

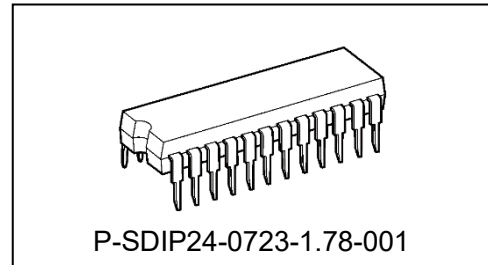
TOSHIBA BiCD Integrated Circuit Silicon Monolithic

# 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.)

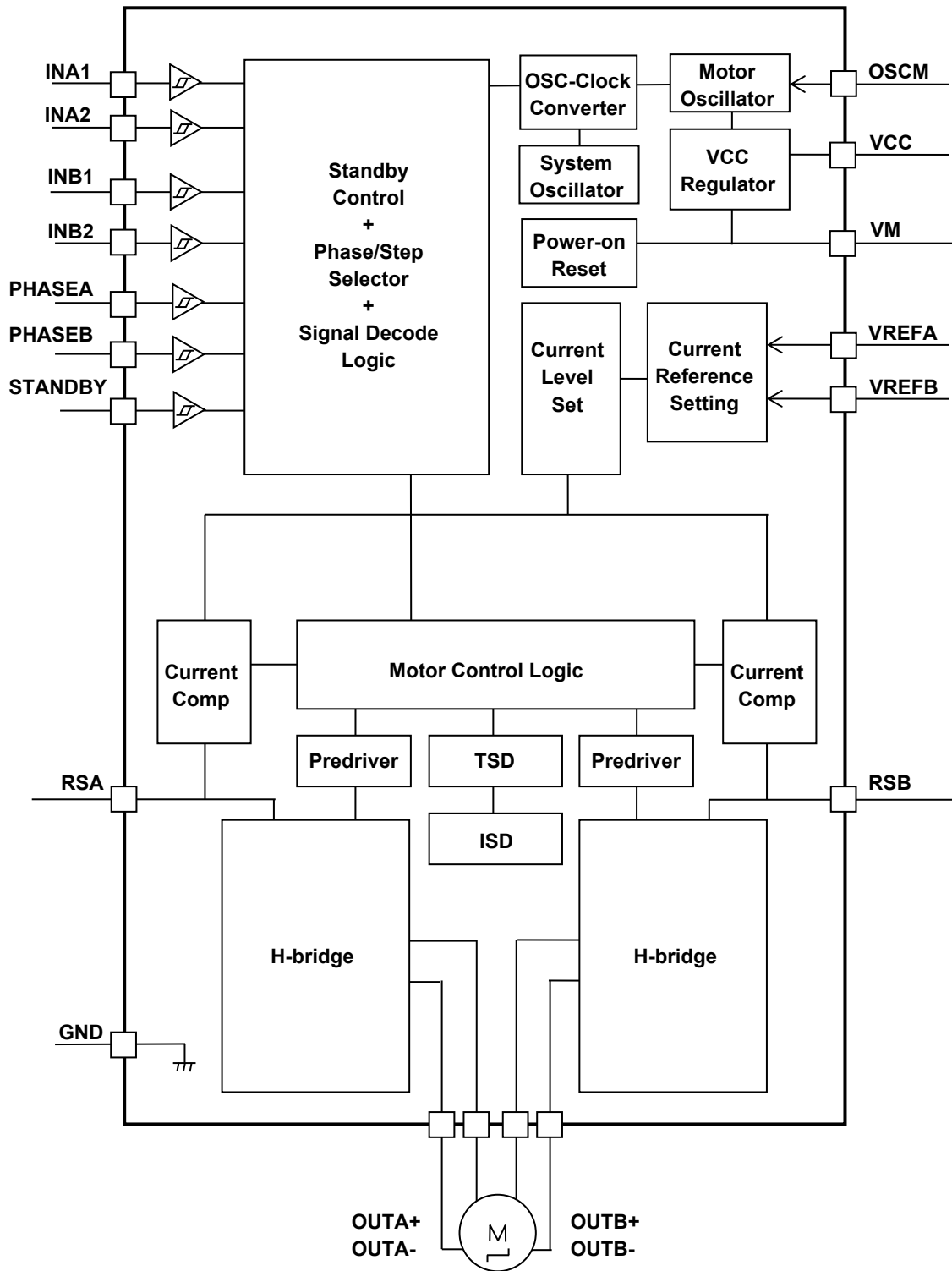
## 2. Features

- BiCD process integrated monolithic IC.
- PWM controlled constant-current drive.
- Allows full, half, quarter step operation.
- Low on-resistance (High + Low side = 0.49  $\Omega$  (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.

Start of commercial production  
2014-10

**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 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.

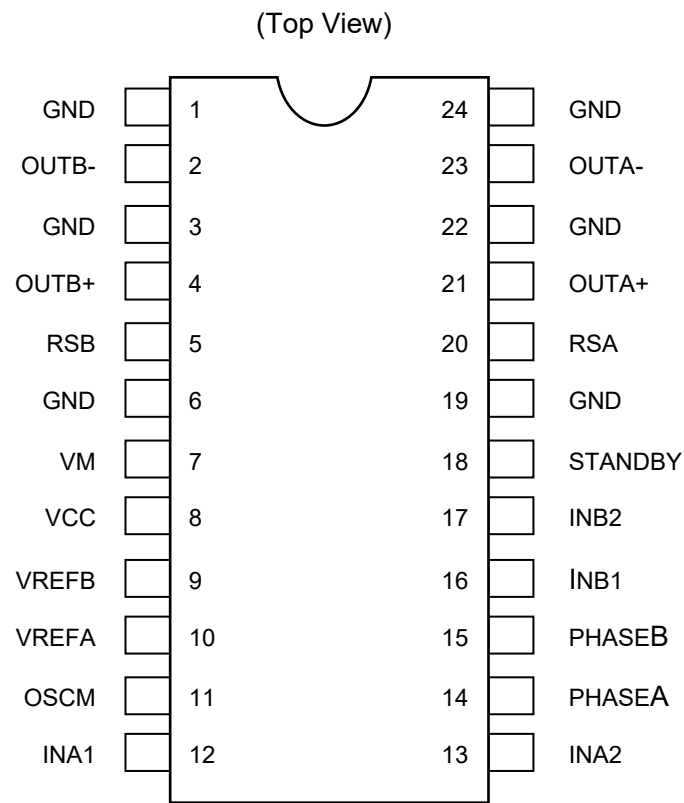
Careful attention should be paid to the layout of the output, VCC(VM) and GND traces, to avoid short circuits across output pins or to the power supply or ground. If such a short circuit occurs, the device may be permanently damaged.

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), 5.0 V (Typ.), 5.25 V (Max)  VREF voltage range 0 V to 3.6 V	
OSCM	OSCM frequency setting range 0.64 MHz (Min), 1.12 MHz (Typ.), 2.4 MHz (Max)	
OUTA+ OUTA- OUTB+ OUTB-	motor output pin  VM power supply voltage range 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 positive current. The flow from OUT- to OUT+ is negative 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 %
-	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 %	-	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 %
-	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 %	-	L	L	0 %
H	H	H	+100 %	H	L	H	+38 %

