

TC78S600FTG Usage Considerations

The TC78S600FTG is a PWM constant-current type 2-phase bipolar stepping motor driver IC. The TC78S600FTG can be used in applications that require 1-2-phase, W1-2-phase, 2W1-2 phase, and 4W1-2 phase excitation modes. The TC78S600FTG is capable of forward and reverse driving using only a clock signal.

(1) Operating range of power supply voltage

Characteristics	Symbol	Operating power supply voltage range	Absolute maximum ratings	Unit
Control power supply voltage	V _{CC}	2.7 to 5.5	6	V
Motor power supply voltage	V _M	2.5 to 15	18	V

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. Please use the IC within the specified operating ranges.

(2) Power ON/OFF sequence with control input signals

When power supply is applied or turned off, STBY signal or ENABLE signal should be low. If STBY or ENABLE signal is high in turning on and shutdown the power supply, unexpected current may flow in the output pin depending on the conditions.

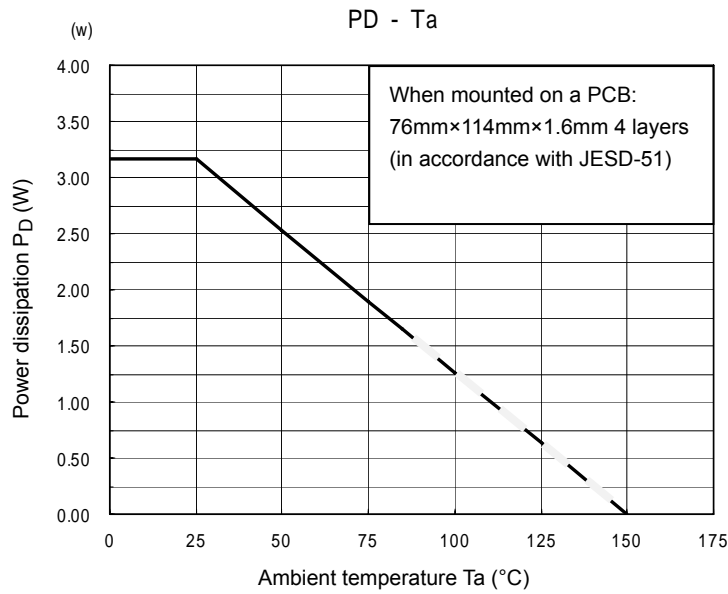
1. Output current

The absolute maximum rating is 1.0 A (peak). 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.

The average permissible current is restricted by total power dissipation. Please use the IC within the range of the power dissipation.

2. Power dissipation

P_D - T_a curve of the TC78S600FTG in each mounted condition is shown below.
 (Upper limit of operating range of T_a is 85°C.)



Power consumption in each excitation mode is calculated at a rough estimate as follows:

When I_{out} is 0.6 A, output saturated voltage ($V_{SAT (U + L)}$) is 0.96 V (Max).

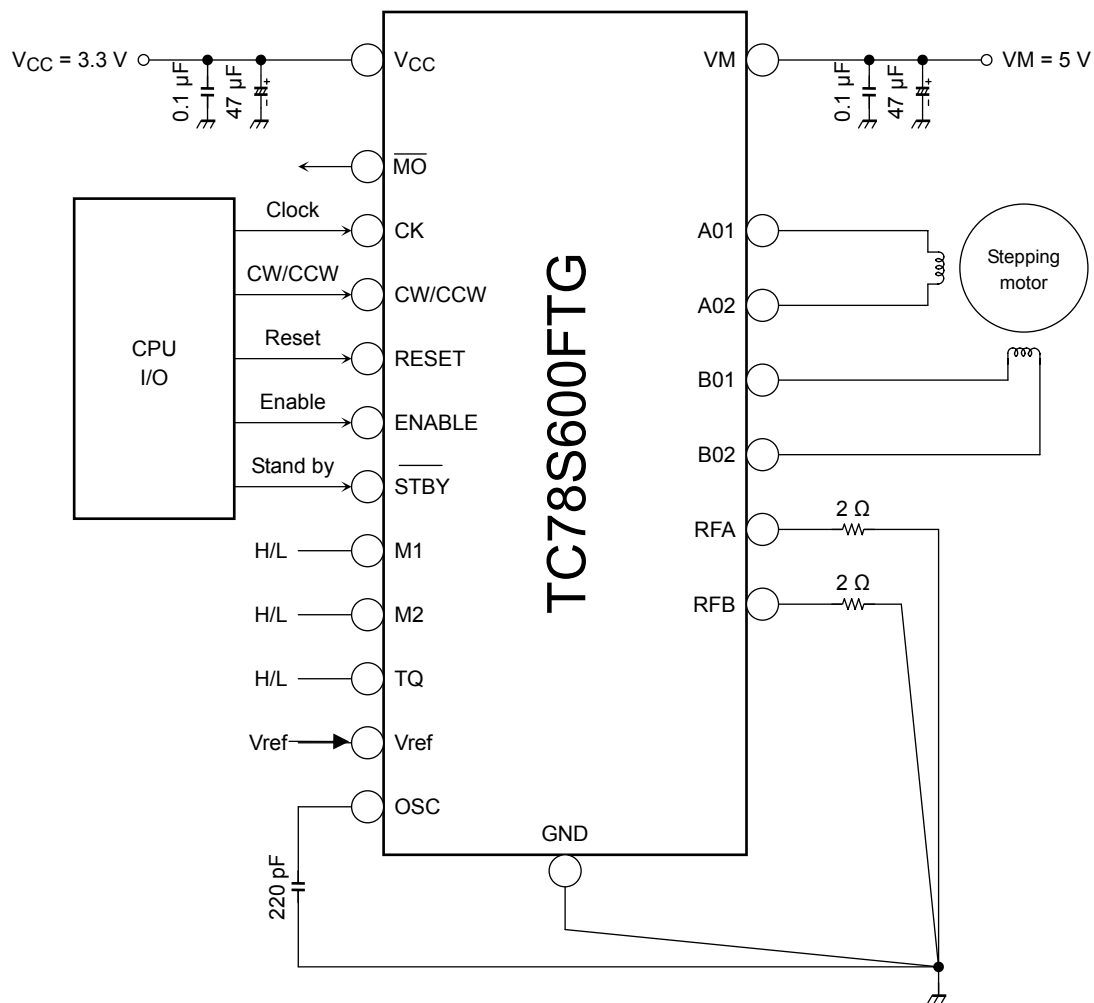
When V_{CC} is 3.3 V, consumption current I_{CC1} is 6 mA (max). When V_M is 5 V, I_{M1} is 2 mA (max).

