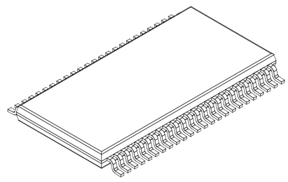
BiCD Integrated Circuit Silicon Monolithic

TB62213AFNG

BiCD Constant-Current Two-Phase Bipolar Stepping Motor Driver IC

The TB62213AFNG is a two-phase bipolar stepping motor driver using a PWM chopper.
Fabricated with the BiCD process, the TB62213AFNG is rated at 40 V/3.0 A .
The on-chip voltage regulator allows control of a stepping motor with a single VM power supply.



HTSSOP48-P-300-0.50

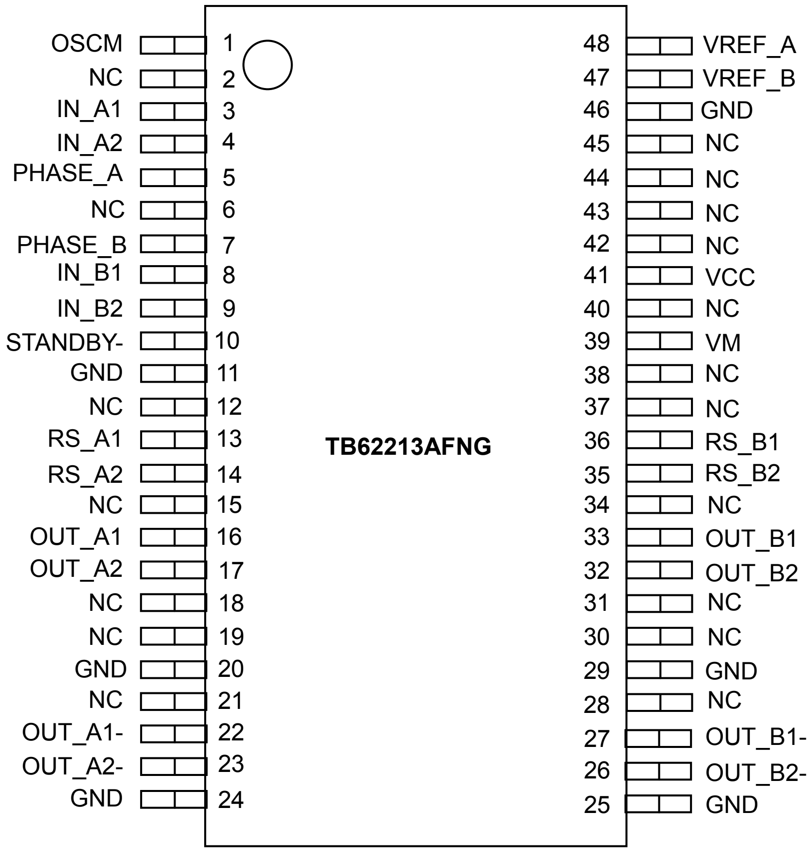
Weight: 0.2 g (Typ)

Features

- Bipolar stepping motor driver
- PWM constant-current drive
- Allows two-phase, 1-2-phase and W1-2 phase excitations.
- BiCD process: Uses DMOS FETs as output power transistors.
- High voltage and current: 40 V/3.0 A (absolute maximum ratings)
- Thermal shutdown (TSD), overcurrent shutdown (ISD), and power-on resets (PORs)
- Packages: HTSSOP48-P-300-0.50

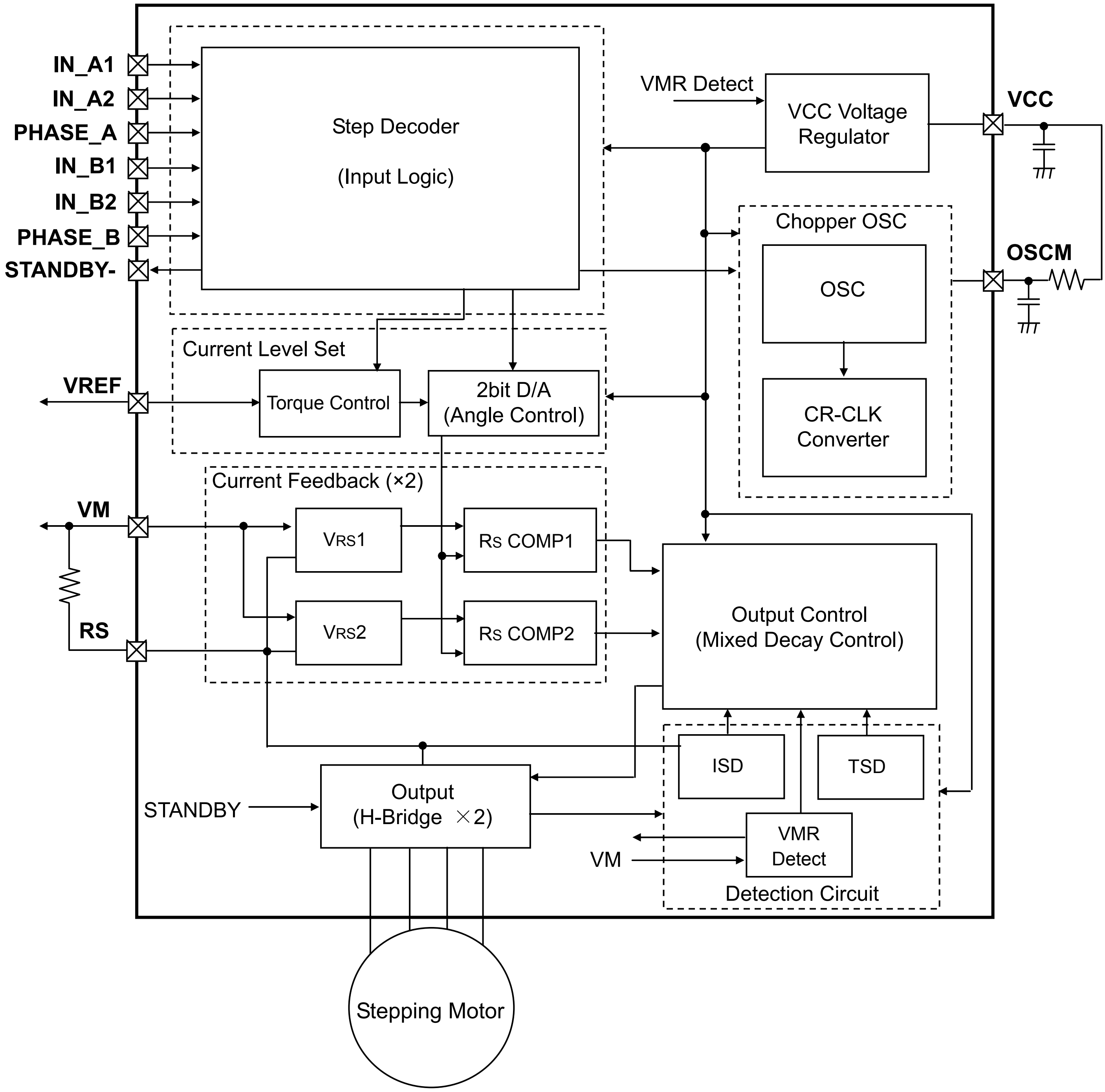
Pin Assignment

(Top View)



