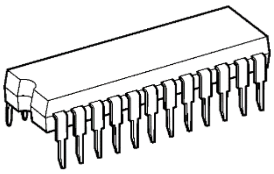
TOSHIBA BiCD Integrated Circuit Silicon Monolithic

TB67S101ANG

PHASE-in controlled Bipolar Stepping Motor Driver

1. Description

TB67S101ANG is a two-phase bipolar stepping motor driver using a PWM chopper. The interface is Phase control. Fabricated with the BiCD process, the rating is 50 V/4.0 A



P-SDIP24-0723-1.78-001

Weight: 1.3 g (Typ.)

2. Features

- BiCD process integrated monolithic IC.
- PWM controlled constant-current drive.
- Allows full, half, quarter step operation.
- Low on-resistance (High + Low side = 0.49 Ω (Typ.)) MOSFET output stage.
- High efficiency motor current control mechanism (Advanced Dynamic Mixed Decay)
- High voltage and current (For specification, please refer to absolute maximum ratings and operation ranges)
- Built-in error detection circuits (Thermal shutdown (TSD), over-current shutdown (ISD), and power-on reset (POR))
- Built-in VCC regulator for internal circuit use.
- Chopping frequency of a motor can be customized by external resistor and capacitor.
- Package: P-SDIP24-0723-1.78-001

Note: Please be careful about thermal conditions during use.

3. Block Diagram

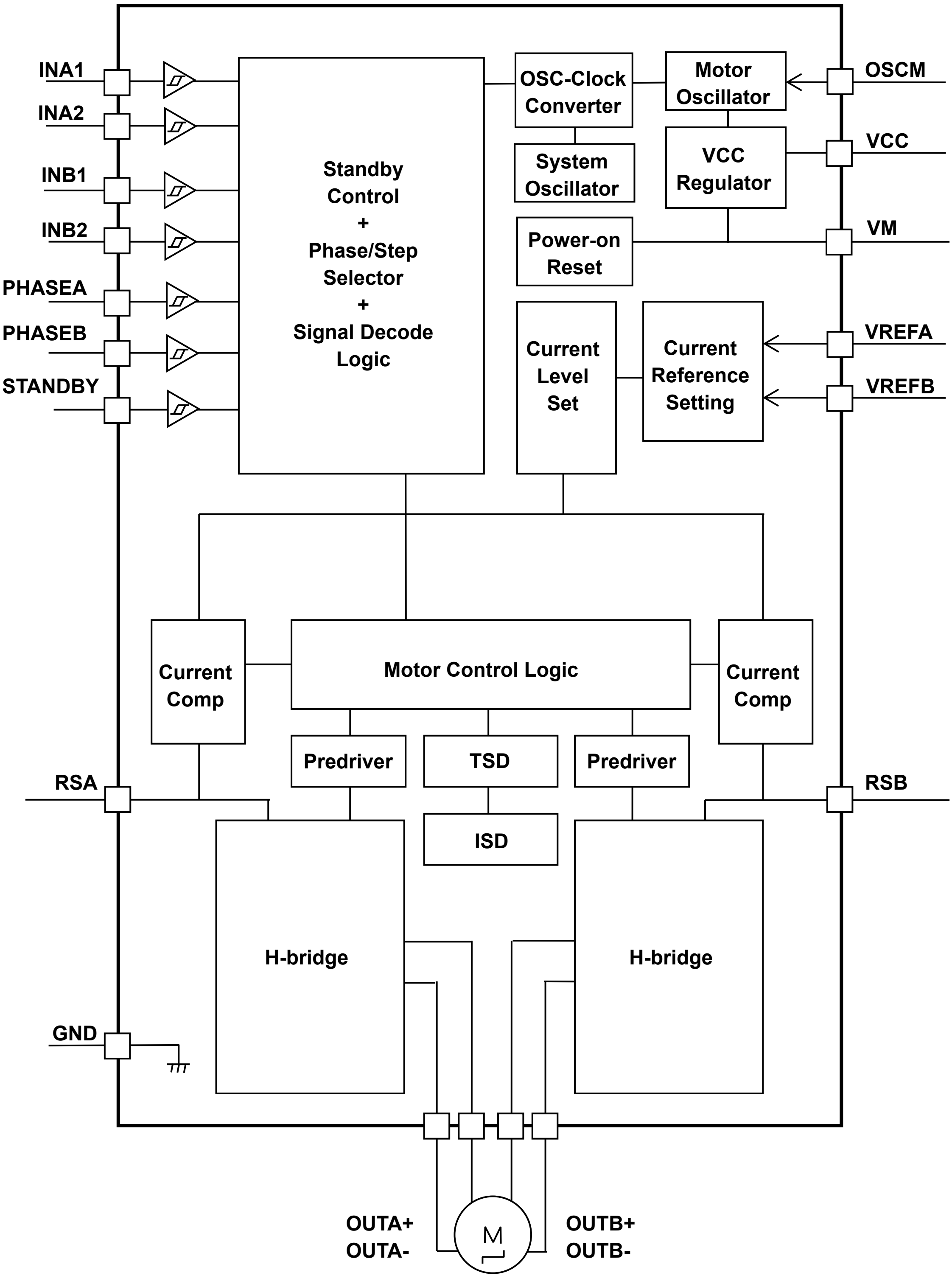


Figure 3.1 Block Diagram

Note: Functional blocks/circuits/constants in the block chart etc. may be omitted or simplified for explanatory purposes.

Note: All the grounding wires of the TB67S101ANG must run on the solder mask on the PCB and be externally terminated at only one point. Also, a grounding method should be considered for efficient heat dissipation.
Careful attention should be paid to the layout of the output, VCC(VM) and GND traces, to avoid short circuits across output pins or to the power supply or ground. If such a short circuit occurs, the device may be permanently damaged.
Also, the utmost care should be taken for pattern designing and implementation of the device since it has power supply pins (VM, RS, OUT, GND) through which a particularly large current may run. If these pins are wired incorrectly, an operation error may occur or the device may be destroyed.
The logic input pins must also be wired correctly. Otherwise, the device may be damaged owing to a current running through the IC that is larger than the specified current.