In 1-2 phase excitation, W1-2 phase excitation, 2W1-2 phase excitation, and 4W1-2 phase excitation, 70 percent of I_{out} (100%) is estimated roughly as an average value because the output wave form is pseudo sine wave form.

$$\begin{aligned}
 P_D &= ((I_{out} \times 0.7) \times V_{SAT (U + L)}) \times 2 + V_{CC} \times I_{CC1} + V_M \times I_{M1} \\
 &= 0.8064 + 0.0198 + 0.01 \\
 &= 0.84 \text{ W}
 \end{aligned}$$

Please confirm the operation in the actual operation conditions because thermal characteristics changes widely depending on the discharge characteristics of the board and the transient characteristics in the mounted state.

3. Application circuit example



(1) Capacitors for the power supply lines

Capacitors for the power supply lines between VCC and GND should be connected as close to the IC as possible.

Recommended value

Characteristic	Recommended Value	Remarks
VCC-GND	10 µF to 100 µF	Electrolytic capacitor
	0.1 µF to 1 µF	Ceramic capacitor

(2) Capacitors for VM terminal

Capacitors for VM terminal between VM and GND should be connected as close to the IC as possible.

Recommended Value

Characteristic	Recommended Value	Remarks
VM-GND	10 µF to 100 µF	Electrolytic capacitor
	0.1 µF to 1 µF	Ceramic capacitor

(3) GND

Metallic exposure part on the back of package is a part of the lead frame.

Since the chip is mounted on this lead frame, using a wide ground trace by soldering the metallic exposure part with the printed wiring board aides heat removal. If a large current flows through a ground trace, the ground trace must be designed to be wide as possible. This pattern on the printed wiring board should be connected to the GND of the IC or should not be connected anything electrically.

(4) Capacitor for the OSC terminal

The internal oscillation frequency is determined by the value of the capacitor connected to the OSC terminal.

When C_{OSC} is 220 pF, the internal oscillation frequency is 320 kHz (typ.).

(5) Resistors for the RFA and RFB terminals

The value of the current detecting resistor (RNF) which is connected to the RFA and RFB terminals determines the current that flows through A- and B-phases of the motor.

When the upper limit of the current across the motor coil is assumed I (Limit),

$$I \text{ (Limit) (A)} = 1/5 \times V_{\text{ref}} \text{ (V)} \div R_{\text{NF}} \text{ (}\Omega\text{)}$$

(Torque setting is 100%, that is to say, TQ pin is high level.)

Ex.) When torque setting is 100 % (TQ=H), V_{ref} is 2.5 V, and the maximum current is 0.5 A, external resistance is 1.0 Ω. Then, when torque setting is changed to 25 % (TQ=L) under the same condition, the maximum current is 0.125 A.

V_{ref} should be set as follows; 0.5V to 3.4V, V_{cc} (max.) - 1.8V.

In case TQ is High, V_{ref} must not exceed 2.5V in using.

Operating accuracy is inferior when V_{ref} is set less than 0.5V.