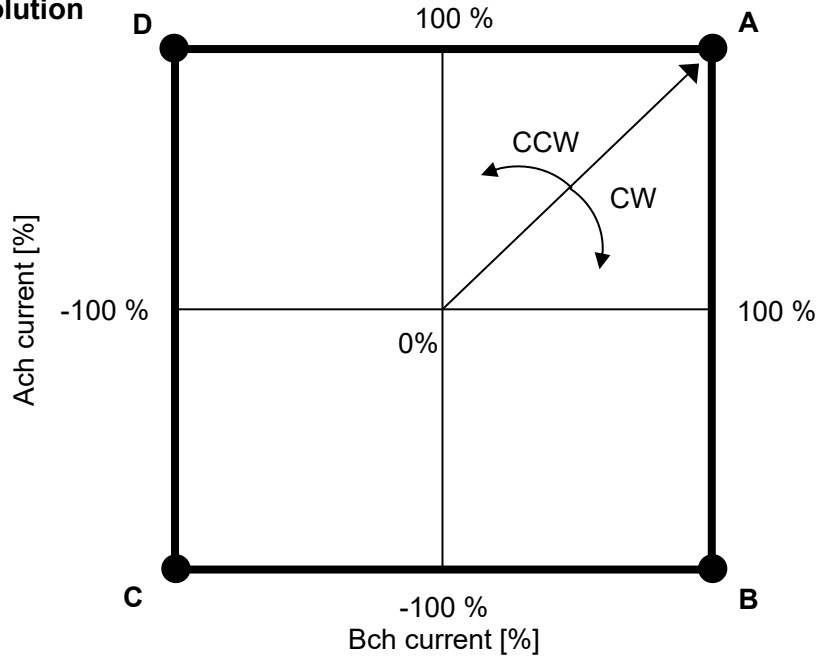
-: Don't care

**Table 6.4 Others**

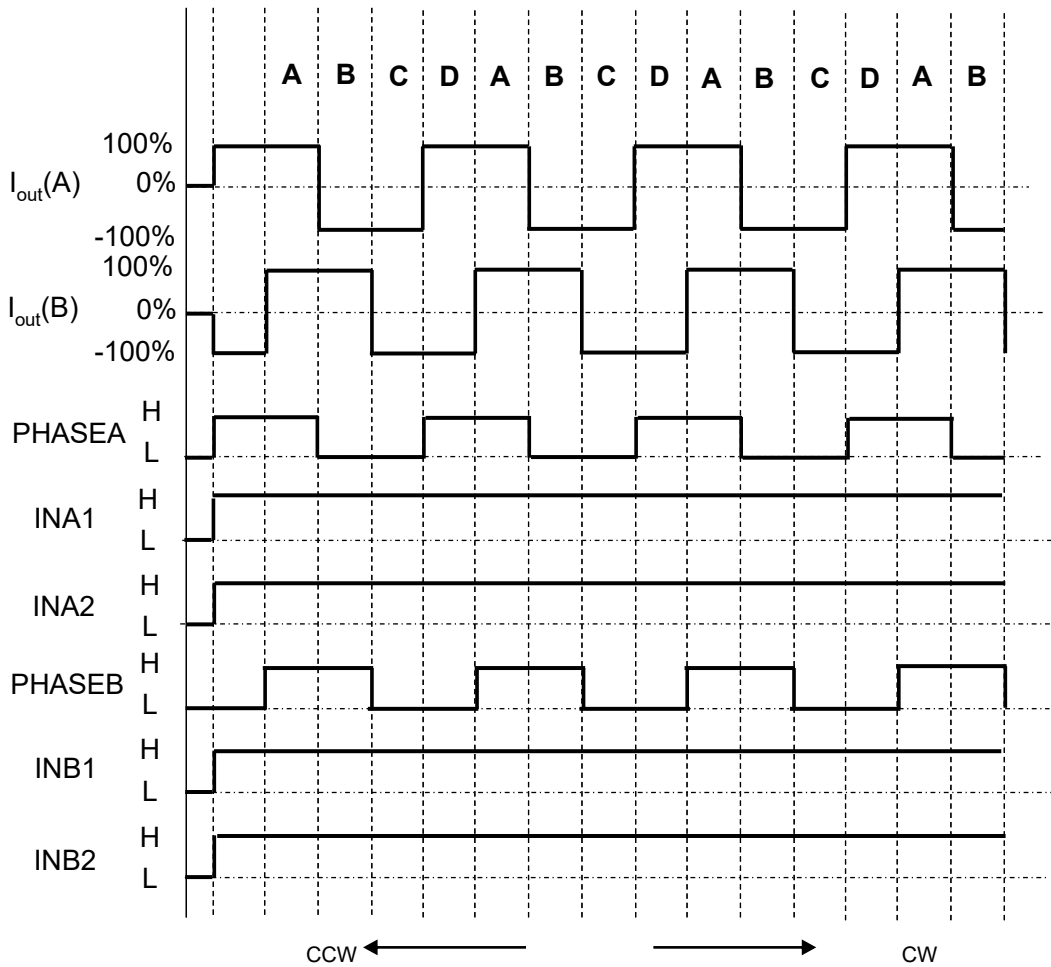
Pin Name	H	L	Notes
INA1, INA2 INB1, INB2	The current value of each ch is set up with 2 input 4 value.		Please refer to the above-mentioned current value setting table.
PHASEA PHASEB	OUT+: H OUT-: L	OUT+: L OUT-: H	When PHASE=H, current flows from OUT+ to OUT- during Charge period.
STANDBY	Standby release	Standby mode	When STANDBY=L, the internal oscillating circuit and the motor output part are stopped.

**6.2. Current phasor**

**6.2.1. Full step resolution**



**Figure 6.1 Current phasor (Full step resolution)**



**Figure 6.2 Timing charts (Full step resolution)**

Note: Timing charts may be simplified for explanatory purpose.

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

6.2.2. Half step resolution

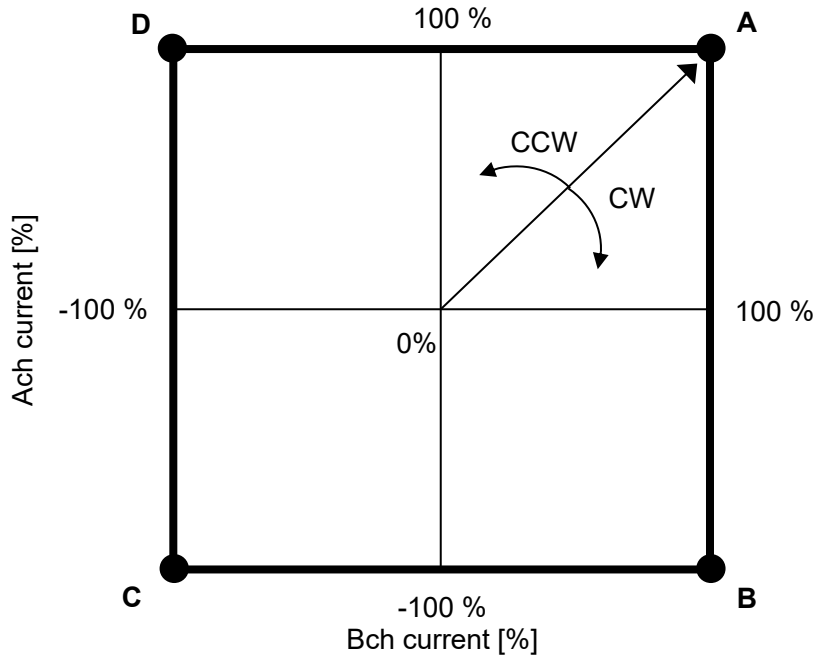


Figure 6.3 Current phasor (Half step resolution)

