C
   *dipping time = 5 seconds
   *the number of times = once
   *use of R-type flux

*: Since this product has a MOS structure, it is sensitive to electrostatic discharge. These ICs are highly sensitive to electrostatic discharge. When handling them, please be careful of electrostatic discharge, temperature and humidity conditions.

Block Diagram



Pin Functions

Pin No.		I/O	Symbol	Functional Description
AHQ	AFG			
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	OUT_B output (Note 1)
10	64(*)	—	PGNDB	Power ground
11	2/4(*)	—	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(*)	—	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)

(*) : Pin assignment of TB6560AFG is different from that of TB6560FG.

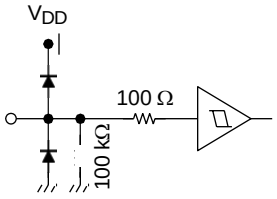
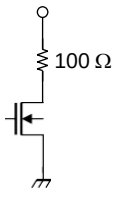
AHQ : No Non-connection (NC)

AFG : Other than the above pins, all are NC
(Since NC pins are not connected to the internal circuit, a potential can be applied to those pins.)

All control input pins: Pull-down resistor 100 kΩ (typ.)

Note 1: If the FG 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
		$V_{MA/B}$	$V_{MA/B}$ 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, $\overline{RESET}$, 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, $\overline{RESET}$, 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, $\overline{RESET}$: H, ENABLE: H (2, 1-2 phase excitation)	—	3	5	mA
		I_{DD2}		Output open, $\overline{RESET}$: H, ENABLE: H (W1−2, 2W1-2 phase excitation)	—	3	5	
		I_{DD3}		$\overline{RESET}$: L, ENABLE: L	—	2	5	
		I_{DD4}		$\overline{RESET}$: H, ENABLE: L	—	2	5	
Consumption current V_M pin		I_{M1}	1	$\overline{RESET}$: H/L, ENABLE: L	—	0.5	1	mA
		I_{M2}		$\overline{RESET}$: 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 step 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

When the ENABLE signal goes Low level, it sets an OFF on the output. The output changes to the Initial mode shown in the table below when the $\overline{\text{RESET}}$ signal goes Low level. In this mode, the status of the CLK and CW/CCW pins are irrelevant.

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.

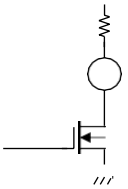
TQ2	TQ1	Current Ratio
L	L	100%
L	H	75%
H	L	50%
H	H	20% (weak excitation)

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

Open-drain connection



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