4. Pin Assignments

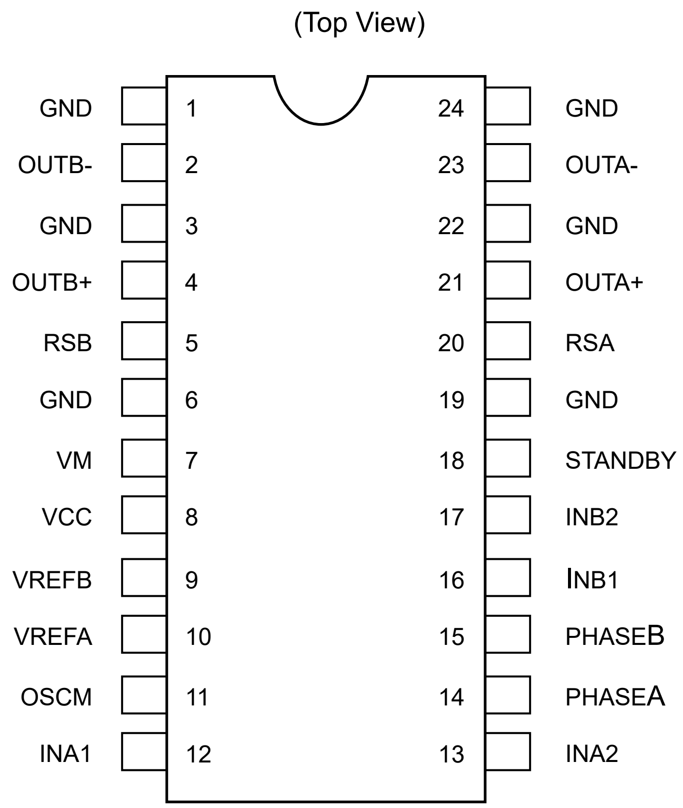


Figure 4.1 Pin Assignments

5. Pin Description

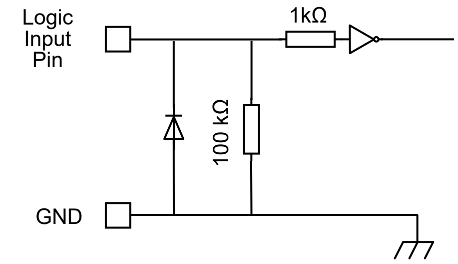
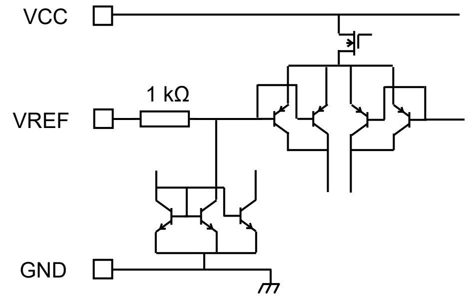
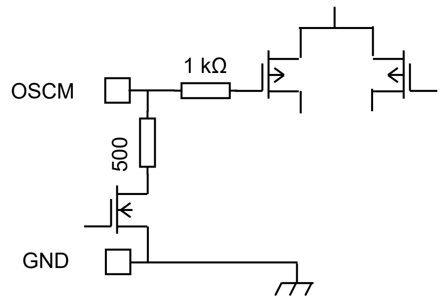
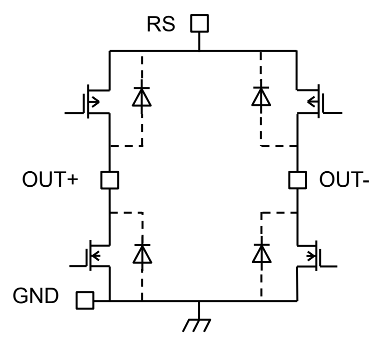
5.1. TB67S101ANG (SDIP24)

Table 5.1 Pin Description

Pin No.	Pin Name	Function
1	GND	Ground pin
2	OUTB-	Motor Bch (-) output pin
3	GND	Ground pin
4	OUTB+	Motor Bch (+) output pin
5	RSB	Motor Bch current sense pin
6	GND	Ground pin
7	VM	Motor power supply pin
8	VCC	Internal VCC regulator monitor pin
9	VREFB	Motor Bch output set pin
10	VREFA	Motor Ach output set pin
11	OSCM	Oscillating circuit frequency for chopping set pin
12	INA1	Motor Ach excitation control input 1
13	INA2	Motor Ach excitation control input 2
14	PHASEA	Current direction signal input for motor Ach
15	PHASEB	Current direction signal input for motor Bch
16	INB1	Motor Bch excitation control input 1
17	INB2	Motor Bch excitation control input 2
18	STANDBY	All-function-initializing and Low power dissipation mode
19	GND	Ground pin
20	RSA	Motor Ach current sense pin
21	OUTA+	Motor Ach (+) output pin
22	GND	Ground pin
23	OUTA-	Motor Ach (-) output pin
24	GND	Ground pin

5.2. Input/Output equivalent circuit

Table 5.2 Input/Output equivalent circuit

Pin name	IN/OUT signal	Equivalent circuit
INA1 INA2 PHASEA INB1 INB2 PHASEB STANDBY	Digital input (VIH/VIL) VIH: 2.0 V (Min) to 5.5 V (Max) VIL: 0 V (Min) to 0.8 V (Max)	
VCC VREFA VREFB	VCC voltage range 4.75 V (Min) to 5.0 V (Typ.) to 5.25 V (Max) VREF voltage range 0 V to 3.6 V	
OSCM	OSCM frequency setting range 0.64 MHz (Min) to 1.12 MHz (Typ.) to 2.4 MHz (Max)	
OUTA+ OUTA- OUTB+ OUTB- RSA RSB	VM power supply voltage range 10 V (Min) to 47 V (Max) OUT pin voltage 10 V (Min) to 47 V (Max)	

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

6. Functional Description (Stepping motor)

Motor output current (Iout): The flow from OUT+ to OUT- is plus current. The flow from OUT- to OUT+ is minus current.

6.1. Step resolution select function

Table 6.1 Full step resolution

Ach				Bch			
Input			Output	Input			Output
PHASEA	INA1	INA2	Iout(A)	PHASEB	INB1	INB2	Iout(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 %

Note: Please set INA1, INA2, INB1, and INB2 to Low until VM power supply reaches the proper operating range.

Table 6.2 Half step resolution

Ach				Bch			
Input			Output	Input			Output
PHASEA	INA1	INA2	Iout(A)	PHASEB	INB1	INB2	Iout(B)
H	H	H	+100 %	H	H	H	+100 %
-	L	L	0 %	H	H	H	+100 %
L	H	H	-100 %	H	H	H	+100 %
L	H	H	-100 %	-	L	L	0 %
L	H	H	-100 %	L	H	H	-100 %
-	L	L	0 %	L	H	H	-100 %
H	H	H	+100 %	L	H	H	-100 %
H	H	H	+100 %	-	L	L	0 %

-: Don't care

Table 6.3 Quarter step resolution

Ach				Bch			
Input			Output	Input			Output
PHASEA	INA1	INA2	Iout(A)	PHASEB	INB1	INB2	Iout(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 %

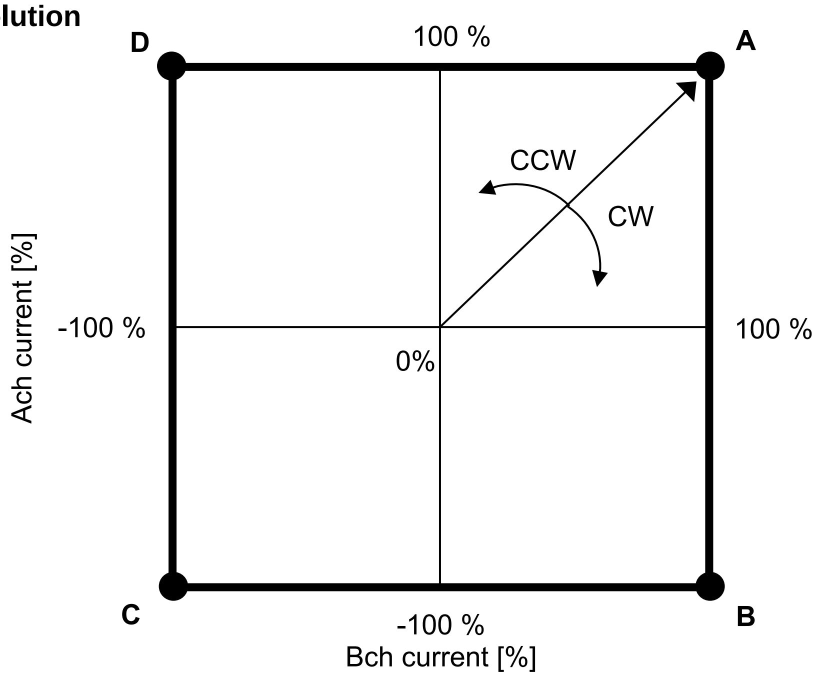
X: Don't care

Table 6.4 Others

Pin Name	H	L	Notes
INA1, INA2 INB1, INB2	The current value of each ch is set up with 2 input 4 value.		Please refer to the above-mentioned current value setting table.
PHASEA PHASEB	OUT+: H OUT-: L	OUT+: L OUT-: H	In PHASE=H, Charge current flows in the direction of OUT- from OUT+.
STANDBY	Standby release	Standby mode	In STANDBY= L, an internal oscillating circuit and a motor output part are stopped. (The drive of a motor cannot be performed.)