・Block Diagram

In the block diagram, part of the functional blocks or constants may be omitted or simplified for explanatory purposes.



Note: All the grounding wires of the TB62213AFNG must run on the solder within the mask of the PCM. It must also be externally terminated at a single point. Also, the grounding method should be considered for efficient heat dissipation.

Application Notes

Careful attention should be paid to the layout of the output, V_{DD} (V_M) and GND traces, to avoid short circuits across output pins or to the power supply or ground. If such a short circuit occurs, the TB62213AFNG may be permanently damaged.
Also, the utmost care should be taken for pattern designing and implementation of the TB62213AFNG since it has power supply pins (V_M, R_S, OUT, GND) through which a particularly large current may run. If these pins are wired incorrectly, an operation error may occur or the TB62213AFNG may be destroyed.
The logic input pins must be correctly wired, too. Otherwise, the TB62213AFNG may be damaged owing to a current running through the IC that is larger than the specified current.

Pin Function

TB62213AFNG (HTSSOP48)

Function explanation of terminal number 1 to 28

Pin No.	Pin Name	Function
1	OSCM	Oscillator pin for PWM choppers
2	NC	No-connect
3	IN_A1	A-phase excitation control input
4	IN_A2	A-phase excitation control input
5	PHASE_A	Current direction signal input for A phase
6	NC	No-connect
7	PHASE_B	Current direction signal input for B phase
8	IN_B1	B-phase excitation control input
9	IN_B2	B-phase excitation control input
10	STANDBY-	Output; Wait for power saving by disabling OSCM
11	GND	Logic ground
12	NC	No-connect
13	RS_A1	The sink current sensing of A-phase motor coil
14	RS_A2	The sink current sensing of A-phase motor coil
15	NC	No-connect
16	OUT_A1	A-phase positive driver output
17	OUT_A2	A-phase positive driver output
18	NC	No-connect
19	NC	No-connect
20	GND	Motor power ground
21	NC	No-connect
22	OUT_A1-	A-phase negative driver output
23	OUT_A2-	A-phase negative driver output
24	GND	Motor power ground
25	GND	Motor power ground
26	OUT_B2-	B-phase negative driver output
27	OUT_B1-	B-phase negative driver output
28	NC	No-connect

Function explanation of terminal number 29 to 48

Pin No.	Pin Name	Function
29	GND	Motor power ground
30	NC	No-connect
31	NC	No-connect
32	OUT_B2	B-phase positive driver output
33	OUT_B1	B-phase positive driver output
34	NC	No-connect
35	RS_B2	The sink current sensing of B-phase motor coil
36	RS_B1	The sink current sensing of B-phase motor coil
37	NC	No-connect
38	NC	No-connect
39	VM	Power supply
40	NC	No-connect
41	VCC	Smoothing filter for logic power supply
42	NC	No-connect
43	NC	No-connect
44	NC	No-connect
45	NC	No-connect
46	GND	Logic ground
47	VREF_B	Tunes the current level for B-phase motor drive.
48	VREF_A	Tunes the current level for A-phase motor drive.

・Please use the pin of NC with Open.

・Please connect the pins with the same names, at the nearest point of the device.

Output Function Table

Operation explanation

IOUT: The current that flows OUT_X to OUT_X- is defined plus current. The current that flows OUT_X- to OUT_X is defined minus current.

<Two-Phase>

PHASE A				PHASE B			
Input			Output	Input			Output
PHASE_A	IN_A1	IN_A2	I_{OUT}(A)	PHASE_B	IN_B1	IN_B2	I_{OUT}(B)
H	H	H	100%	H	H	H	100%
L	H	H	-100%	H	H	H	100%
L	H	H	-100%	L	H	H	-100%
H	H	H	100%	L	H	H	-100%

Please make IN_A1, IN_A2, IN_B1, and IN_B2 Low when you turn on the power supply.

<1-2-phase >

PHASE A				PHASE B			
Input			Output	Input			Output
PHASE_A	IN_A1	IN_A2	I_{OUT}(A)	PHASE_B	IN_B1	IN_B2	I_{OUT}(B)
H	H	H	100%	H	H	H	100%
X	L	L	0%	H	H	H	100%
L	H	H	-100%	H	H	H	100%
L	H	H	-100%	X	L	L	0%
L	H	H	-100%	L	H	H	-100%
X	L	L	0%	L	H	H	-100%
H	H	H	100%	L	H	H	-100%
H	H	H	100%	X	L	L	0%

X: Don't care

<W1-2 phase>

PHASE A				PHASE B			
Input			Output	Input			Output
PHASE_A	IN_A1	IN_A2	I_{OUT}(A)	PHASE_B	IN_B1	IN_B2	I_{OUT}(B)
H	H	L	71%	H	H	L	71%
H	L	H	38%	H	H	H	100%
X	L	L	0%	H	H	H	100%
L	L	H	-38%	H	H	H	100%
L	H	L	-71%	H	H	L	71%
L	H	H	-100%	H	L	H	38%
L	H	H	-100%	X	L	L	0%
L	H	H	-100%	L	L	H	-38%
L	H	L	-71%	L	H	L	-71%
L	L	H	-38%	L	H	H	-100%
X	L	L	0%	L	H	H	-100%
H	L	H	38%	L	H	H	-100%
H	H	L	71%	L	H	L	-71%
H	H	H	100%	L	L	H	-38%
H	H	H	100%	X	L	L	0%
H	H	H	100%	H	L	H	38%

X: Don't care

Other Functions

Pin Name	H	L	Notes
IN X	Outputs enabled	Outputs disabled	When IN_X is deasserted Low (where X indicates a phase), its outputs assume the high-impedance state, regardless of the state of that phase.
PHASE X	OUT_X: H	OUT_X (−): H	When PHASE_X is High, a current normally flows from OUT_X to OUT_X (−).
STANDBY-	Normal operation mode	Standby mode	When STANDBY is Low, both the oscillator and output drivers are disabled. The TB62213AFNG cannot drive a motor.