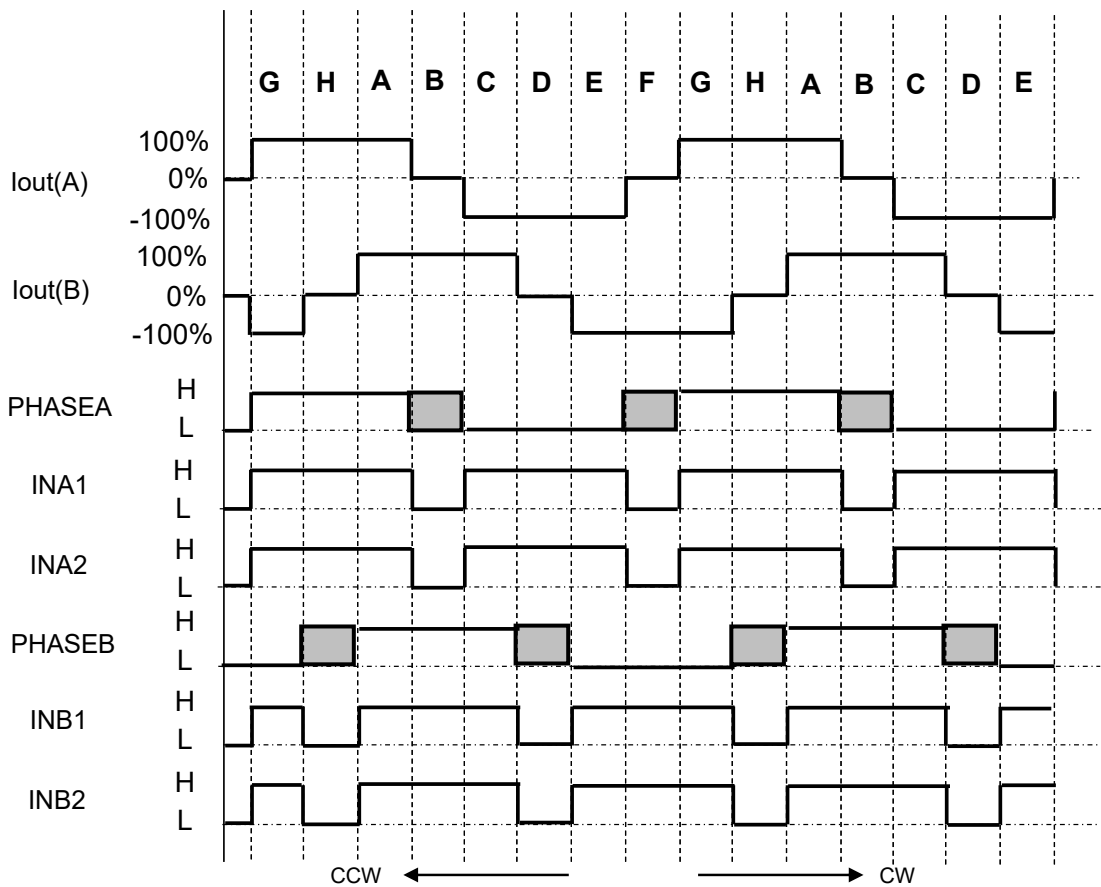


Figure 6.4 Timing charts (Half step resolution)

Note: Timing charts may be simplified for explanatory purpose.

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

6.2.3. Quarter step resolution

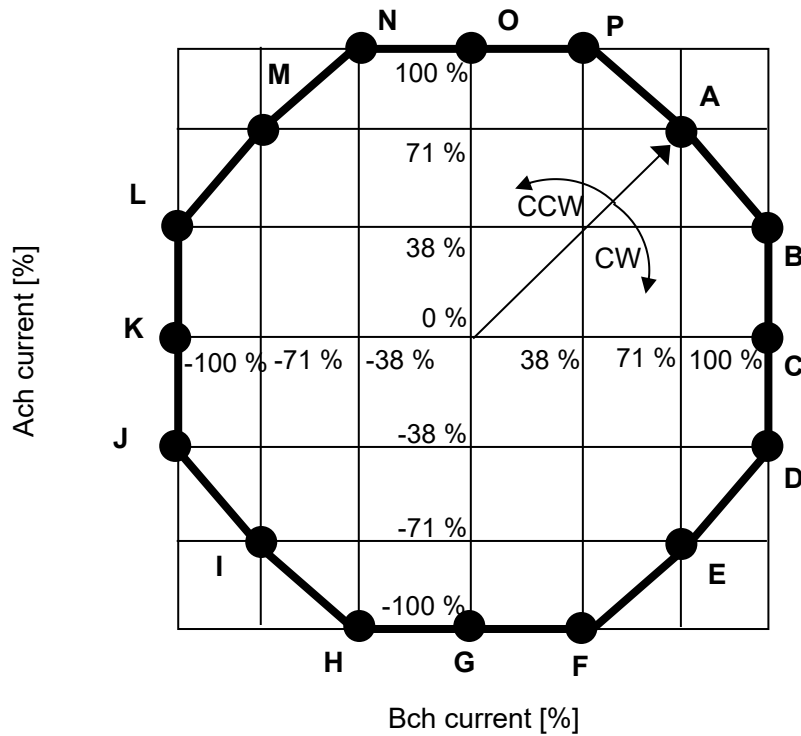


Figure 6.5 Current phasor (Quarter step resolution)

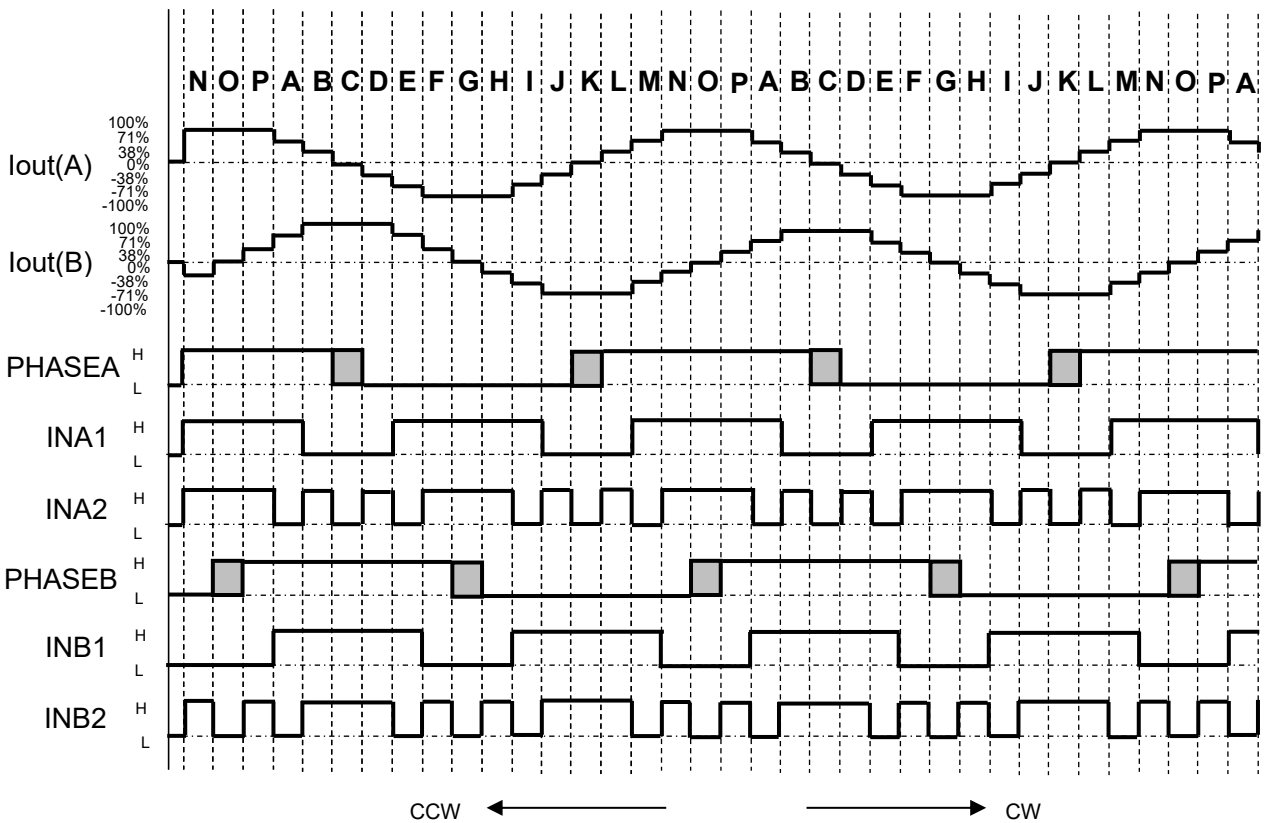


Figure 6.6 Timing charts (Quarter step resolution)

Note: Timing charts may be simplified for explanatory purpose.

Note: 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.