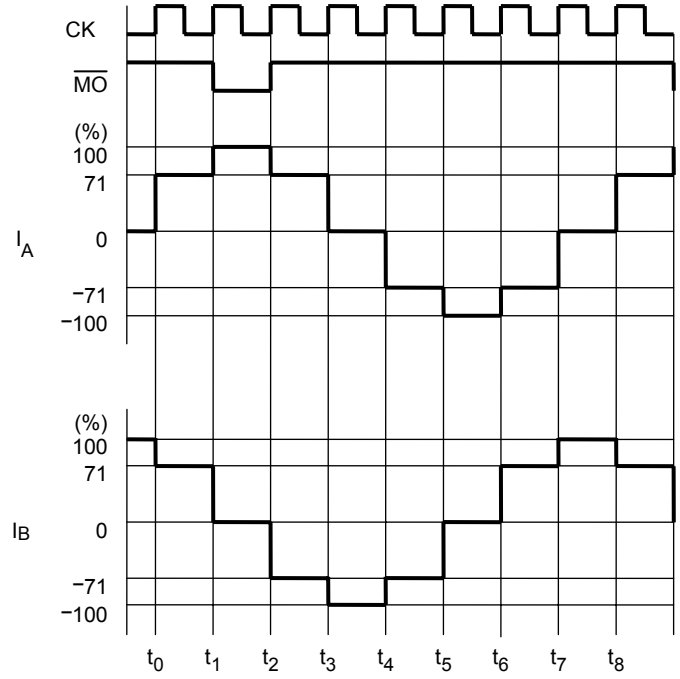
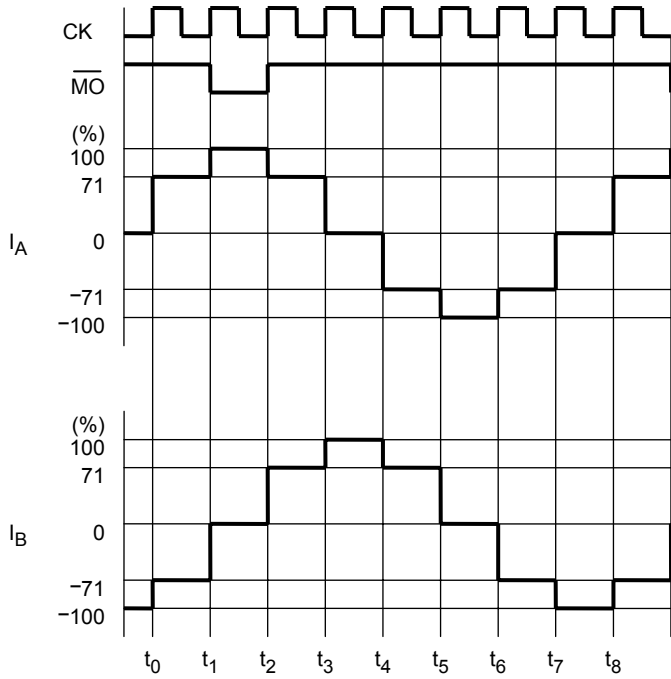
The resistance of 0.25Ω or more should be connected to RNF.