Protection Features

(1) Thermal shutdown (TSD)
The thermal shutdown circuit turns off all the outputs when the junction temperature (T_j) exceeds 150°C (typ.). The outputs retain the current states.
The TB62213AFNG exits TSD mode and resumes normal operation when the TB62213AFNG is rebooted or both the STANDBY pin are switched to Low.

(2) Power-ON-resets (PORs) for VMR and VCCR (VM and VCC voltage monitor)
The outputs are forced off until VM and VCC reach the rated voltages.

(3) Overcurrent shutdown (ISD)

Each phase has an overcurrent shutdown circuit, which turns off the corresponding outputs when the output current exceeds the shutdown trip threshold (above the maximum current rating: 3.1 A minimum). The TB62213AFNG exits ISD mode and resumes normal operation when the TB62213AFNG is rebooted or both the STANDBY pin are switched to Low.

This circuit provides protection against a short circuit by temporarily disabling the device. Important notes on this feature will be provided later.

Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Motor power supply	V_M	40	V
Motor output voltage	V_{OUT}	40	V
Motor output current(Note 1)	I_{OUT}	3.0	A
Logic power supply	V_{CC}	6.0	V
Logic input voltage	V_{IN}	6.0	V
Power dissipation (Note 2)	P_D	1.12	W
Operating temperature	T_{opr}	−20 to 85	°C
Storage temperature	T_{stg}	−55 to 150	°C
Junction temperature	$T_{j\ (MAX)}$	150	°C

Note 1: The absolute maximum rating is 3.0A.

Note 2: Stand-alone (Ta = 25°C)
Ta: Ambient temperature
T_{opr}: Ambient temperature while the TB62213AFNG is active

T_j: Junction temperature while the TB62213AFNG is active. The maximum junction temperature is limited by the thermal shutdown (TSD) circuitry. It is advisable to keep the maximum current below a certain level so that the maximum junction temperature, $T_{j\ (MAX)}$, will not exceed 120°C.

When Ta exceeds 25°C, it is necessary to do the derating with 10.4 mW/°C.

Note: The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating (s) may cause device breakdown, damage or deterioration, and may result in injury by explosion or combustion.
The value of even one parameter of the absolute maximum ratings should not be exceeded under any circumstances. The TB62213AFNG does not have overvoltage protection. Therefore, the device is damaged if a voltage exceeding its rated maximum is applied.

All voltage ratings, including supply voltages, must always be followed. The other notes and considerations described later should also be referred to.

Operating Ranges (Note1)

Characteristics	Symbol	Min	Typ.	Max	Unit	Remarks
Motor power supply	V_M	10.0	24.0	38.0	V	-
Motor output voltage	I_{OUT}	-	1.8	2.4	A	Per phase
Logic input viltage	$V_{IN(H)}$	2.0	3.3	5.5	V	Logic high level
	$V_{IN(L)}$	-0.4	-	1.0	V	Logic low level
PHASE signal input frequency(Note2)	f_{PHASE}	1.0	-	400	kHz	-
Chopper frequency	f_{chop}	40	100	150	kHz	-
V_{ref} reference voltage	V_{ref}	GND	-	3.6	V	-
Voltage across the current-sensing resistor pins	V_{RS}	0.0	±1.0	±1.5	V	-

Note 1: Please have and use the margin for the absolute maximum rating.

Note 2: There is no problem in the condition of 500ns or less at the risetime of the CLK signal even if a frequency less than it is input though the lower bound of the frequency of the input of the signal of the CLK input is assumed to be 1kHz.

Please note that repeated input of the signal by chattering can be generated when standing up of the signal becomes duller.

Electrical Characteristics 1 (Ta = 25°C, VM = 24 V, unless otherwise specified)

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Digital input voltage	High	V_{IN}	Digital input pins	2	3.3	5.0	V
	Low			GND	-	0.8	
Input hysteresis voltage		$V_{IN (HIS)}$	Digital input pins (Note)	100	200	300	mV
Digital input current	High	$I_{IN (H)}$	V_{IN} = 5 V at the digital input pins under test	35	50	75	μA
	Low	$I_{IN (L)}$	V_{IN} = 0 V at the digital input pins under test	-	-	1	
Power consumption		I_{M1}	Outputs open, $\overline{\text{STANDBY}}$ = Low	-	2	3	mA
		I_{M2}	Outputs open, $\overline{\text{STANDBY}}$ = High	-	3.5	5	
		I_{M3}	Outputs open (two-phase excitation)	-	5	7	
Output leakage current	High-side	I_{OH}	V_{RS} = VM = 40 V: V_{OUT} = 0 V	-	-	1	μA
	Low-side	I_{OL}	V_{RS} = VM = V_{OUT} = 40 V	1	-	-	
Chanel-to-channel current differential		ΔI_{OUT1}	Channel-to-channel error	−5	0	5	%
Output current error relative to the predetermined value		ΔI_{OUT2}	I_{OUT} = 1 A	−5	0	5	%
R_S pin current		I_{RS}	V_{RS} = VM = 24 V	0	-	10	μA
Drain-source ON-resistance of the output transistors (upper and lower sum)		$R_{ON (D-S)}$	I_{OUT} = 2.0 A, T_j = 25°C	0.4	0.6	0.8	Ω
Chopping current		Phase	Step0	-	0	-	%
			Step1	33	38	43	%
			Step2	66	71	76	%
			Step3	-	100	-	%

Note: $V_{IN (L \to H)}$ is defined as the V_{IN} voltage that causes the outputs to change when a pin under test is gradually raised from 0 V. $V_{IN (H \to L)}$ is defined as the V_{IN} voltage that causes the outputs to change when the pin is then gradually lowered.
The difference between $V_{IN (L \to H)}$ and $V_{IN (H \to L)}$ is defined as the input hysteresis.