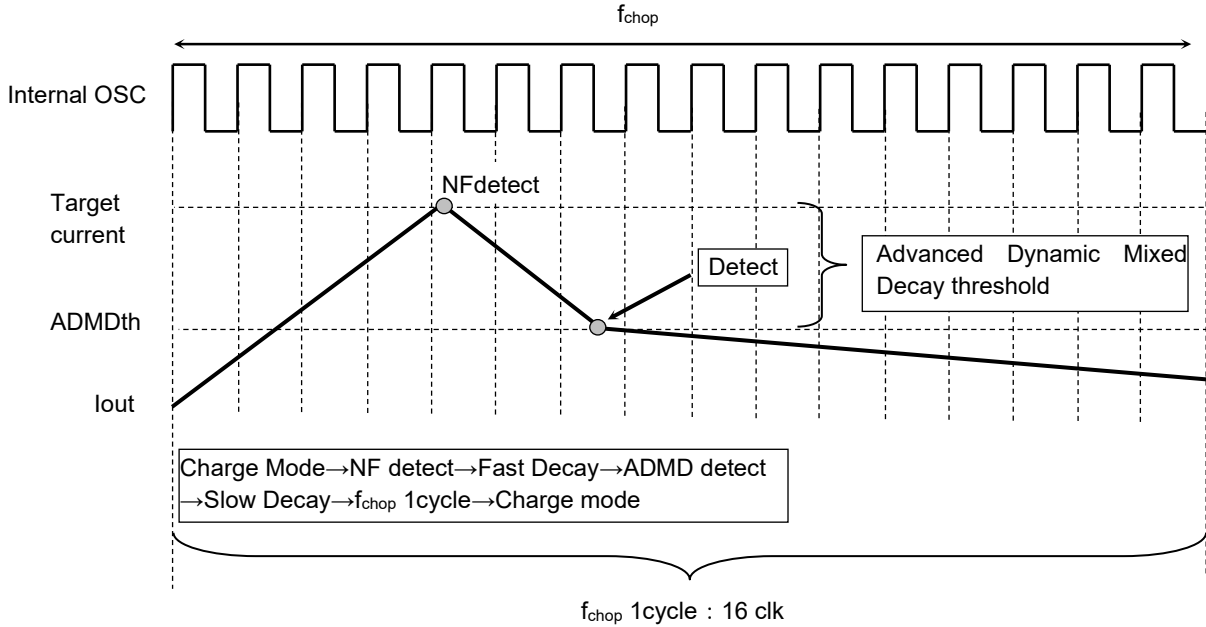


Figure 6.7 ADMD constant current control

6.3.2. Auto Decay Mode current waveform

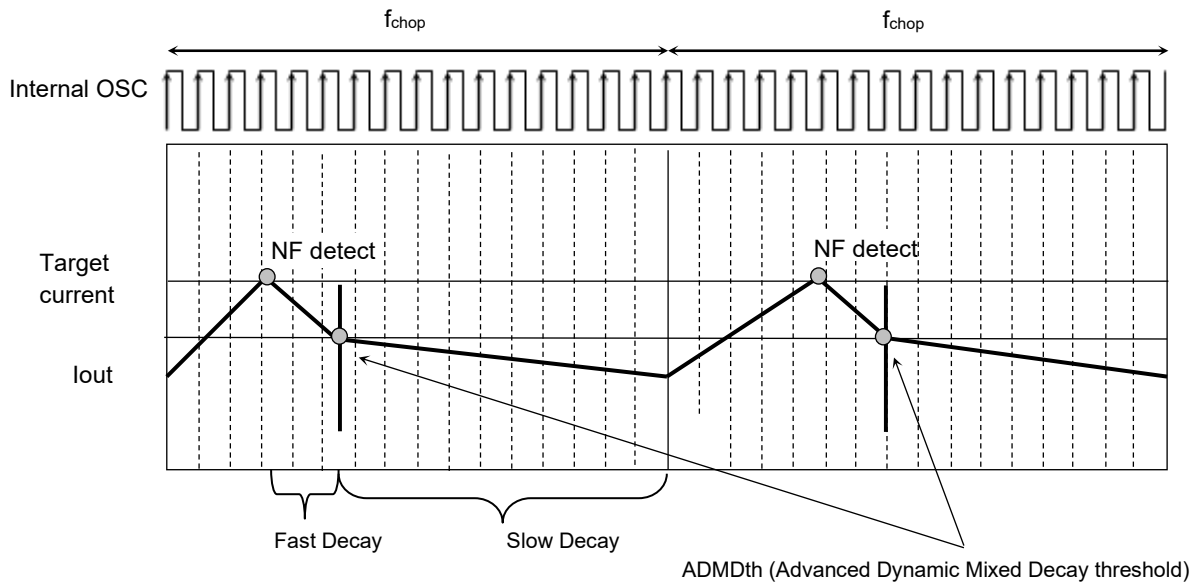
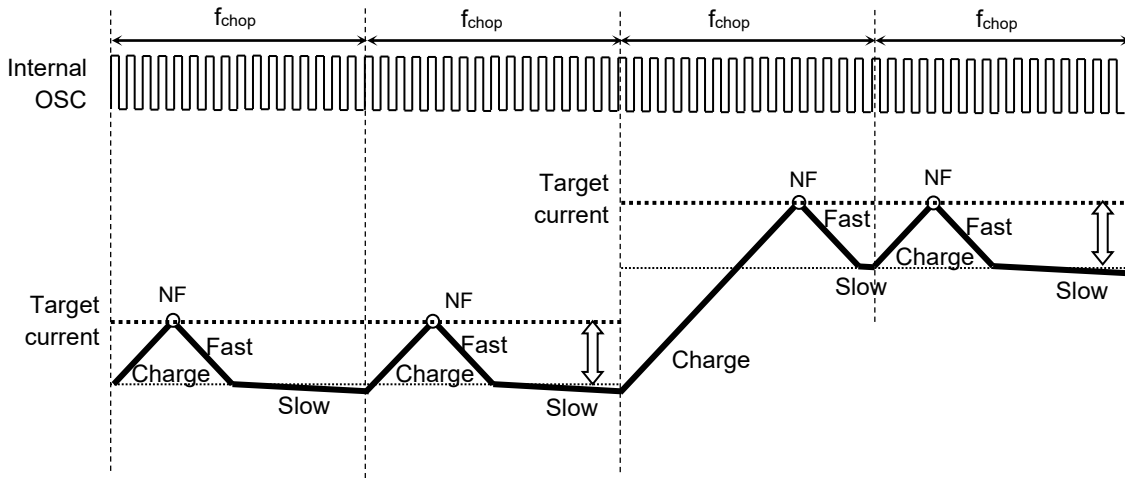


Figure 6.8 Auto Decay Mode current waveform

Note: Timing charts may be simplified for explanatory purpose.