6.2. Current phasor

6.2.1. Full step resolution



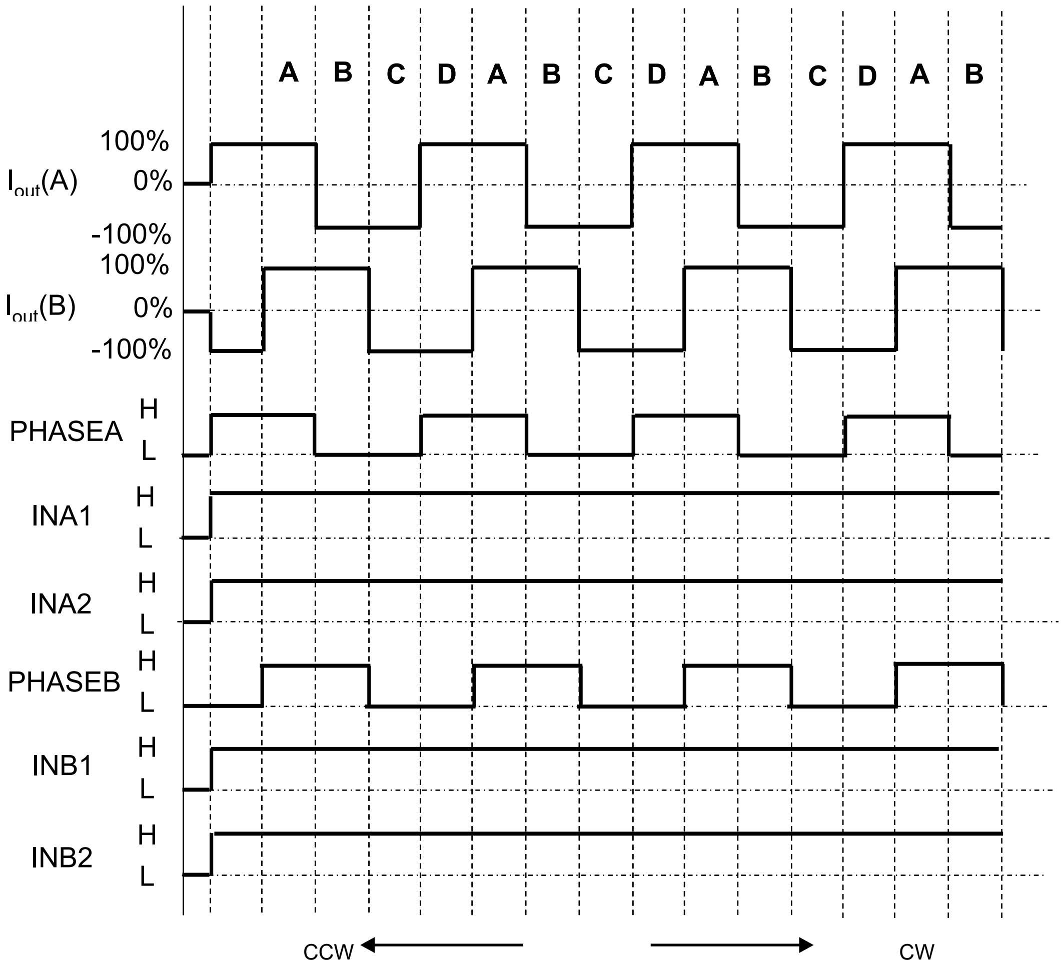


Figure 6.1 Full step resolution

Note: Timing charts may be simplified for explanatory purpose.
Please set INA1, INA2, INB1, and INB2 to Low until VM power supply reaches the proper operating range.

6.2.2. Half step resolution

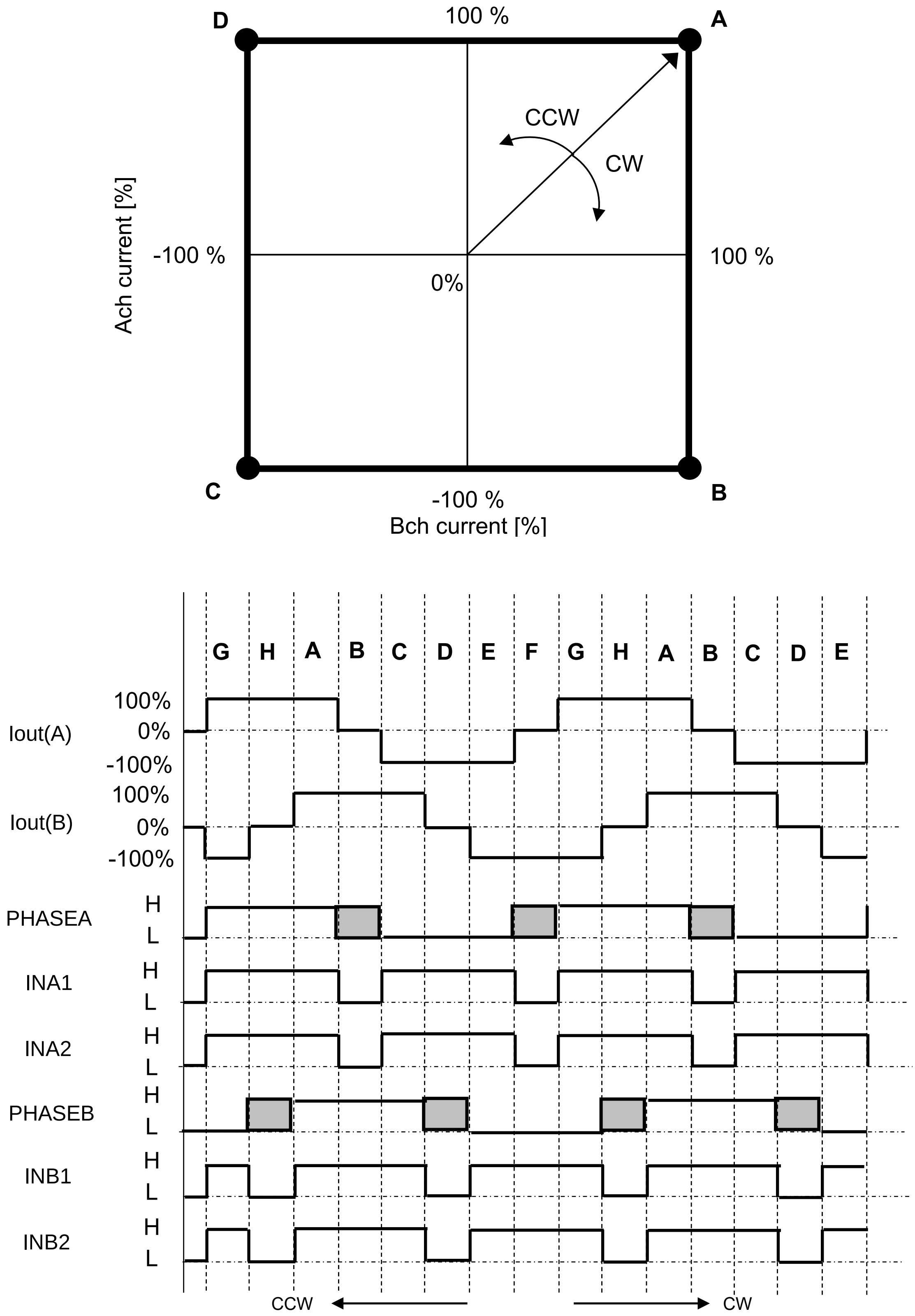


Figure 6.2 Half step resolution

Note: Timing charts may be simplified for explanatory purpose.
Please set INA1, INA2, INB1, and INB2 to Low until VM power supply reaches the proper operating range.