Electrical Characteristics 2 (Ta = 25°C, VM = 24 V, unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Supply voltage for internal circuitry	V_{CC}	I_{CC} = 5.0 mA	4.75	5.00	5.25	V
Supply current for internal circuitry	I_{CC}	-	-	2.5	5.0	mA
V_{ref} input voltage range	V_{ref}	VM = 24V, STANDBY = H, f_{PHASE} = 1 kHz	GND	3.0	3.6	V
V_{ref} input current	I_{ref}	Output non-operation V_{ref} = 3.0 V	-	0	1.0	μA
V_{ref} decay rate	$V_{ref\ (GAIN)}$	V_{ref} = 2.0 V	1/4.8	1/5.0	1/5.2	-
TSD threshold (Note 1)	T_{jTSD}	-	140	150	170	°C
V_M recovery voltage	V_{MR}	-	7.0	8.0	9.0	V
Overcurrent trip threshold (Note 2)	ISD	-	3.0	4.0	5.0	A

Note 1: Thermal shutdown (TSD) circuitry
When the junction temperature of the device reaches the threshold, the TSD circuitry is tripped, causing the internal reset circuitry to turn off the output transistors.
The TSD circuitry is tripped at a temperature between 140°C (min) and 170°C (max). Once tripped, the TSD circuitry keeps the output transistors off until both the STANDBY pin are switched to Low or the TB62213AFNG is rebooted.

Note 2: Overcurrent shutdown (ISD) circuitry
When the output current reaches the threshold, the ISD circuitry is tripped, causing the internal reset circuitry to turn off the output transistors.
To prevent the ISD circuitry from being tripped owing to switching noise, it has a masking time of four CR oscillator cycles. Once tripped, it takes a maximum of four cycles to exit ISD mode and resume normal operation.
The ISD circuitry remains active until both the STANDBY pin are switched to Low or the TB62213AFNG is rebooted.
The TB62213AFNG remains in Standby mode while in ISD mode.

Back-EMF

While a motor is rotating, there is a timing at which power is fed back to the power supply. At that timing, the motor current recirculates back to the power supply owing to the effect of the motor back-EMF.

If the power supply does not have enough sink capability, the power supply and output pins of the device might rise above the rated voltages. The magnitude of the motor back-EMF varies with usage conditions and motor characteristics. It must be fully verified that there is no risk that the TB62213AFNG or other components will be damaged or fail owing to the motor back-EMF.

Cautions on Overcurrent Shutdown (ISD) and Thermal Shutdown (TSD)

- The ISD and TSD circuits are only intended to provide temporary protection against irregular conditions such as an output short circuit; they do not necessarily guarantee complete IC safety.
- If the device is used beyond the specified operating ranges, these circuits may not operate properly: then the device may be damaged owing to an output short circuit.
- The ISD circuit is only intended to provide temporary protection against an output short circuit. If such a condition persists for a long time, the device may be damaged owing to overstress. Overcurrent conditions must be removed immediately by external hardware.

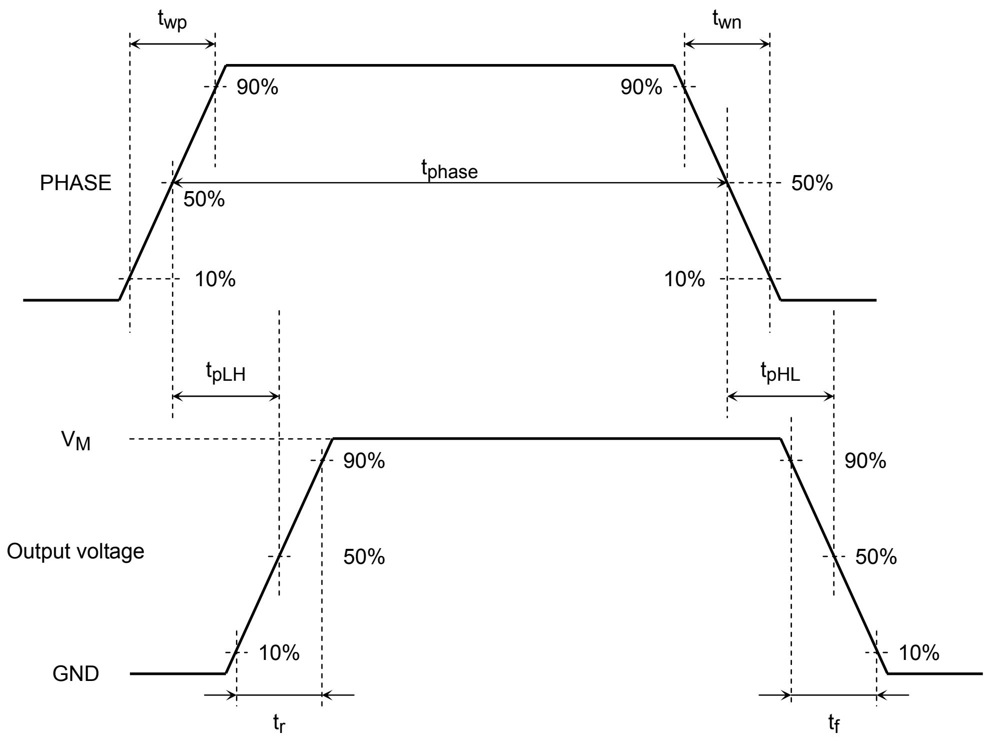
IC Mounting

Do not insert devices in the wrong orientation or incorrectly. Otherwise, it may cause device breakdown, damage and/or deterioration.