4. Excitation mode setting

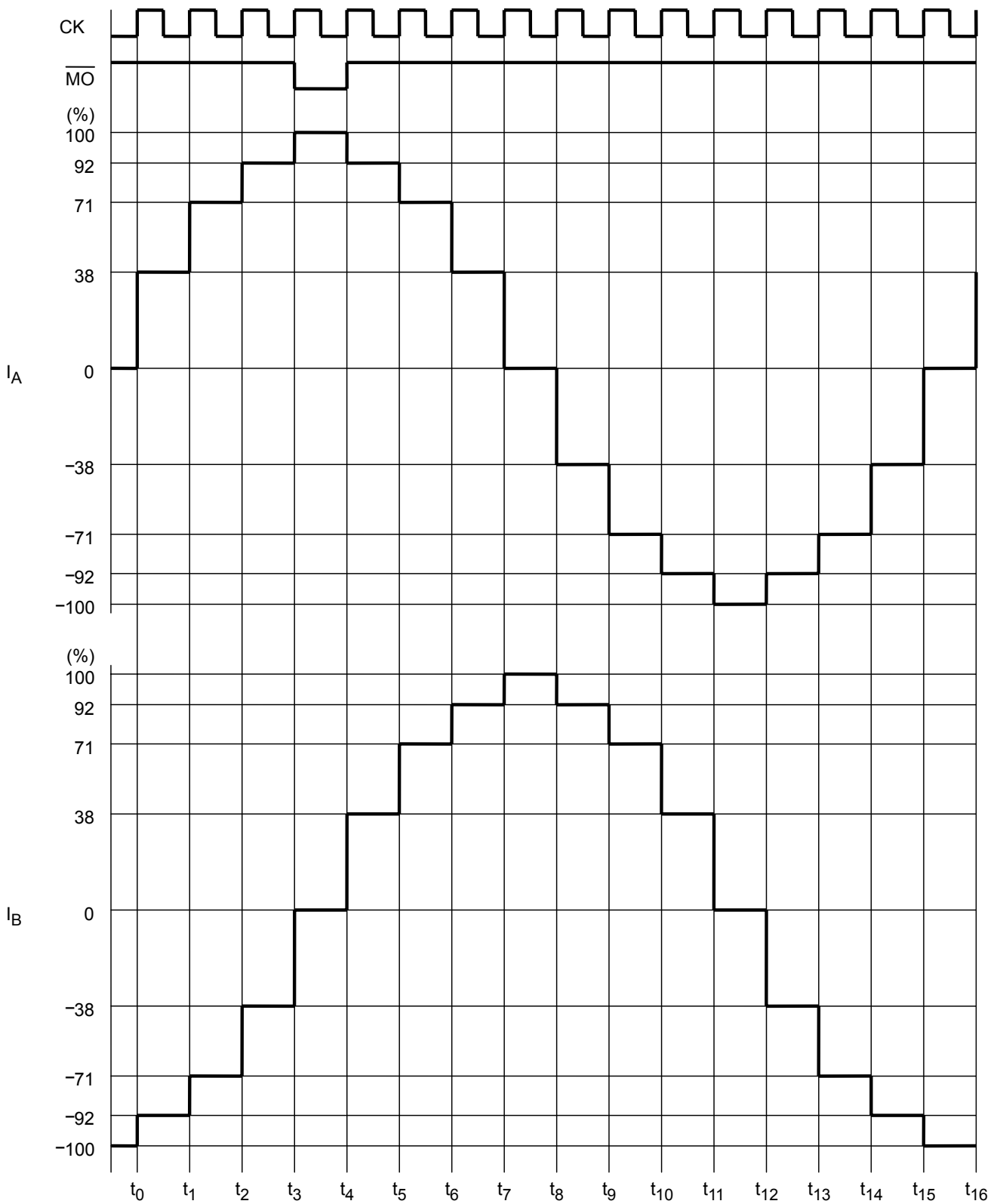
The excitation mode can be selected from 2 phase, 1-2 phase, W1-2 phase, and 2W1-2 phase modes using the M1 and M2 inputs. It is capable of forward and reverse driving of a two-phase bipolar stepping motor with CW and CCW terminals using only a clock signal.

1-2 phase excitation (M1: H, M2: L, CW mode)

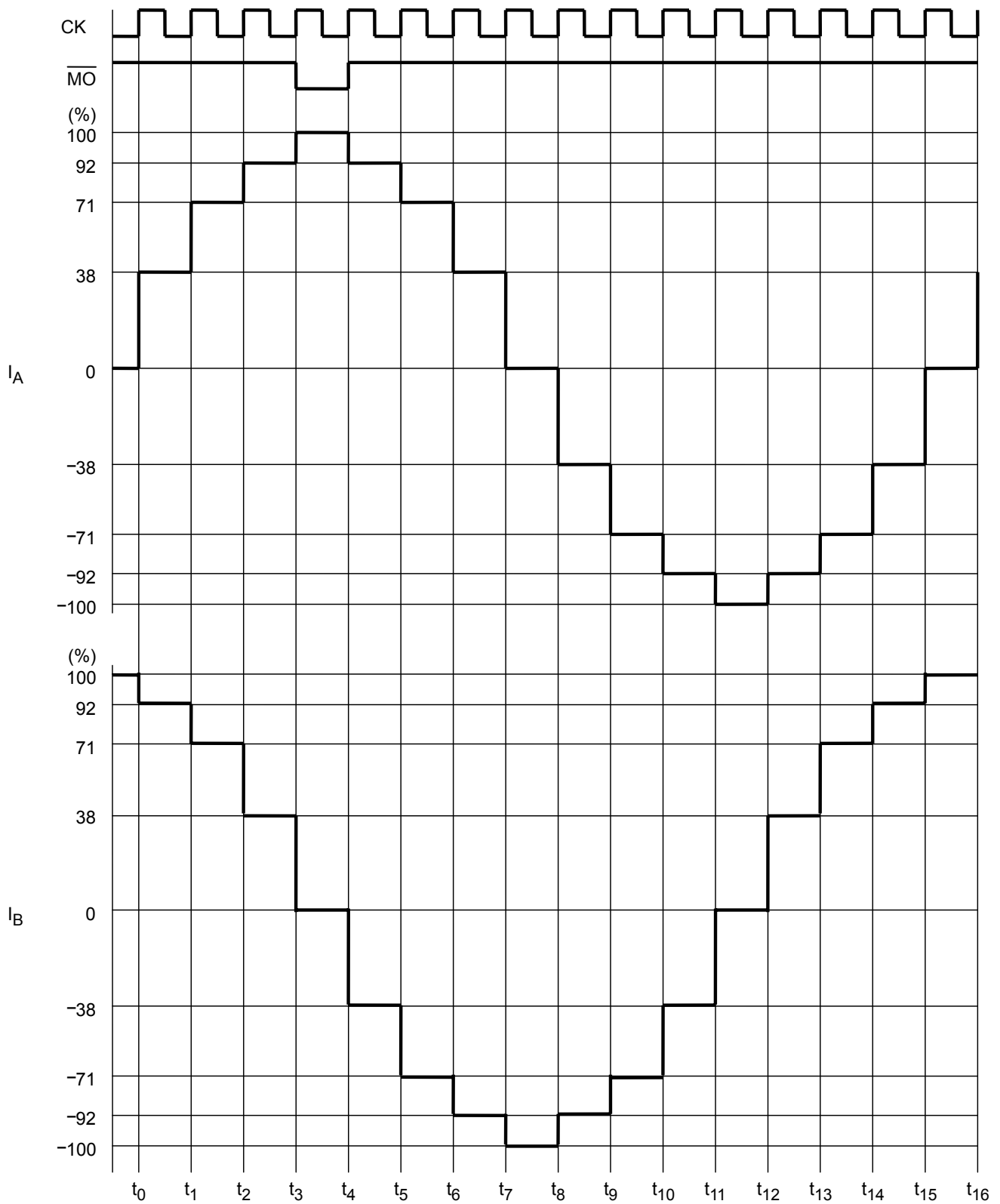
1-2 phase excitation (M1: H, M2: L, CCW mode)