6.2.3. Quarter step resolution

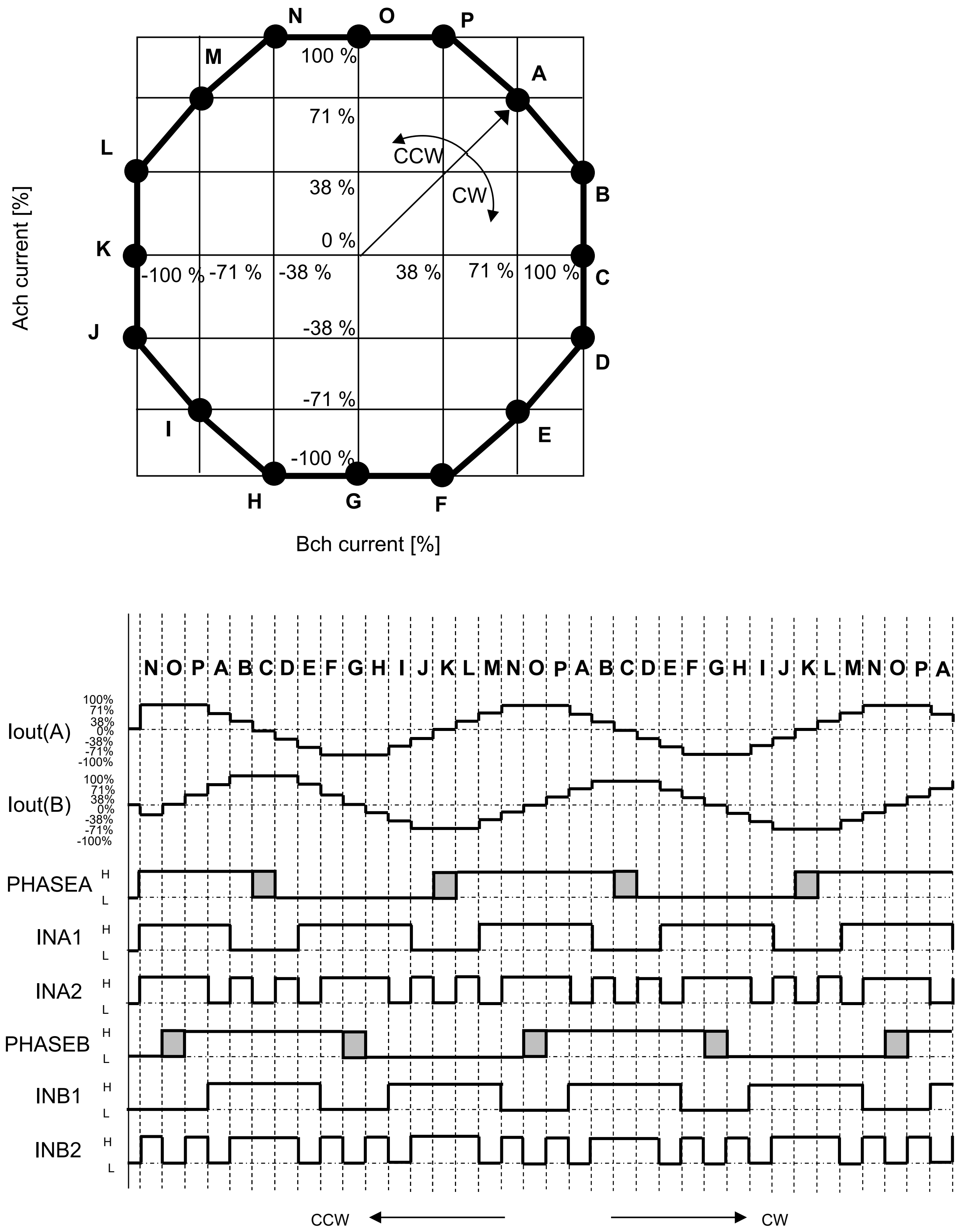


Figure 6.3 Quarter step resolution

Note: Timing charts may be simplified for explanatory purpose.
Please set INA1, INA2, INB1, and INB2 to Low until VM power supply reaches the proper operating range.

6.3. Decay function

6.3.1. ADMD(Advanced Dynamic Mixed Decay) constant current control

The Advanced Dynamic Mixed Decay threshold, which determines the current ripple level during current feedback control, is a unique value.

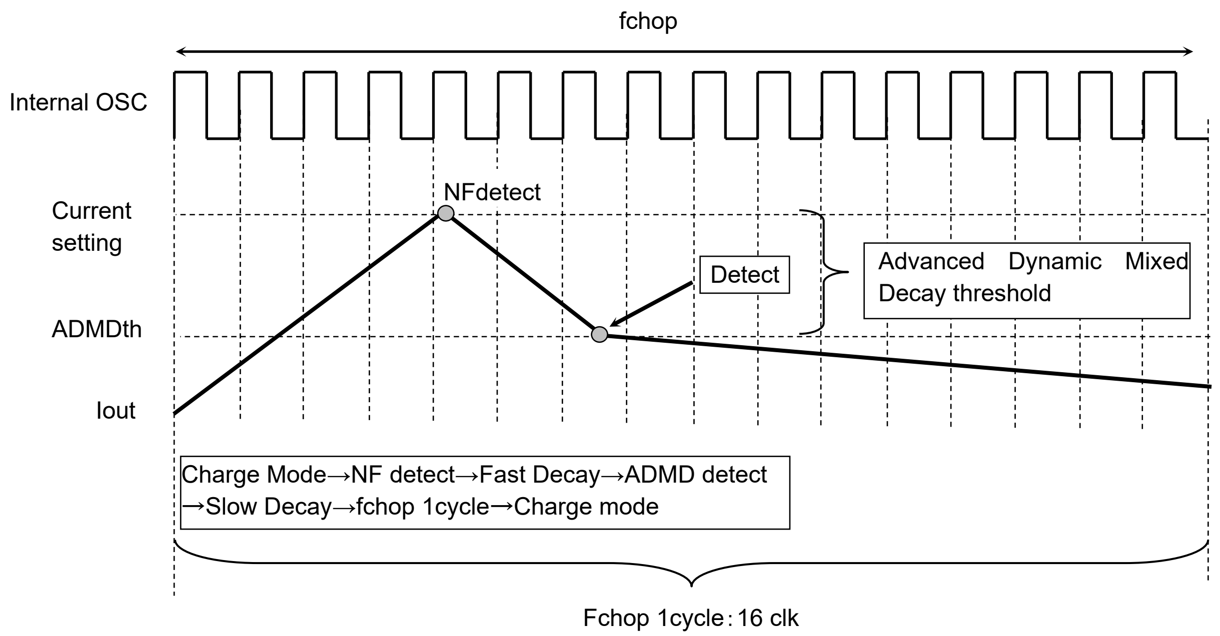


Figure 6.4 ADMD constant current control

Auto Decay Mode current waveform

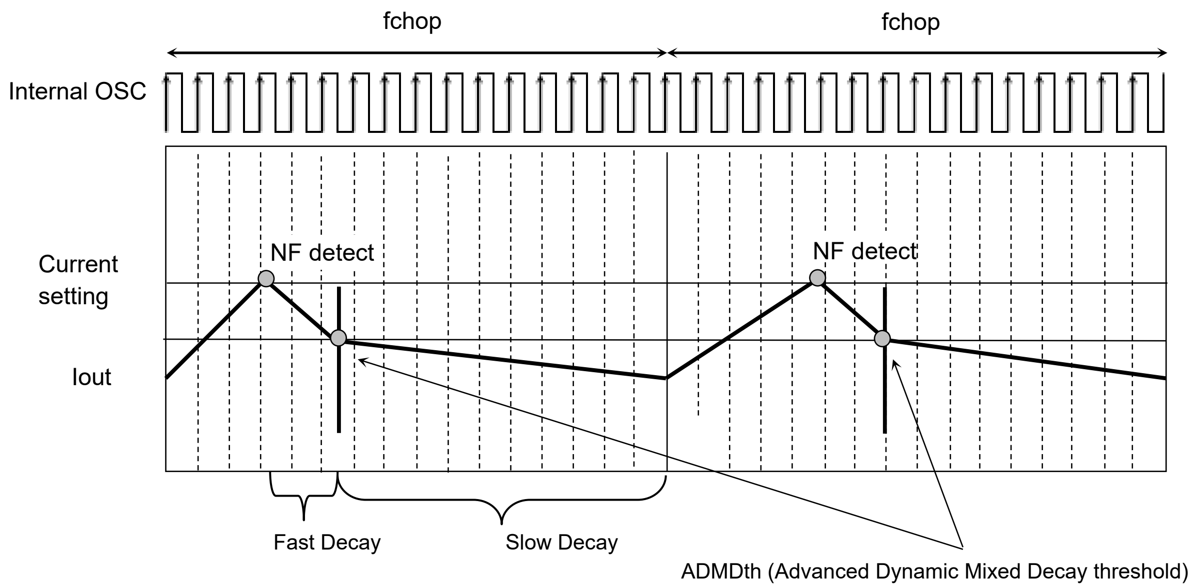


Figure 6.5 Auto Decay Mode current waveform

Note: Timing charts may be simplified for explanatory purpose.