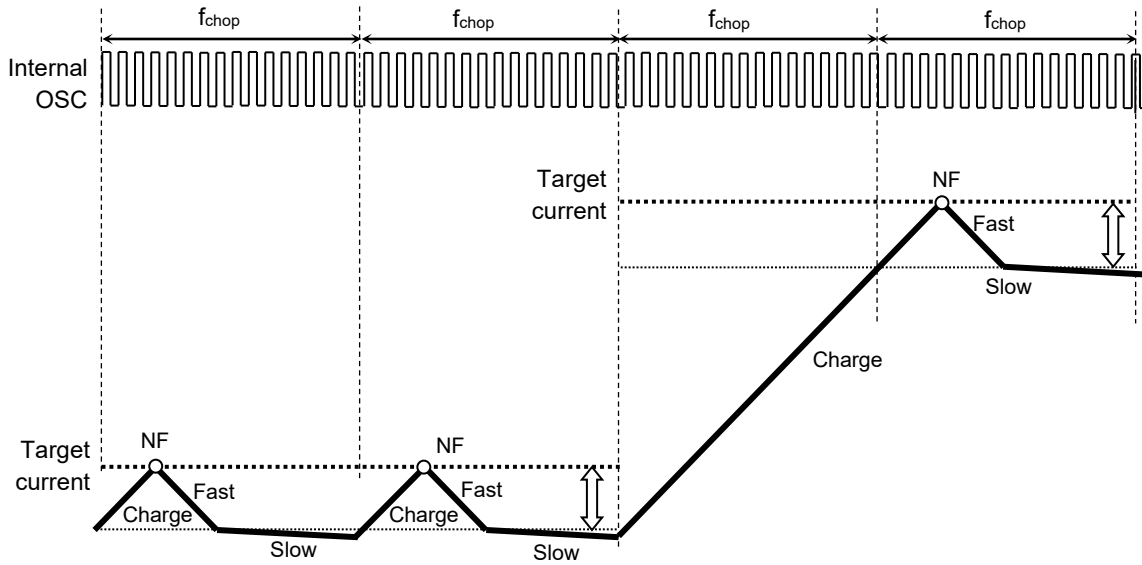
**6.3.3. ADMD current waveform**

**6.3.3.1. When the next current step is higher:**



**Figure 6.9 When the next current step is higher**

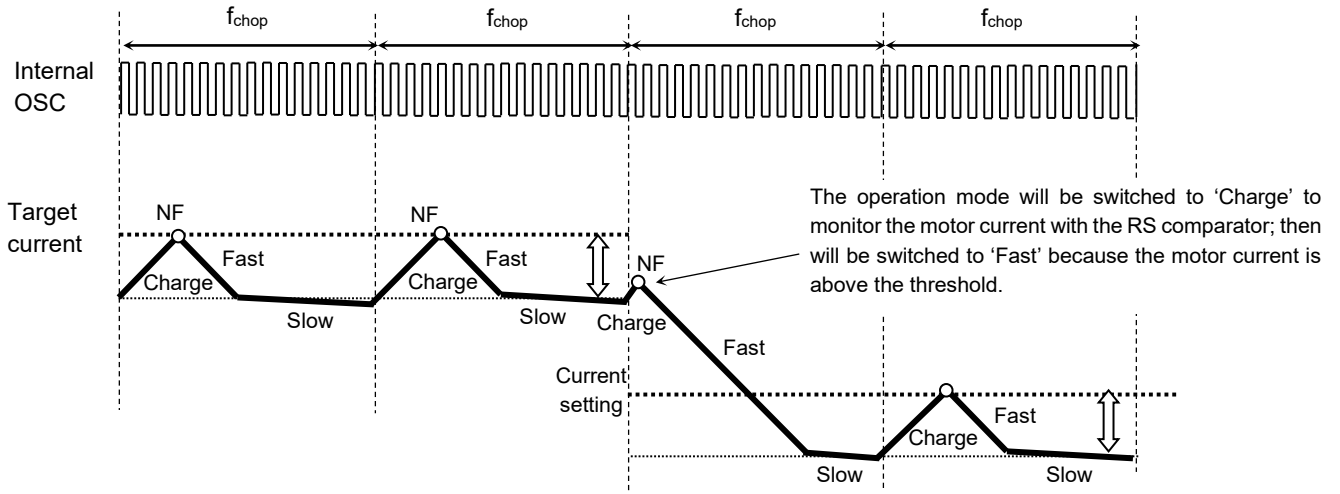
**6.3.3.2. When Charge period is more than 1 f<sub>chop</sub> cycle:**



**Figure 6.10 When Charge period is more than 1 f<sub>chop</sub> cycle**

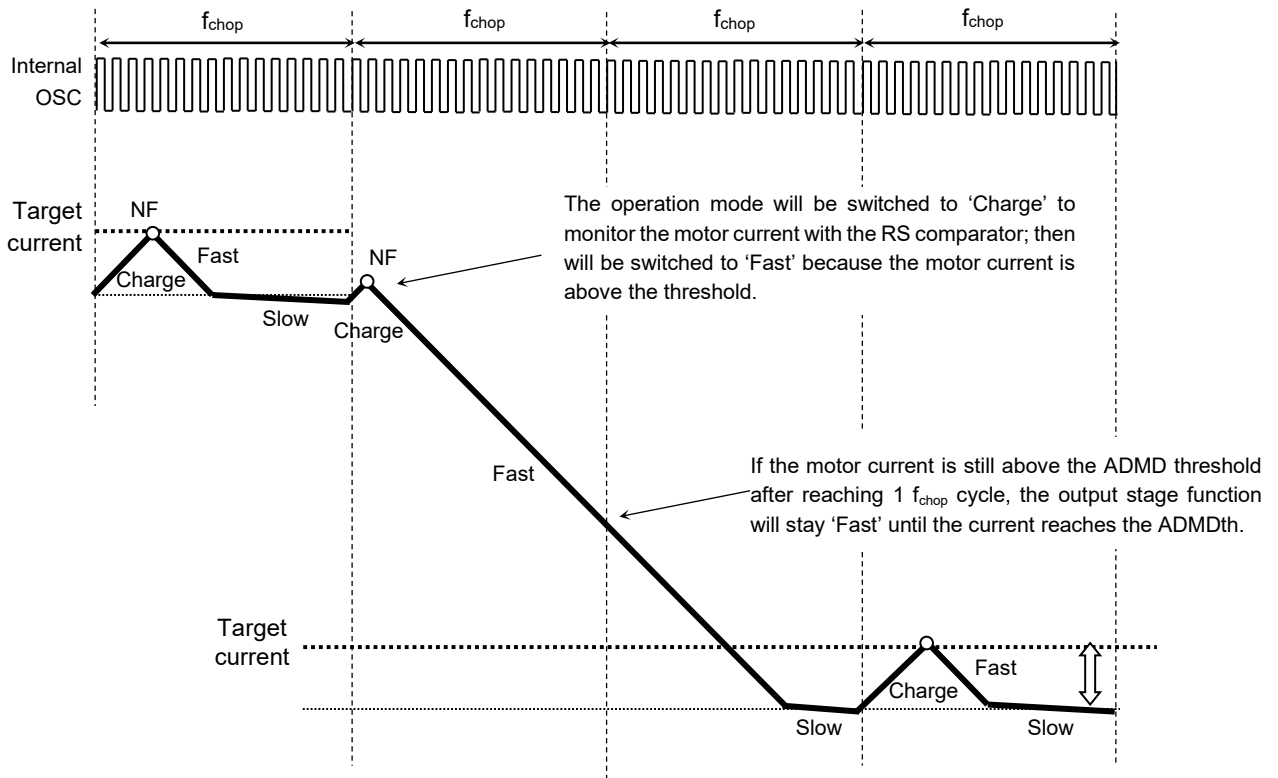
When the Charge period is longer than  $f_{chop}$  cycle, the Charge period will be extended until the motor current reaches the NF threshold. Once the current reaches the next current step, then the sequence will go on to decay mode.

**6.3.3.3. When the next current step is lower:**



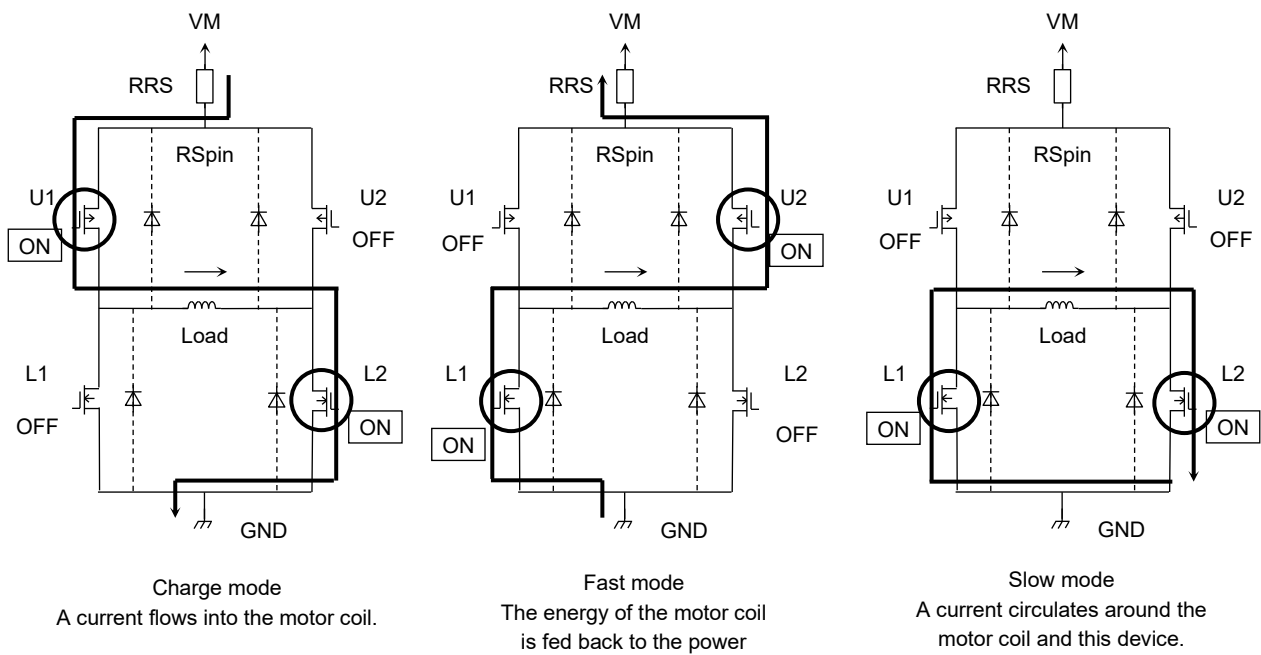
**Figure 6.11 When the next current step is lower**