AC Electrical Characteristics (Ta = 25°C, VM = 24 V, 6.8 mH/5.7 Ω)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Phase frequency	f_{PHASE}	AC	f_{OSC} = 1600 kHz	1.0	-	400	kHz
Minimum phase pulse width	t_{PHASE}	AC	-	100	-	-	ns
	t_{wp}	AC		50	-	-	
	t_{wn}	AC		50	-	-	
Output transistor switching characteristics	t_r	AC	-	150	200	250	ns
	t_f	AC		100	150	180	
	t_{pLH} (P) MAX	AC	PHASE to OUT	500	850	1200	
	t_{pHL} (P) MAX	AC		500	850	1200	
	t_{pLH} (P) MIN	AC		250	600	950	
	t_{pHL} (P) MIN	AC		250	600	950	
Blanking time for current spike prevention	t_{BLANK}	AC	I_{OUT} = 1.0 A	300	400	500	ns
OSC oscillation reference frequency	f_{CR}	AC	C_{OSC} = 270 pF, R_{OSC} = 3.6 kΩ	1200	1600	2000	kHz
Chopper frequency range	f_{chop} (RANGE)	AC	VM = 24 V, outputs enabled ACTIVE (I_{OUT} = 1.0 A)	40	100	150	kHz
Predefined chopper frequency	f_{chop}	AC	Outputs enabled (I_{OUT} = 1.0 A), C_R = 1600 kHz	-	100	-	kHz
ISD masking time	t_{ISD} (Mask)	AC	This time will be the number of CLK OSCM. After ISD threshold is exceeded owing to an output short circuit to power or ground	-	4	-	-
ISD on-time	t_{ISD}	AC		-	-	8	

Timing Charts of Output Transistors Switching



Calculation of the Predefined Output Current

For PWM constant-current control, the TB62213AFNG uses a clock generated by the CR oscillator. The peak output current can be set via the current-sensing resistor (R_{RS}) and the reference voltage (V_{ref}), as follows:

$I_{OUT} = V_{ref}/5 \div R_{RS}\ (\Omega)$

where, 1/5 is the V_{ref} decay rate, $V_{ref\ (GAIN)}$. For the value of $V_{ref\ (GAIN)}$, see the Electrical Characteristics table.

For example, when V_{ref} = 3 V, to generate an output current (I_{OUT}) of 1.8 A, R_{RS} is calculated as:

$RRS = (V_{ref}/5) \div I_{OUT} = (3/5) \div 1.8 = 0.33\ \Omega$. ($\geq$ 1.1 W)

Calculation of the OSCM oscillation frequency (chopper reference frequency)

OSCM oscillation frequency (fOSCM) and chopper frequency (fchop) are computable in the following expressions.

fOSCM=1/[0.60x{Cx(R1+500)}] ………C,R1: External constant for OSCM (C=270pF , R1=3.6kΩ)

fchop = fOSCM / 16

Because the loss of the gate in IC rises, generation of heat grows though wavy reproducibility goes up because the pulsating flow of the current decreases when the chopper frequency is raised.

There is a possibility of the current pulsating flow increasing though a decrease in generation of heat can be expected by lowering the chopper frequency.

The thing set within the range of the frequency from 40 to about 100kHz based on the frequency generally of about 70 kHz is recommended.

IC Power Consumption

The power consumed by the TB62213AFNG is approximately the sum of the following: 1) the power consumed by the output transistors, and 2) the power consumed by the digital logic and pre-drivers.

- The power consumed by the output transistors is calculated, using the RON (D-S) value of 0.8 Ω .
- Whether in Charge, Fast Decay or Slow Decay mode, two of the four transistors comprising each H-bridge contribute to its power consumption at a given time.

Thus the power consumed by each H-bridge is given by:

$$P\ (out) = 2\ (Hsw) \times I_{OUT}\ (A) \times V_{DS}\ (V) = 2\ (Hsw) \times Iout\ (A)^2 \times R_{ON}\ (\Omega) \text{ .. } (1)$$

In two-phase excitation mode (in which two phases have a phase difference of 90°), the average power consumption in the output transistors is calculated as follows:

Ron = 0.8 Ω (@2.0 A)
Iout (peak: Max) = 1.8 A
VM = 24 V

$$P\ (out) = 2Hsw \times 1.8^2\ (A) \times 0.8\ (\Omega) = 5.2\ (W) \text{ .... } (2)$$

The power consumption in the IM domain is calculated separately for normal operation and standby modes:

Normal operation mode: I (IM3) = 5.0 mA (typ.)
Standby mode: I (IM1) = 3.5 mA (typ.)

The current consumed in the digital logic portion of the TB62213AFNG is indicated as IMx. The digital logic operates off a voltage regulator internally connected to the VM power supply. It consists of the digital logic connected to VM (24 V) and the network affected by the switching of the output transistors. The total power consumed by IMx can be estimated as:

$$P\ (I_M) = 24\ (V) \times 0.005\ (A) = 0.12 (W) \text{ .... } (3)$$

Hence, the total power consumption of the TB62213AFNG is:

$$P = P\ (out) + P\ (I_M) = 5.32 (W)$$

The standby power consumption is given by:

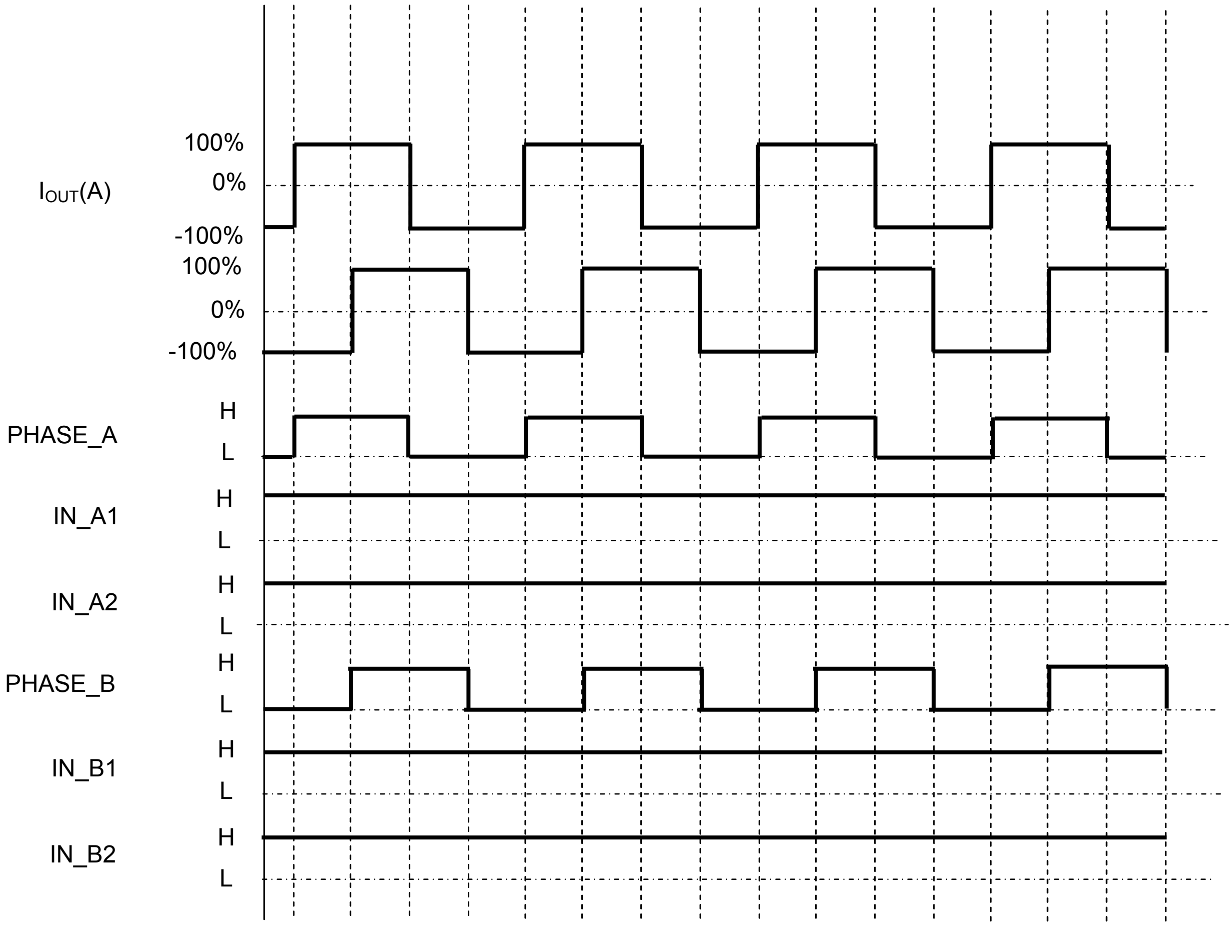
$$P\ (Standby) + P\ (out) = 24\ (V) \times 0.0035\ (A) = 0.084\ (W)$$