6.3.2. ADMD current waveform

6.3.2.1. When the next current step is higher:

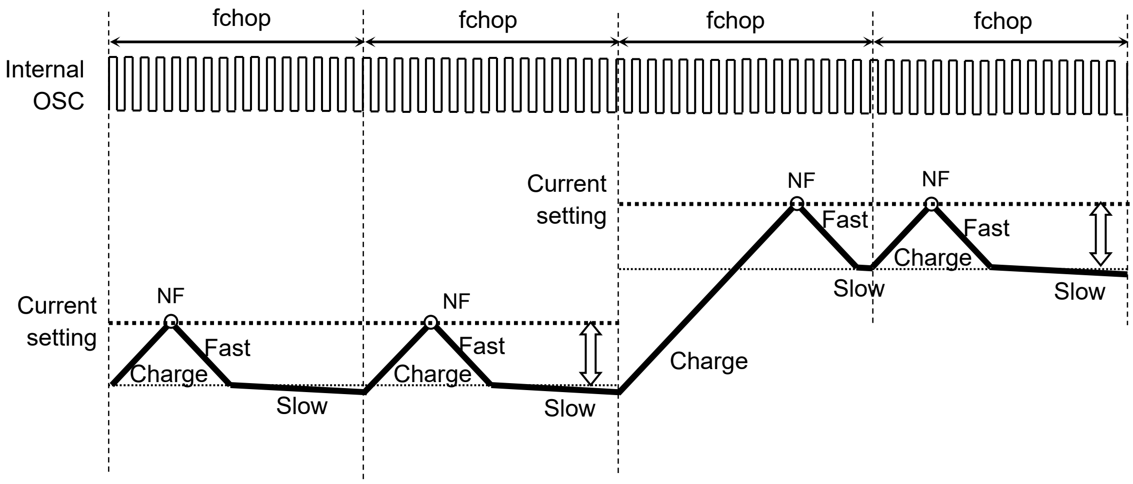


Figure 6.6 When the next current step is higher

6.3.2.2. When Charge period is more than 1 fchop cycle:

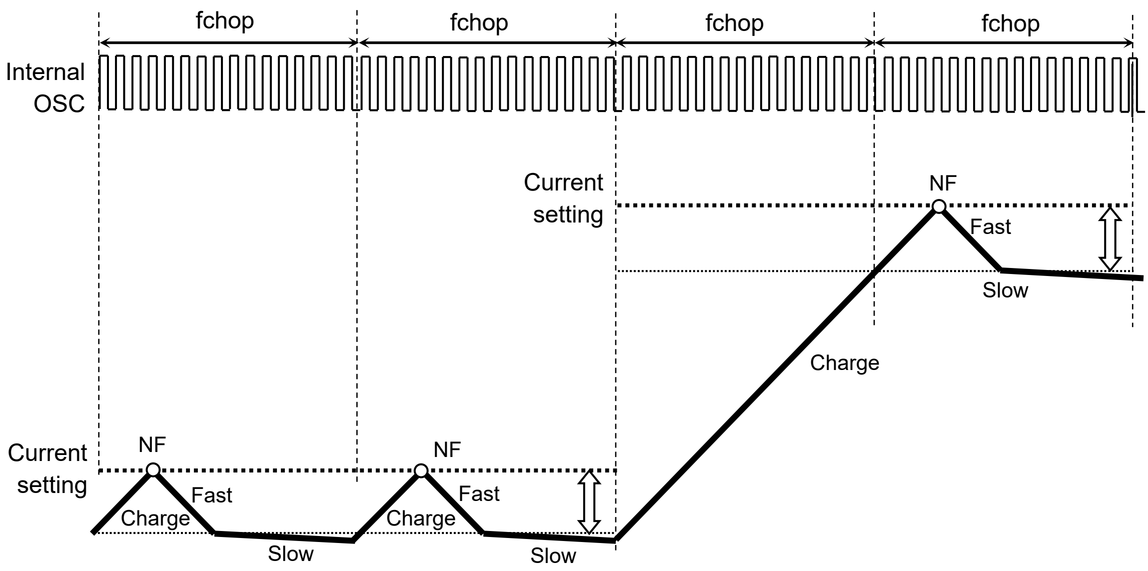


Figure 6.7 When Charge period is more than 1 fchop cycle

Note: When the Charge period is longer than fchop cycle, the Charge period will be extended until the motor current reaches the NF threshold. Once the current reaches the next current step, then the sequence will go on to decay mode.

6.3.2.3. When the next current step is lower:

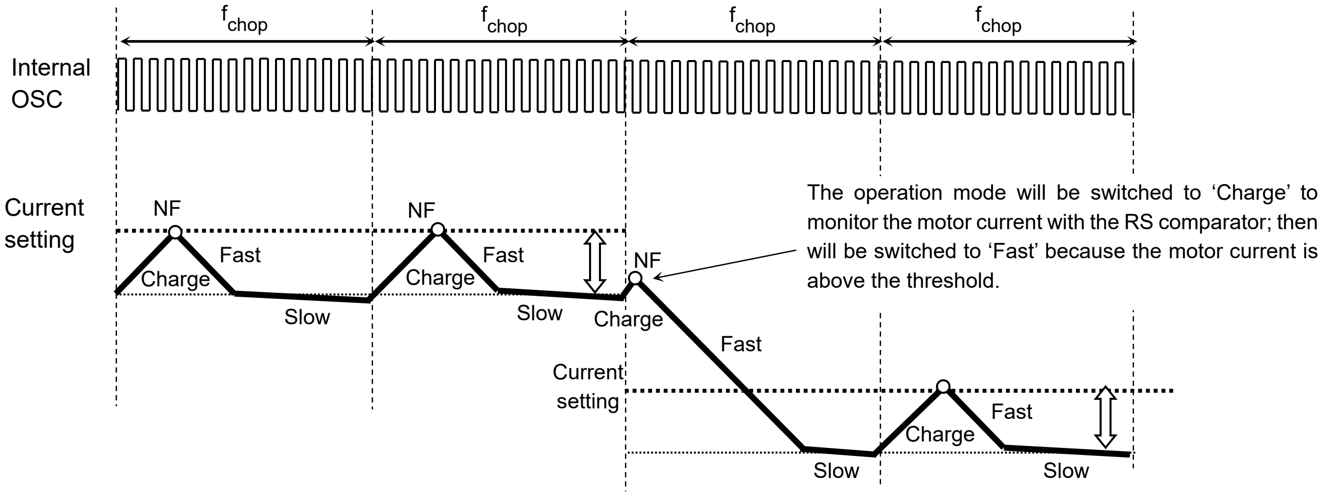


Figure 6.8 When the next current step is lower

6.3.2.4. When the Fast continues past 1 fchop cycle (the motor current not reaching the ADMD threshold during 1 fchop cycle)