**6.3.3.4. When the Fast continues past 1  $f_{chop}$  cycle (the motor current not reaching the ADMD threshold during 1  $f_{chop}$  cycle)**



**Figure 6.12 When the Fast continues past 1  $f_{chop}$  cycle**

**6.4. Output Transistor Operation Mode**



**Figure 6.13 Output transistor function mode**

**6.4.1. 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 (V<sub>REF</sub>), as follows:

$$I_{out (Max)} = V_{REF (gain)} \times \frac{V_{REF (V)}}{R_{RS} (\Omega)}$$

V<sub>REF (gain)</sub>: the V<sub>REF</sub> decay rate is 1 / 5.0 (Typ.)

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

$$I_{out} = 3.0 \text{ V} / 5.0 / 0.51 \Omega = 1.18 \text{ A}$$

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

An approximation of the OSCM oscillation frequency (f<sub>OSCM</sub>) and chopper frequency (f<sub>chop</sub>) can be calculated by the following expressions.

$$f_{OSCM} = 1 / [0.56 \times \{C_x(R1 + 500)\}]$$

Note: C, R1: External components for OSCM (C = 270 pF, R1 = 5.1 kΩ => f<sub>OSCM</sub> = About 1.12 MHz (Typ.))

$$f_{chop} = f_{OSCM} / 16$$

Note: When f<sub>OSCM</sub> is 1.12 MHz, f<sub>chop</sub> is approximately 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.

Lowering the chopping frequency can reduce heat generation; however, it may increase the current ripple. The typical chopping frequency is approximately 70 kHz. A setting in the range of 50 to 100 kHz is recommended.

## 7. Absolute maximum ratings

Table 7.1 Absolute Maximum Ratings ( $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics		Symbol	Rating	Unit	Remarks
Motor power supply		VM	50	V	-
Motor output voltage		$V_{out}$	50	V	-
Motor output current		$I_{out}$	4.0	A	-
Internal Logic power supply		$V_{CC}$	6.0	V	When externally applied.
Logic input voltage		$V_{IN(H)}$	6.0	V	-
		$V_{IN(L)}$	-0.4	V	-
$V_{REF}$ input voltage		VREF	5.0	V	-
Power dissipation	Device alone	$P_D$	1.78	W	(Note1)
	When mounted on a PCB		2.5	W	(Note2)
Operating temperature		$T_{opr}$	-20 to 85	$^\circ\text{C}$	-
Storage temperature		$T_{stg}$	-55 to 150	$^\circ\text{C}$	-
Junction temperature		$T_{j(Max)}$	150	$^\circ\text{C}$	-

Note 1: Device alone. ( $T_a = 25\text{ }^\circ\text{C}$ )

If the ambient temperature is above  $25\text{ }^\circ\text{C}$ , the power dissipation must be de-rated by  $14.2\text{ mW}/^\circ\text{C}$ .

Note 2: When mounted on a specially designed PCB (4-layer, Mount condition ; $R_{th(j-a)}=50\text{ }^\circ\text{C}/\text{W}$ ,  $T_a = 25\text{ }^\circ\text{C}$ )

If the ambient temperature is above  $25\text{ }^\circ\text{C}$ , the power dissipation must be de-rated by  $20\text{ mW}/^\circ\text{C}$ .

$T_a$ : Ambient temperature

$T_{opr}$ : Ambient temperature while the IC is active

$T_j$ : 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,  $T_j$  (MAX), will not exceed  $120\text{ }^\circ\text{C}$ .

### Caution: Absolute maximum ratings

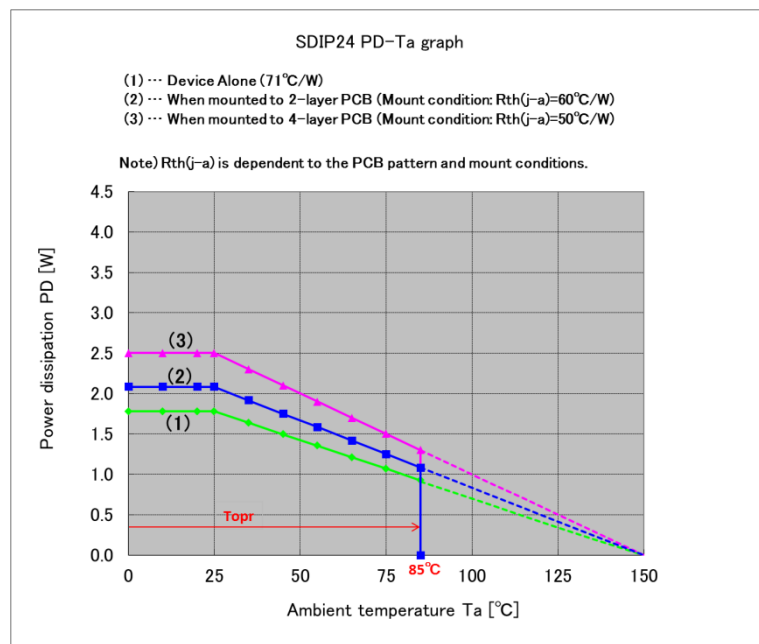
The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.

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. 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



**Figure 7.1 (For reference) PD-Ta graph**

Note: The power dissipation depends on the PCB layout and mounting conditions so please be careful.  
 Also, when the ambient temperature is high, the allowed power dissipation 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	I <sub>out</sub>	-	1.0	-	A	(Note1)
Logic input voltage	V <sub>IN(H)</sub>	2.0	-	5.5	V	Logic input High Level
	V <sub>IN(L)</sub>	0	-	0.8	V	Logic input Low Level
Phase input frequency	f <sub>PHASE</sub>	-	-	400	kHz	
Chopper frequency	f <sub>chop(range)</sub>	40	70	150	kHz	
V <sub>REF</sub> 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

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

**Table 9.1 Electrical Specifications 1**

Characteristics		Symbol	Test condition	Min	Typ.	Max	Unit
Logic input voltage	HIGH	$V_{IN(H)}$	Logic input pin (Note1)	2.0	-	5.5	V
	LOW	$V_{IN(L)}$	Logic input pin (Note1)	0	-	0.8	V
Logic input hysteresis voltage		$V_{IN(HYS)}$	Logic input pin (Note1)	100	-	300	mV
Logic input current	HIGH	$I_{IN(H)}$	Logic input voltage = 3.3 V	-	33	-	$\mu$ A
	LOW	$I_{IN(L)}$	Logic input voltage = 0 V	-	-	1	$\mu$ A
Power consumption		$I_{M1}$	Output pins = open, STANDBY = L	-	2	3.5	mA
		$I_{M2}$	Output pins = open, STANDBY = H	-	3.5	5.5	mA
		$I_{M3}$	Output pins=open Full step resolution	-	5.5	7	mA
Output leakage current	High-side	$I_{OH}$	$V_{RS} = VM = 50$ V, $V_{out} = 0$ V	-	-	1	$\mu$ A
	Low-side	$I_{OL}$	$V_{RS} = VM = V_{out} = 50$ V	1	-	-	$\mu$ A
Motor current channel differential		$\Delta I_{out1}$	$V_{REF} = 1.65$ V, $I_{out} = 1.5$ A, $RS = 0.22\Omega$ setting (Note2)	0	-	5	%
Motor current setting accuracy		$\Delta I_{out2}$	$V_{REF} = 1.65$ V, $I_{out} = 1.5$ A, $RS = 0.22\Omega$ setting	-5	0	5	%
RS pin current		$I_{RS}$	$V_{RS} = VM = 24$ V	0	-	10	$\mu$ A
Motor output ON-resistance (High-side + Low-side)		$R_{on(S)_PN}$	$T_j = 25$ °C, High-side + Low-side	—	0.49	0.6	$\Omega$

Note: 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.