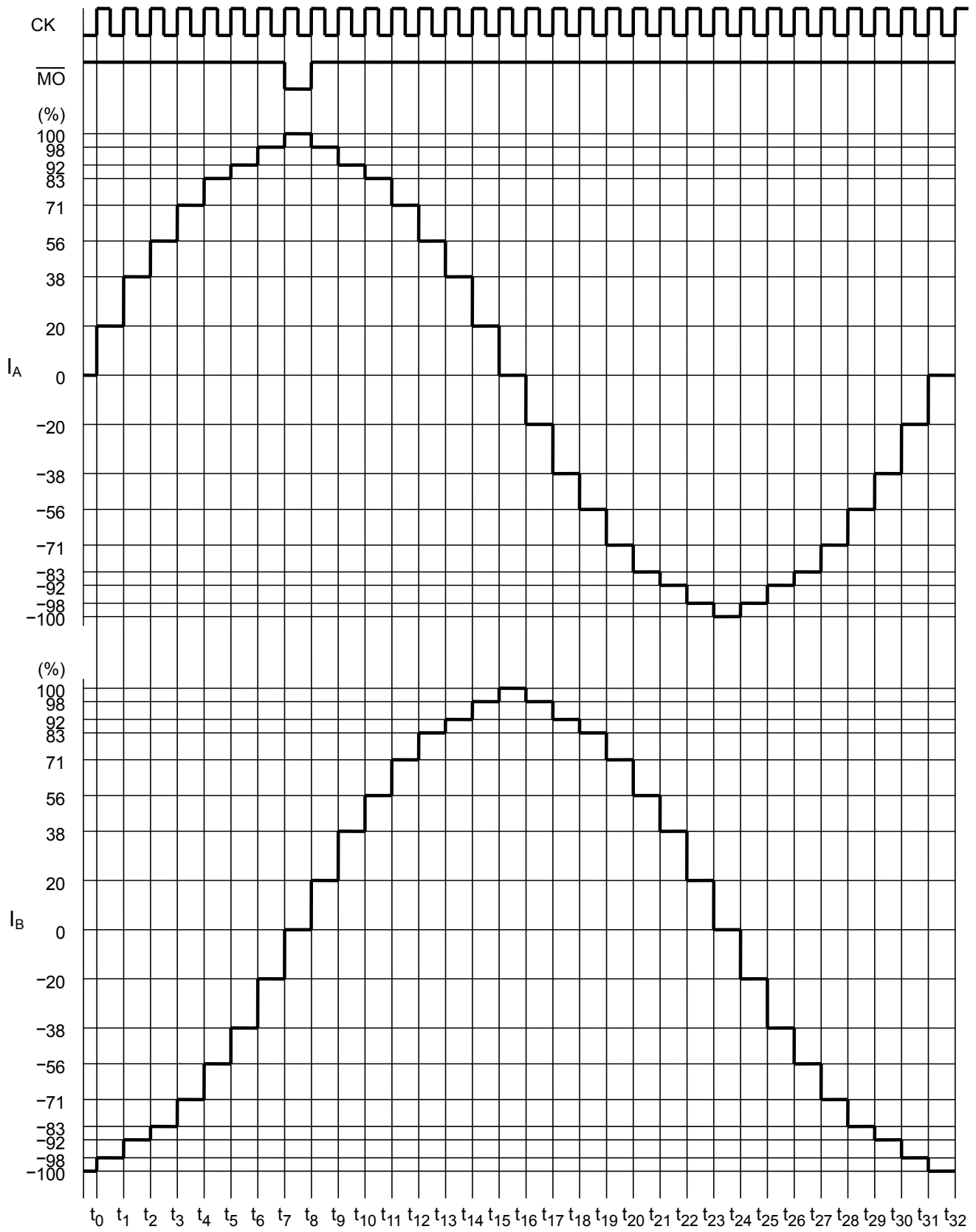
W1-2 phase excitation (M1: L, M2: H, CW mode)