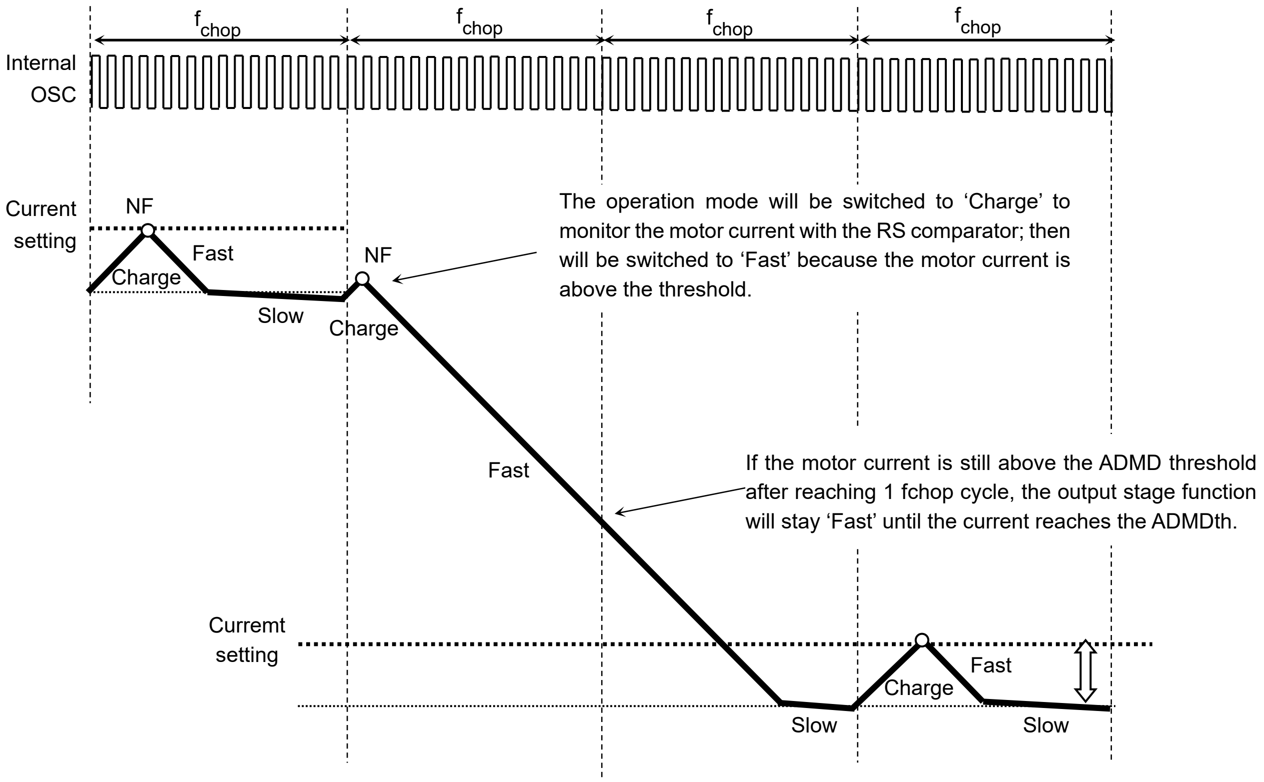


Figure 6.9 When the Fast continues past 1 fchop cycle

6.4. Output Transistor Operation Mode

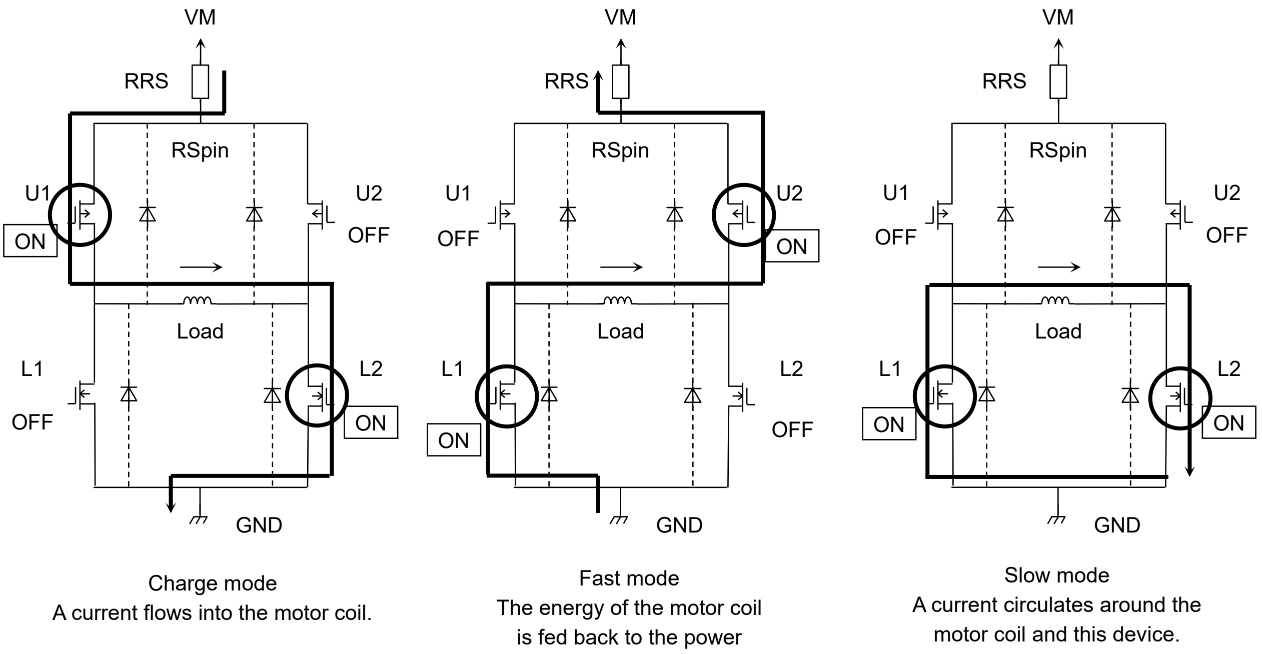


Figure 6.10 Output transistor function mode

Output transistor function

Table 6.5 Output MOSFET function

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

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

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

This IC controls the motor current to be constant by 3 modes listed above.

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

6.5. Calculation of the Predefined Output Current

For PWM constant-current control, this IC uses a clock generated by the OSCM oscillator.
The peak output current (Setting current value) can be set via the current-sensing resistor (RS) and the reference voltage (Vref), as follows:

$$\text{Iout(Max)} = \text{Vref(gain)} \times \frac{\text{Vref (V)}}{\text{RRS}}$$

Vref(gain): the Vref decay rate is 1 / 5.0 (Typ.)

For example: In the case of a 100 % setup
when Vref = 3.0 V, Torque = 100 %, RRS = 0.51 Ω, the motor constant current (Setting current value) will be calculated as:

Iout = 3.0 V / 5.0 / 0.51 Ω = 1.18 A

6.6. Calculation of the OSCM oscillation frequency (chopper reference frequency)

An approximation of the OSCM oscillation frequency (fOSCM) and chopper frequency (fchop) can be calculated by the following expressions.

fOSCM = 1/[0.56 x {Cx(R1 + 500)}]
………C, R1: External components for OSCM (C = 270 pF , R1 = 5.1 kΩ => fOSCM = About 1.12 MHz (Typ.))

fchop = fOSCM / 16
………fOSCM = 1.12 MHz => fchop = Arround 70 kHz

If chopping frequency is raised, Ripple of current will become small and wave-like reproducibility will improve. However, the gate loss inside IC goes up and generation of heat becomes large.

By lowering chopping frequency, reduction in generation of heat is expectable. However, Ripple of current may become large. It is a standard about about 70 kHz. A setup in the range of 50 to 100 kHz is recommended.

7. Absolute maximum ratings

Table 7.1 Absolute Maximum Ratings (T_a = 25 °C)

Characteristics		Symbol	Rating	Unit	Remarks
Motor power supply		VM	50	V	-
Motor output voltage		Vout	50	V	-
Motor output current		Iout	4.0	A	-
Internal Logic power supply		VCC	6.0	V	When externally applied.
Logic input voltage		VIN(H)	6.0	V	-
		VIN(L)	-0.4	V	-
Vref input voltage		Vref	5.0	V	-
Power dissipation	Device alone	PD	1.78	W	(Note1)
	When mounted on a PCB		2.5	W	(Note2)
Operating temperature		Topr	-20 to 85	°C	-
Storage temperature		Tstg	-55 to 150	°C	-
Junction temperature		Tj(Max)	150	°C	-

Note 1: Device alone. (Ta =25 °C)
If the ambient temperature is above 25 °C, the power dissipation must be de-rated by 14.2 mW/°C.
Note 2: When mounted on a specially designed PCB (4-layer, Mount condition ;Rth(j-a)=50 °C/W, Ta =25 °C)
If the ambient temperature is above 25 °C, the power dissipation must be de-rated by 20 mW/°C.