Note1:  $V_{IN(H)}$  is defined as the  $V_{IN}$  voltage that causes the outputs (OUTA, OUTB) to change when a pin under test is gradually raised from 0 V.  $V_{IN(L)}$  is defined as the  $V_{IN}$  voltage that causes the outputs (OUTA, OUTB) to change when the pin is then gradually lowered. The difference between  $V_{IN(H)}$  and  $V_{IN(L)}$  is defined as the input hysteresis.

Note2: Motor current channel differential satisfies the following equation.

The absolute value of the difference in output current settings between any two channels [A]  $\leq$  average of the output setting current values  $\times$  output current error (Maximum) [A]

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

**Table 9.2 Electrical Specifications 2**

Characteristics	Symbol	Test condition	Min	Typ.	Max	Unit
VREF input current	I <sub>REF</sub>	V <sub>REF</sub> = 2.0 V	-	0	1	μA
VCC voltage	V <sub>CC</sub>	I <sub>CC</sub> = 5.0 mA	4.75	5.0	5.25	V
VCC current	I <sub>CC</sub>	V <sub>CC</sub> = 5.0 V	-	2.5	5	mA
VREF gain rate	V <sub>REF (gain)</sub>	V <sub>REF</sub> = 2.0 V	1/5.2	1/5.0	1/4.8	—
Thermal shutdown (TSD) threshold (Note1)	T <sub>JTSD</sub>	—	145	160	175	°C
VM recovery voltage	V <sub>MR</sub>	—	7.0	8.0	9.0	V
Over-current detection (ISD) threshold (Note2)	I <sub>SD</sub>	—	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.

### 9.2.1. 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 TB67S101A or other components will be damaged or fail due to the motor back-EMF.

### 9.2.2. 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.

### 9.2.3. IC Mounting

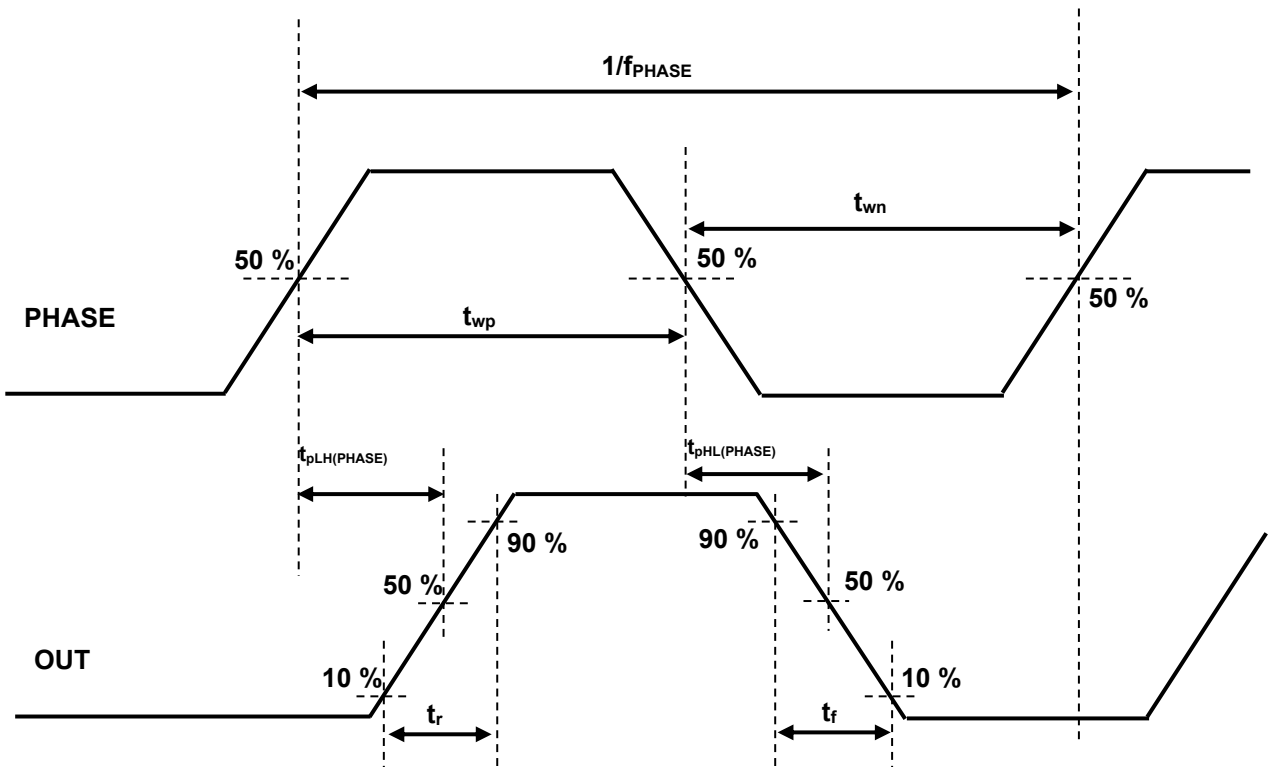
Do not insert devices incorrectly or in the wrong orientation. Otherwise, it may cause breakdown, damage and/or deterioration of the device.

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

**Table 9.3 AC Electrical Specification**

Characteristics	Symbol	Test condition	Min	Typ.	Max	Unit
Minimum PHASE pulse width	$f_{PHASE (Min)}$	—	100	-	-	ns
	$t_{wp}$	—	50	-	-	
	$t_{wn}$	—	50	-	-	
Output transistor switching specific	$t_r$	—	30	80	130	ns
	$t_f$	—	40	90	140	
	$t_{pLH(PHASE)}$	PHASE - Output	250	-	1200	
	$t_{pHL(PHASE)}$	PHASE - Output	250	-	1200	
Analog noise blanking time	$A_{tBLK}$	VM = 24 V, I <sub>out</sub> = 1.5 A Analog t <sub>BLK</sub>	250	400	550	ns
Oscillator frequency accuracy	$\Delta f_{OSCM}$	C <sub>osc</sub> = 270 pF, R <sub>osc</sub> = 5.1 kΩ	-15	-	+15	%
Oscillator reference frequency	$f_{OSCM}$	C <sub>osc</sub> = 270 pF, R <sub>osc</sub> = 5.1 kΩ	952	1120	1288	kHz
Chopping frequency	$f_{chop}$	Output: Active (I <sub>OUT</sub> = 1.5 A), f <sub>OSCM</sub> = 1120 kHz	-	70	-	kHz

### AC Electrical Specification Timing chart



**Figure 9.1 AC Timing chart**

Note: Timing charts may be simplified for explanatory purpose.