Board design should be fully verified, taking thermal dissipation into consideration.

Phase Sequences

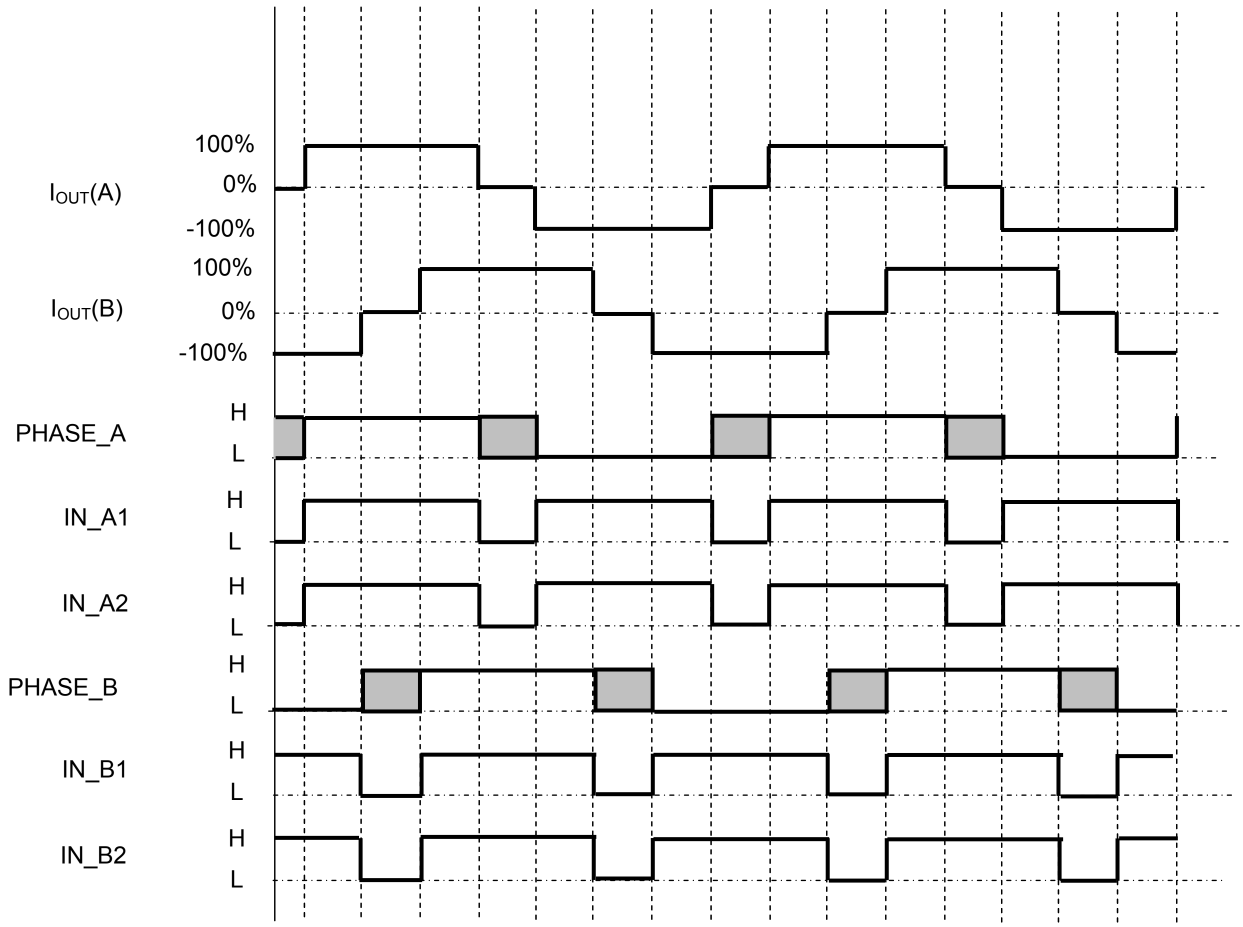
2-Phase Excitation Mode

Timing charts may be simplified for explanatory purposes.