Ta: Ambient temperature
Topr: Ambient temperature while the IC is active
Tj: Junction temperature while the IC 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, Tj (MAX), will not exceed 120 °C.

Caution: Absolute maximum ratings

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 TB67S101ANG does not have overvoltage detection circuit. 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.

(For reference) PD-Ta graph

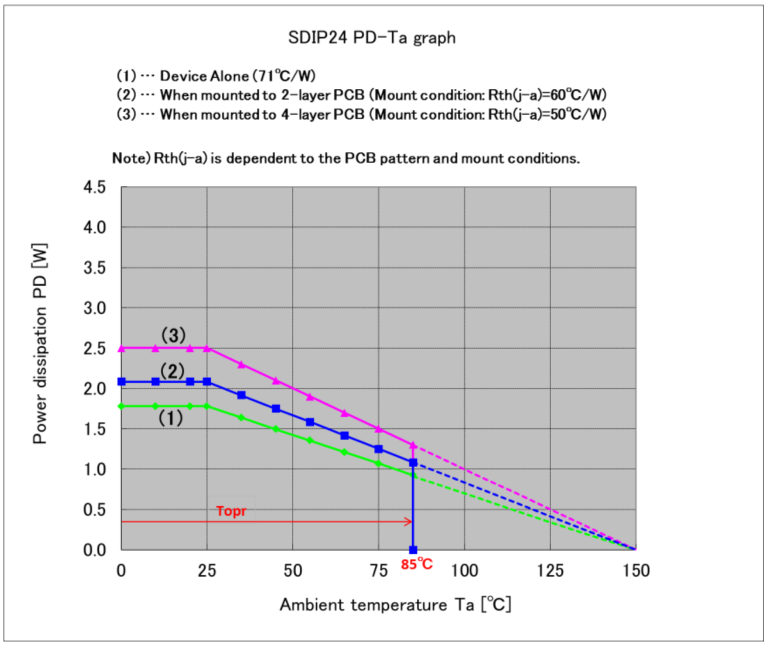


Figure7 (For reference) PD-Ta graph

Note: The power dissipation depends on the PCB layout and mounting conditions so please becareful.
Also, when the ambient temperature is high, the allowed power disspation will be smaller.

8. Operation Ranges

Table 8.1 Operation Ranges (Ta = -20 to 85 °C)

Characteristics	Symbol	Min	Typ.	Max	Unit	Remarks
Motor power supply	VM	10	24	47	V	
Motor output current	Iout	-	1.0	-	A	(Note1)
Logic input voltage	VIN(H)	2.0	-	5.5	V	Logic input High Level
	VIN(L)	0	-	0.8	V	Logic input Low Level
Phase input frequency	fPHASE	-	-	400	kHz	
Chopper frequency	fchop(range)	40	70	150	kHz	
Vref input voltage	Vref	GND	2.0	3.6	V	

Note1: Maximum current for actual usage may be limited by the operating circumstances such as operating conditions (exciting mode, operating time, and so on), ambient temperature, and heat conditions (board condition and so on).

9. Electrical Specifications

Table 9.1 Electrical Specifications 1 (Ta = 25 °C, VM = 24 V, unless specified otherwise)

Characteristics		Symbol	Test condition	Min	Typ.	Max	Unit
Logic input voltage	HIGH	VIN(H)	Logic input pin (Note)	2.0	-	5.5	V
	LOW	VIN(L)	Logic input pin (Note)	0	-	0.8	V
Logic input hysteresis voltage		VIN(HYS)	Logic input pin (Note)	100	-	300	mV
Logic input current	HIGH	IIN(H)	Logic input voltage = 3.3 V	-	33	-	μA
	LOW	IIN(L)	Logic input voltage = 0 V	-	-	1	μA
Power consumption		IM1	Output pins = open, STANDBY = L	-	2	3.5	mA
		IM2	Output pins = open, STANDBY = H	-	3.5	5.5	mA
		IM3	Output pins=open Full step resolution	-	5.5	7	mA
Output leakage current	High-side	IOH	VRS = VM = 50 V, Vout = 0 V	-	-	1	μA
	Low-side	IOL	VRS = VM = Vout = 50 V	1	-	-	μA
Motor current channel differential		ΔIout1	Current differential between Ch	-5	0	5	%
Motor current setting accuracy		ΔIout2	Iout = 1.5 A	-5	0	5	%
RS pin current		IRS	VRS = VM = 24 V	0	-	10	μA
Motor output ON-resistance (High-side + Low-side)		Ron(S)_PN	Tj = 25 °C, Forward direction (High-side + Low-side)	—	0.49	0.6	Ω

Note: VIN(H) is defined as the VIN voltage that causes the outputs (OUTA,OUTB) to change when a pin under test is gradually raised from 0 V. VIN(L) is defined as the VIN voltage that causes the outputs (OUTA, OUTB) to change when the pin is then gradually lowered. The difference between VIN(H) and VIN(L) is defined as the input hysteresis.

When the logic signal is applied to the device whilst the VM power supply is not asserted; the device is designed not to function, but for safe usage, please apply the logic signal after the VM power supply is asserted and the VM voltage reaches the proper operating range.

Table 9.2 Electrical Specifications 2 (Ta = 25°C, VM = 24 V, unless specified otherwise)

Characteristics	Symbol	Test condition	Min	Typ.	Max	Unit
Vref input current	Iref	Vref = 2.0 V	-	0	1	μA
VCC voltage	VCC	ICC = 5.0 mA	4.75	5.0	5.25	V
VCC current	ICC	VCC = 5.0 V	-	2.5	5	mA
Vref gain rate	Vref(gain)	Vref = 2.0 V	1/5.2	1/5.0	1/4.8	—
Thermal shutdown(TSD) threshold (Note1)	T_jTSD	—	145	160	175	°C
VM recovery voltage	VMR	—	7.0	8.0	9.0	V
Over-current detection (ISD) threshold (Note2)	ISD	—	4.1	4.9	5.7	A

Note1: About TSD
When the junction temperature of the device reached the TSD threshold, the TSD circuit is triggered; the internal reset circuit then turns off the output transistors. Noise rejection blanking time is built-in to avoid misdetection. Once the TSD circuit is triggered, the device will be set to standby mode, and can be cleared by reasserting the VM power source, or setting the DMODE pins to standby mode. The TSD circuit is a backup function to detect a thermal error, therefore is not recommended to be used aggressively.

Note2: About ISD
When the output current reaches the threshold, the ISD circuit is triggered; the internal reset circuit then turns off the output transistors. Once the ISD circuit is triggered, the device keeps the output off until power-on reset (POR), is reasserted or the device is set to standby mode by DMODE pins. For fail-safe, please insert a fuse to avoid secondary trouble.

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 due 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 TB67S101A or other components will be damaged or fail due 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 the 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 due to an output short-circuit.
The ISD circuit is only intended to provide a temporary protection against an output short-circuit. If such a condition persists for a long time, the device may be damaged due to overstress. Overcurrent conditions must be removed immediately by external hardware.