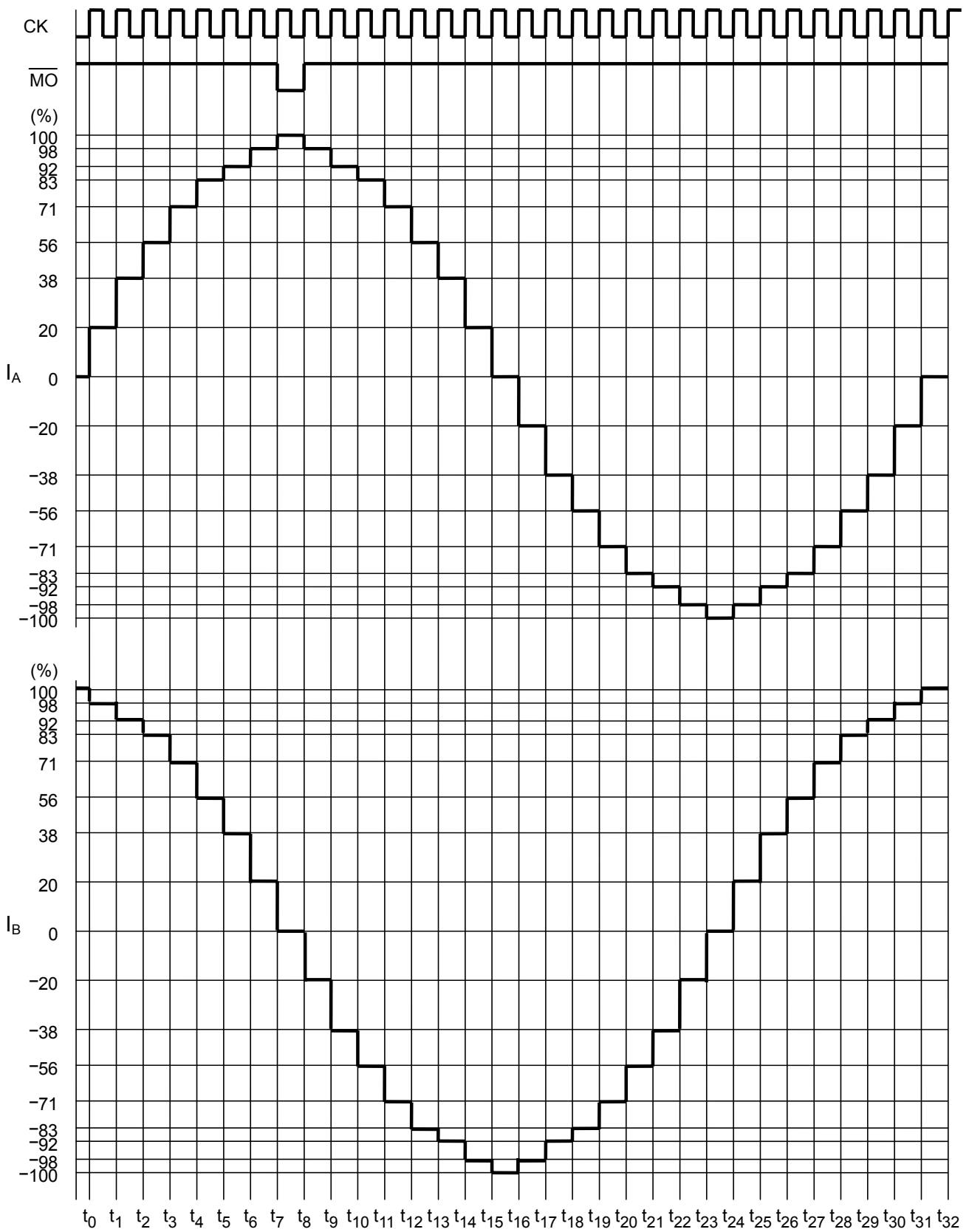
W1-2 phase excitation (M1: L, M2: H, CCW mode)