## 10. Application Circuits

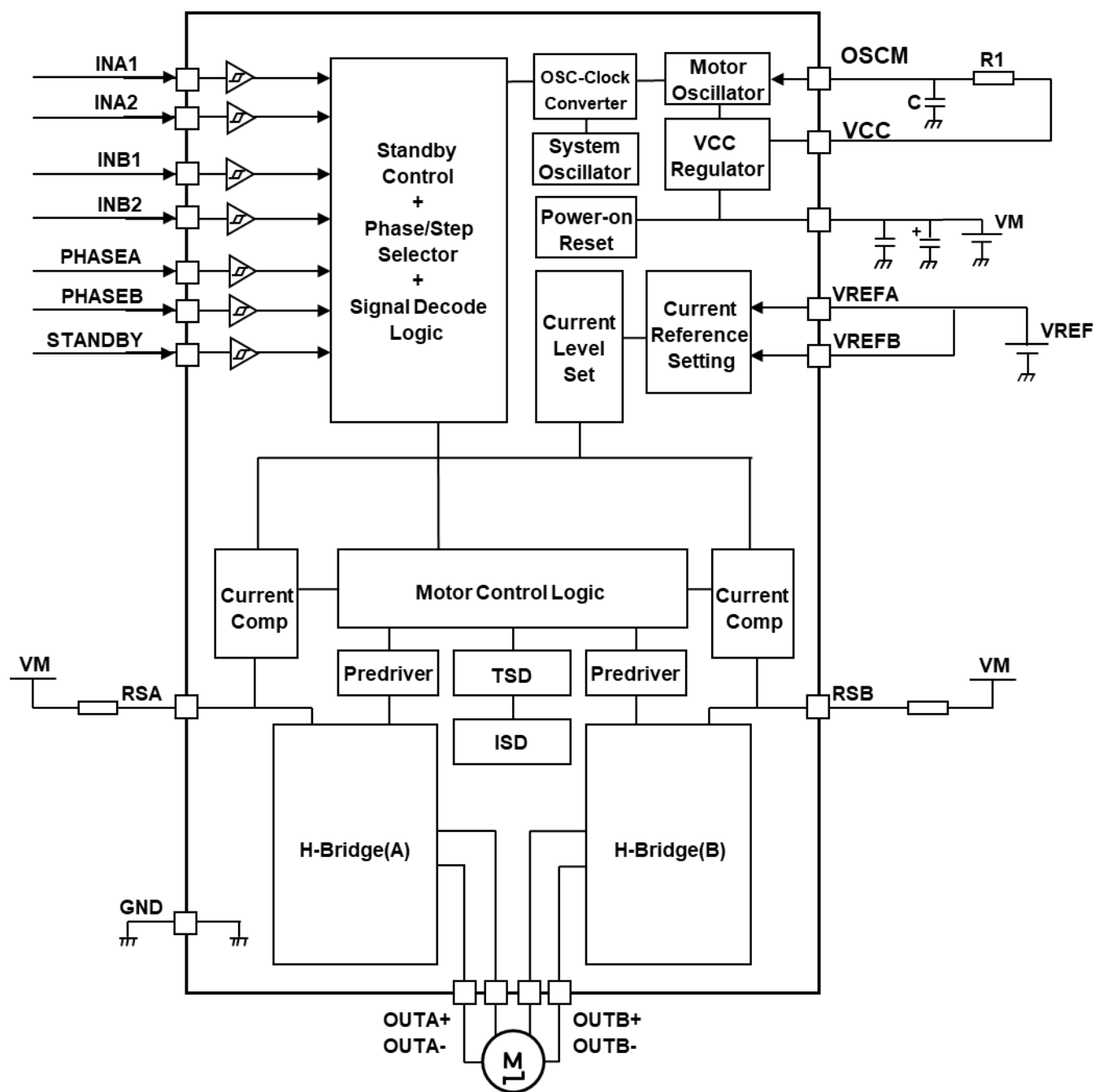


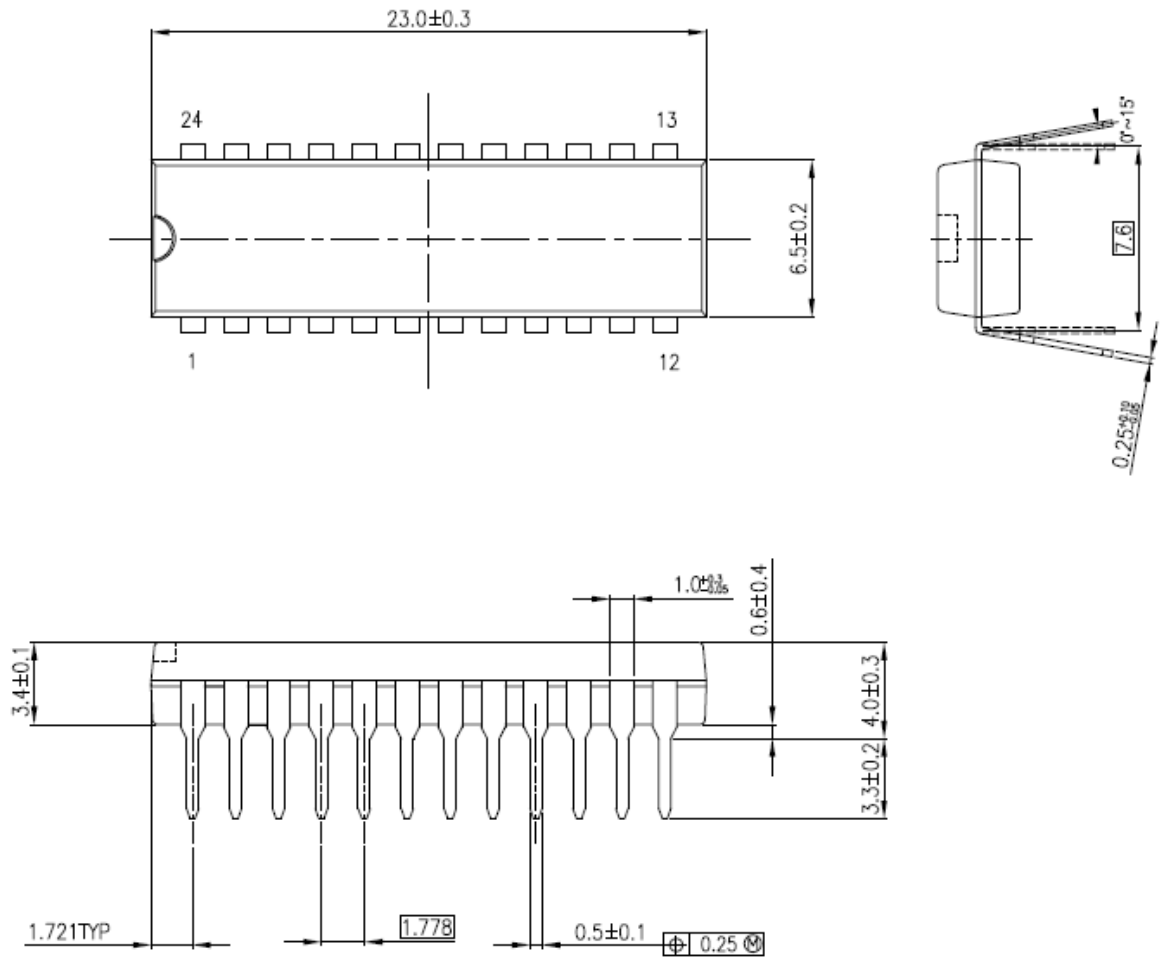
Figure 10.1 Application Circuits

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

## 11. Package Dimensions

P-SDIP24-0723-1.78-001

(unit: mm)



Weight: 1.3 g (Typ.)

## Notes on Contents

- **Block Diagrams**  
Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.
- **Equivalent Circuits**  
The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.
- **Timing Charts**  
Timing charts may be simplified for explanatory purposes.
- **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.  
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- **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 the device breakdown, damage or deterioration, and may result in injury by explosion or combustion.
- (2) 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 the device breakdown, damage or deterioration, and may result in injury by explosion or combustion. In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.
- (3) Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over-current 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 case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- (4) 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.
- (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 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, over-current or IC failure can cause smoke or ignition. (The over-current can 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 on handling of ICs

- (1) Over-current detection circuit  
Over-current detection 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 ( $T_j$ ) 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 reverses the rotation 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.

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