IC Mounting

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

Table 9.3 AC Electrical Specification (Ta = 25 °C, VM = 24 V, 6.8 mH/5.7 Ω)

Characteristics	Symbol	Test condition	Min	Typ.	Max	Unit
Minimum PHASE pulse width	fPHASE(Min)	―	100	-	-	ns
	twp	―	50	-	-	
	twn	―	50	-	-	
Output transistor switching specific	tr	―	30	80	130	ns
	tf	―	40	90	140	
	tpLH(PHASE)	PHASE - Output	250	-	1200	
	tpHL(PHASE)	PHASE - Output	250	-	1200	
Analog noise blanking time	AtBLK	VM = 24 V, Iout = 1.5 A Analog tBLK	250	400	550	ns
Oscillator frequency accuracy	⊿fOSCM	COSC = 270 pF, ROSC = 5.1 kΩ	-15	-	+15	%
Oscillator reference frequency	fOSCM	COSC = 270 pF, ROSC = 5.1 kΩ	952	1120	1288	kHz
Chopping frequency	fchop	Output: Active(IOUT =1.5 A), fOSCM = 1120 kHz	-	70	-	kHz

AC Electrical Specification Timing chart

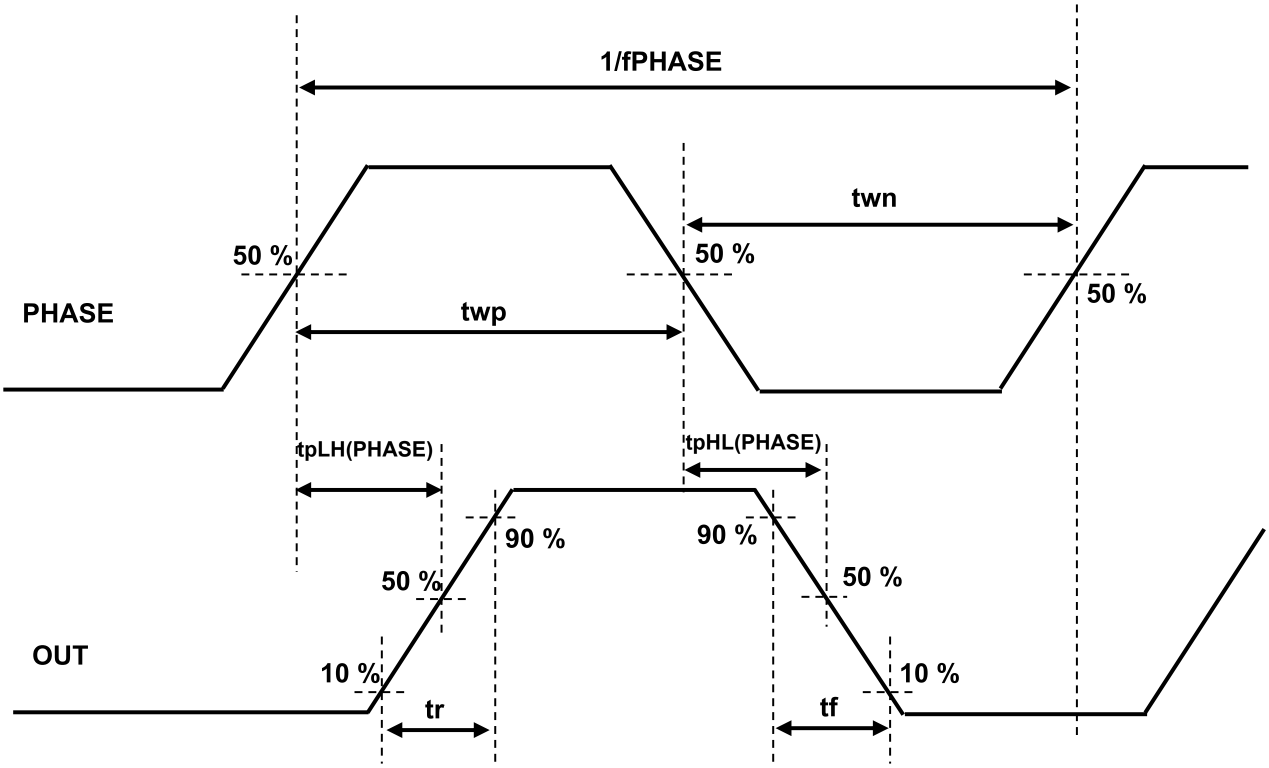


Figure 9.1 AC Timing chart

Note: Timing charts may be simplified for explanatory purpose.

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.

10. IC Usage Considerations

10.1. 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 capacitor, 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.

10.2. Points to remember on handling of ICs

(1) Over-current Protection Circuit

Over-current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over-current protection circuits operate against the over-current, clear the over-current status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over-current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over-current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

(2) 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, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(3) Heat Radiation Design

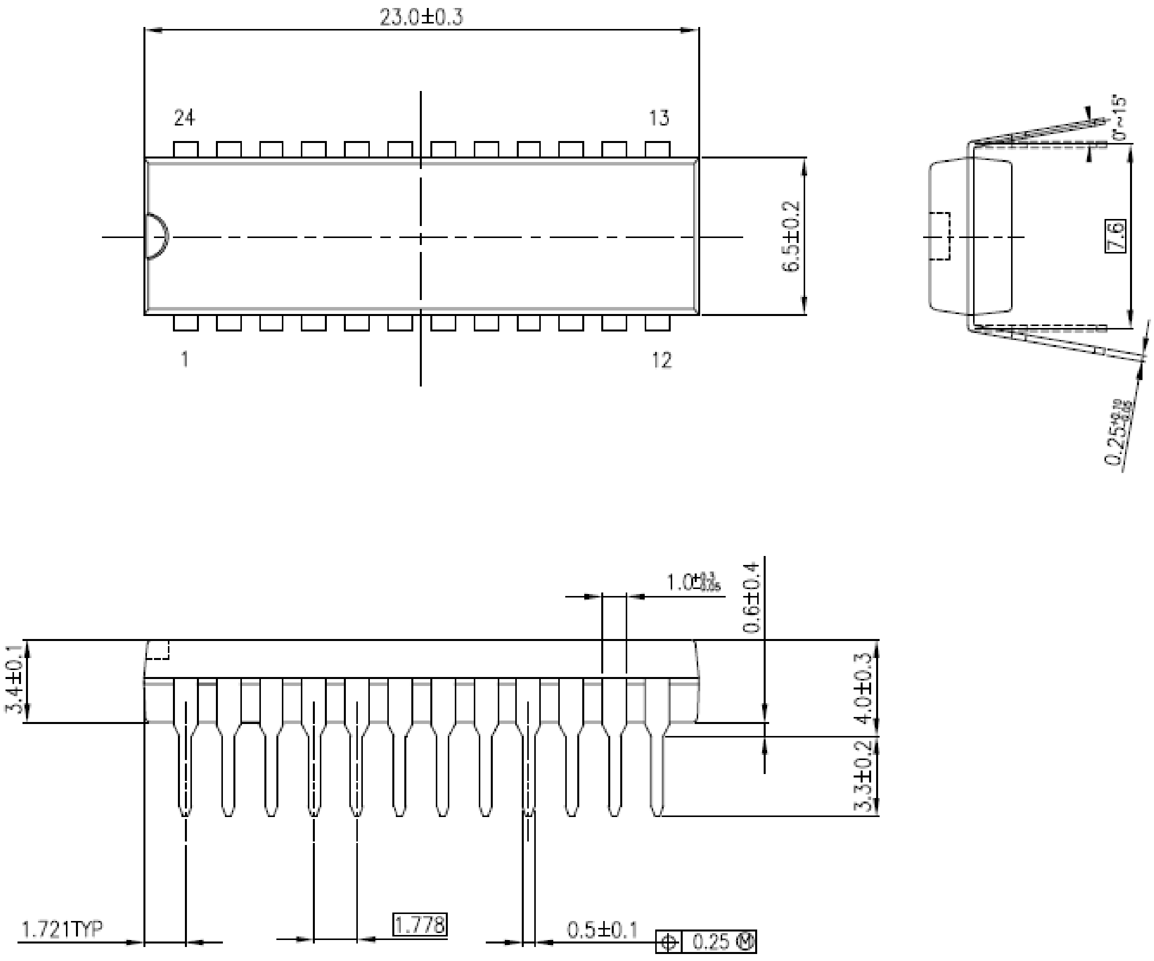
In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (Tj) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

(4) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor’s power supply due 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 absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

11. Package Dimensions

P-SDIP24-0723-1.78-001 **(unit: mm)**



Weight: 1.3 g (Typ.)

RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”.
Hardware, software and systems described in this document are collectively referred to as “Product”.

- TOSHIBA reserves the right to make changes to the information in this document and related Product without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**
- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE").** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative or contact us via our website.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**

Toshiba Electronic Devices & Storage Corporation

https://toshiba.semicon-storage.com/