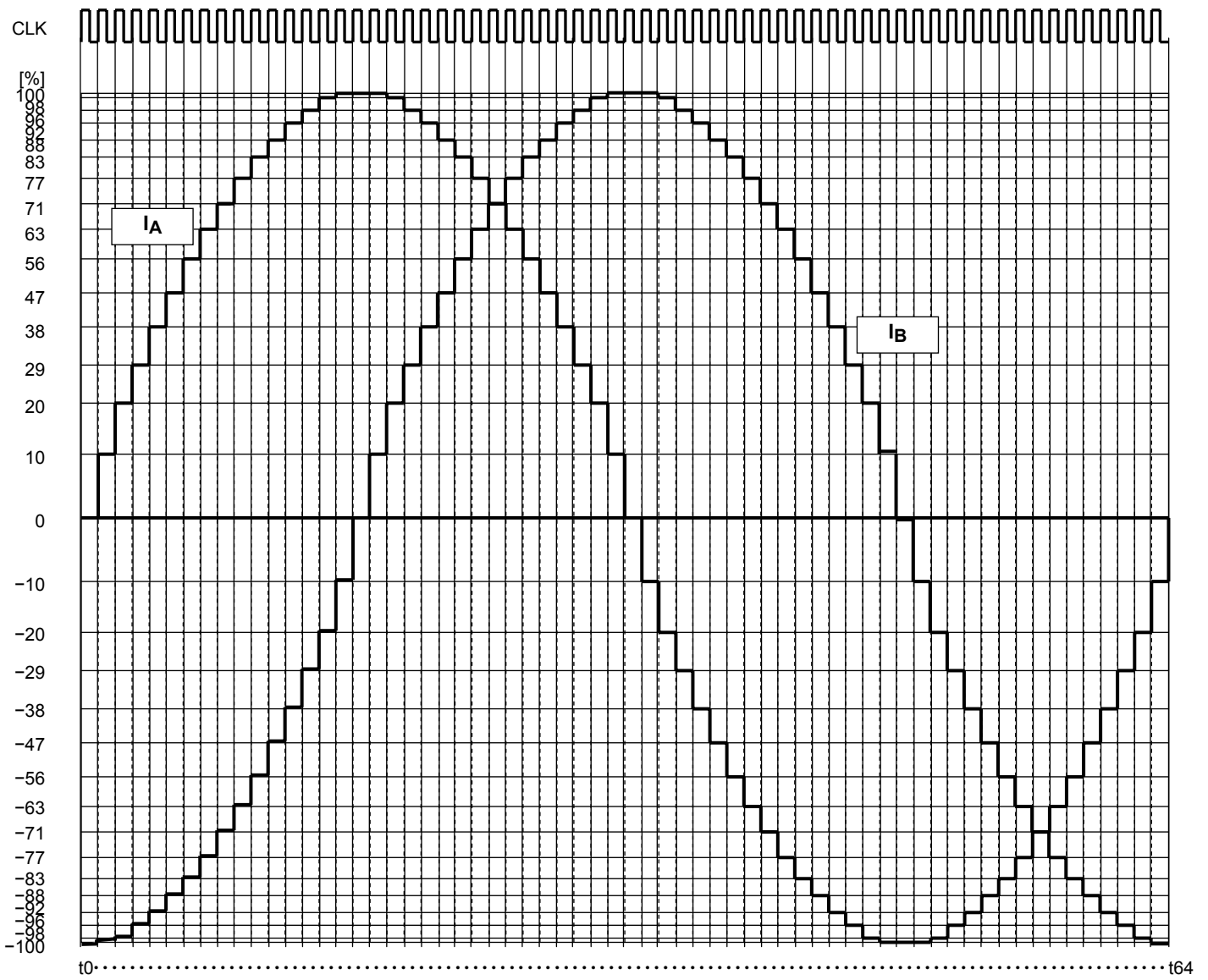
2W1-2 phase excitation (M1: H, M2: H, CW mode)