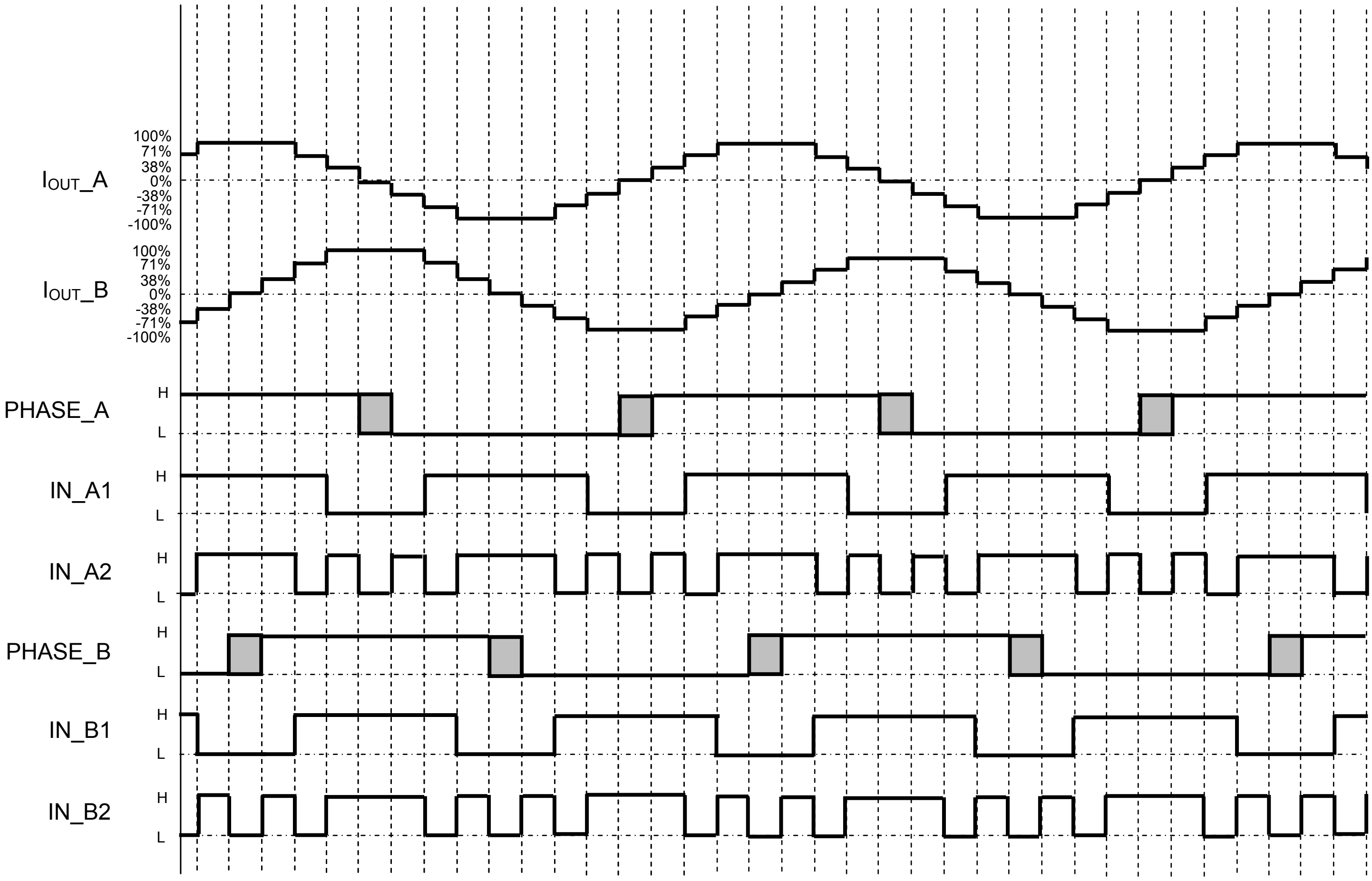


1-2-Phase Excitation

Timing charts may be simplified for explanatory purposes.



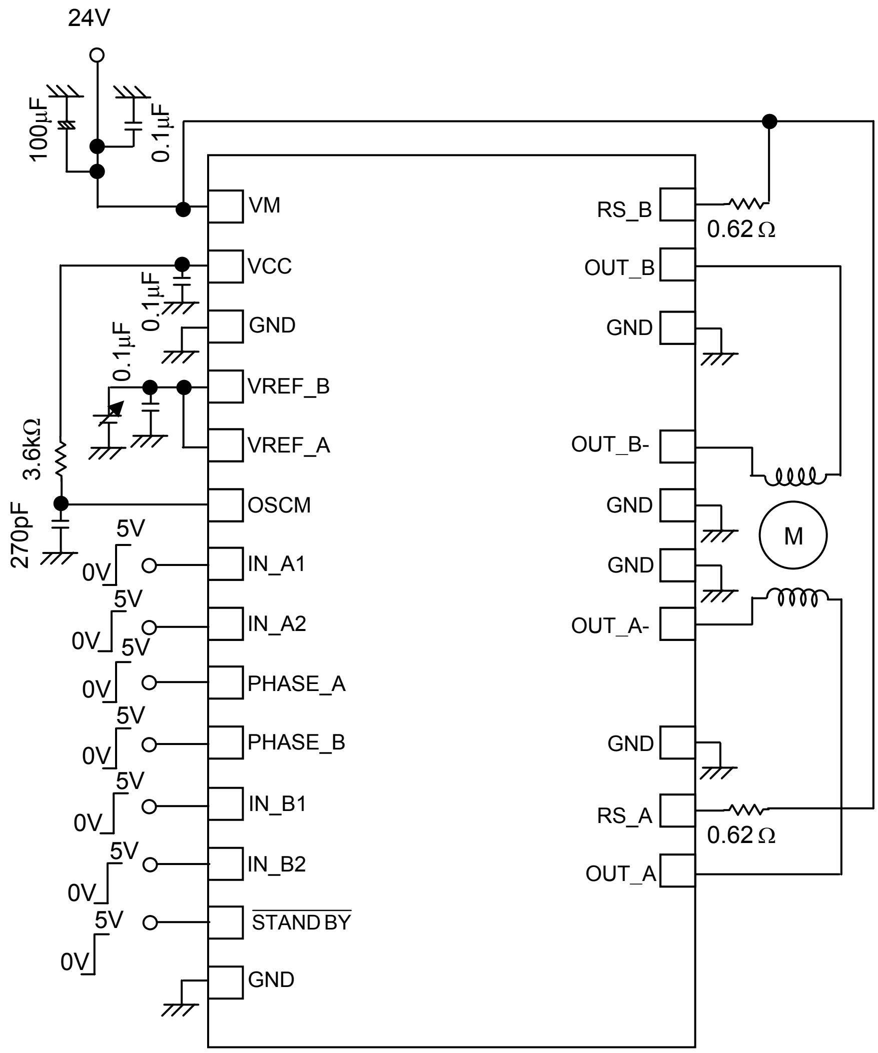
W1-2-Phase Excitation



Application Circuit Example

TB62213AFNG

The values shown in the following figure are typical values. For input conditions, see Operating Ranges.

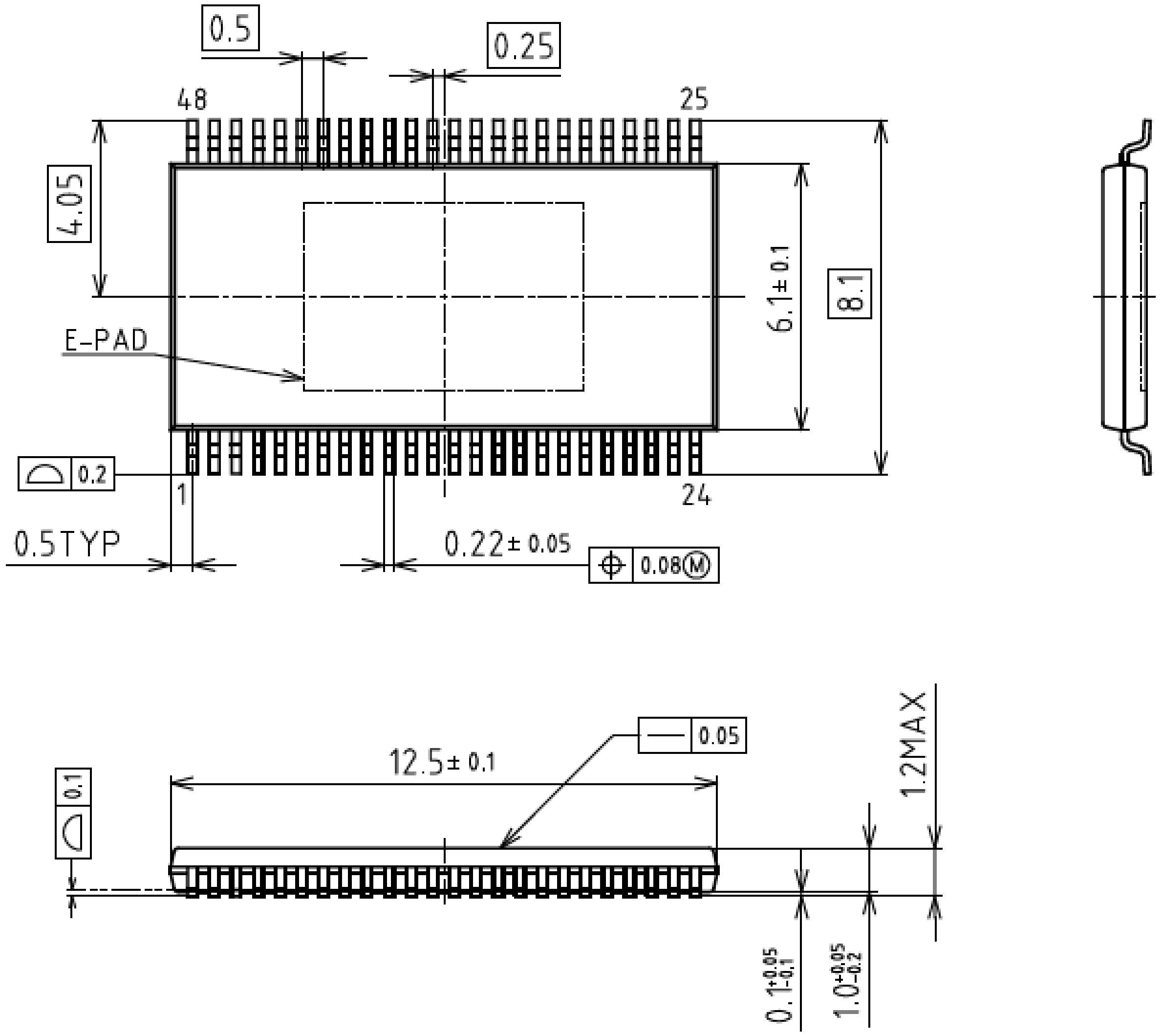


Note: I will recommend the addition of a capacitor if necessary. The GND wiring must become one point as much as possible-earth.

The example of an applied circuit is for reference, and enough evaluation should be done before the mass-production design.
Moreover, it is not the one to permit the use of the industrial property.

Package Dimensions
HTSSOP48

Unit : mm



Weight: 0.2 g (Typ)

Notes on Contents

1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass-production design stage.
Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations

Notes on handling of ICs

(1) The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.Exceeding the rating(s) may cause device breakdown, damage or deterioration, and may result in injury by explosion or combustion.

(2) Use an appropriate power supply fuse to ensure that a large current does not continuously flow in the case of overcurrent and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead to smoke or ignition. To minimize the effects of the flow of a large current in the case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

(3) If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition. Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

(4) Do not insert devices in the wrong orientation or incorrectly. Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause device breakdown, damage or deterioration, and may result in injury by explosion or combustion.
In addition, do not use any device inserted in the wrong orientation or incorrectly to which current is applied even just once.

(5) Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator.
If there is a large amount of leakage current such as from input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, overcurrent or IC failure may cause smoke or ignition. (The overcurrent may cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection-type IC that inputs output DC voltage to a speaker directly.

Points to remember when handling of ICs

Overcurrent Protection Circuit
Overcurrent protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the overcurrent protection circuits operate against the overcurrent, clear the overcurrent status immediately.
Depending on the method of use and usage conditions, exceeding absolute maximum ratings may cause the overcurrent protection circuit to operate improperly or IC breakdown may occur before operation. In addition, depending on the method of use and usage conditions, if overcurrent continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

Thermal Shutdown Circuit
Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over-temperature, clear the heat generation status immediately.
Depending on the method of use and usage conditions, exceeding absolute maximum ratings may cause the thermal shutdown circuit to operate improperly or IC breakdown to occur before operation.

Heat Radiation Design
When using an IC with large current flow such as power amp, regulator or driver, design the device so that heat is appropriately radiated, in order not to exceed the specified junction temperature (TJ) at any time or under any condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, when designing the device, take into consideration the effect of IC heat radiation with peripheral components.

Back-EMF
When a motor rotates in the reverse direction, stops or slows abruptly, current flows back to the motor's power supply owing to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond the absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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