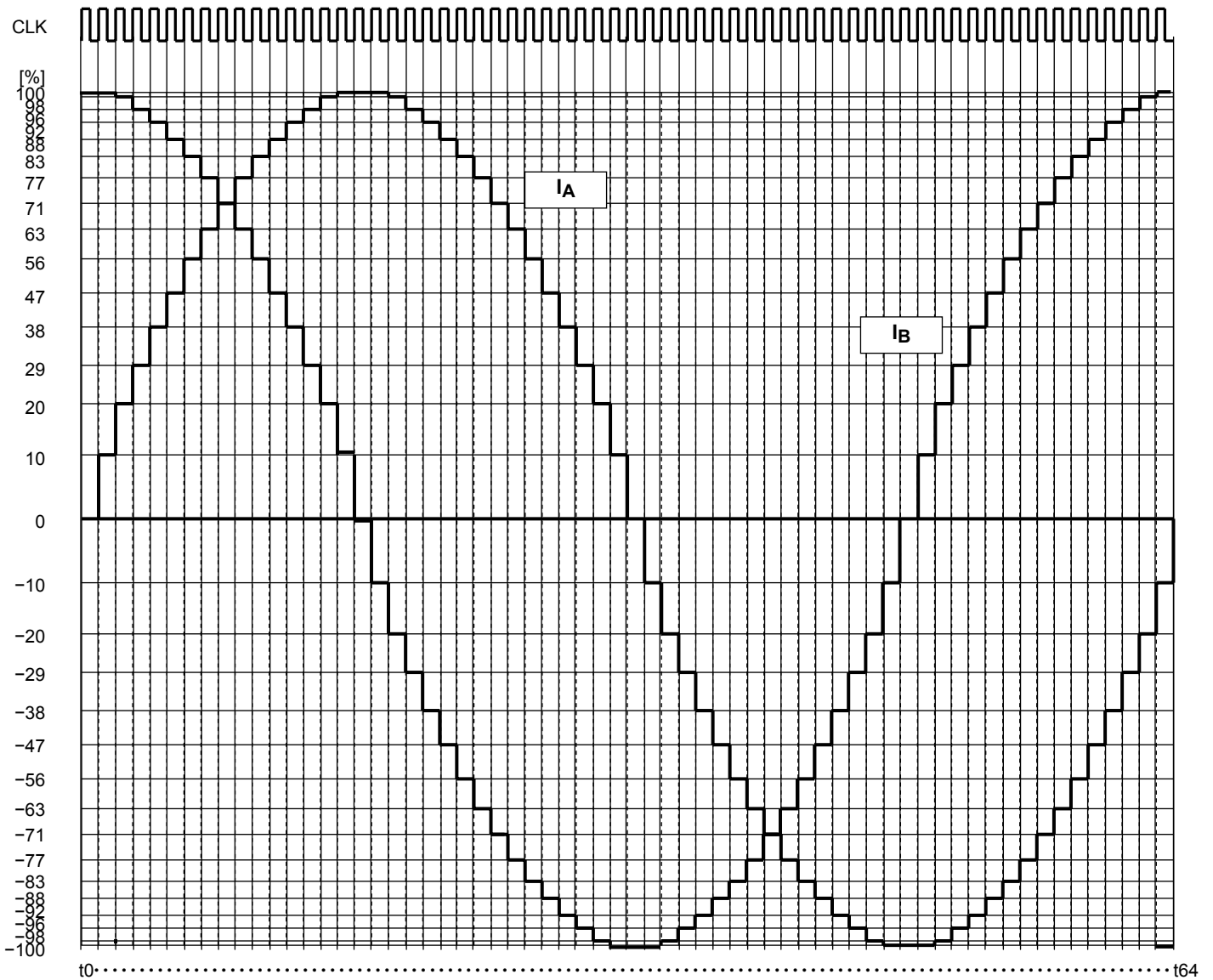
2W1-2 phase excitation (M1: H, M2: H, CCW mode)



4W1-2 phase excitation (M1: L, M2: L, CW mode)



4W1-2 phase excitation (M1: L, M2: L, CCW mode)



6. Supplemental explanation

Pin No.	Symbol	Pin name	Remarks	Supplemental explanation
4, 5	Vcc	Power supply pin for logic block	Vcc(oper)=2.7 to 5.5V	Applied voltage to power supply pin should be within the operating range.
6	STBY	Standby input	See the Input Signals and Operating Modes table.	Power consumption is reduced by turning off almost internal circuits when the current in the motor coil is unnecessary. This signal command has higher priority than other input signals (ENABLE, RESET, and so on). See the Input Signals and Operating Modes table of the data sheet.
7	OSC	Connection pin for an external capacitor used for internal oscillation		Connect the capacitor (Cosc) of 220pF between the OSC pin and the GND pin.
8	M1	Excitation mode setting input 1	See the Excitation Mode Settings table.	The excitation mode is set according to the Excitation Mode Settings table of the data sheet. In case reducing noise is valued, before and after 2W1 - 2 phase excitation should be set. In case the torque is valued, 2-phase excitation should be selected.
9	M2	Excitation mode setting input 2	See the Excitation Mode Settings table.	
10, 11	VM	Power supply pin for output	VM(oper) = 2.5 to 13.5 V	Applied voltage to power supply pin should be within the operating range.
12	CW/CCW	Rotation direction select input	See the Input Signals and Operating Modes table.	The rotation direction is switched by changing the output level.
13	BO2	B - phase output 2	Connect BO2 to a motor coil pin.	Output pin for connecting the motor coil. Do not connect the equipment other than motor.
14	RFB	Connection pin for a B - phase output current detection resistor		IOUT (A) = $1/5 \times Vref(V) / RNF$ () The current is determined when TQ outputs high (torque setting is 100 %). The resistance, motor IC, and GND should be connected as close as possible.
15	BO1	B - phase output 1	Connect BO1 to a motor coil pin.	Output pin for connecting the motor coil. Do not connect the equipment other than motor.
16	AO2	A - phase output 2	Connect AO2 to a motor coil pin.	Output pin for connecting the motor coil. Do not connect the equipment other than motor.
17	RFA	Connection pin for an A - phase output current detection resistor		IOUT (A) = $1/5 \times Vref(V) / RNF$ () The current is determined when TQ outputs high (torque setting is 100 %). The resistance, motor IC, and GND should be connected as close as possible.
18	AO1	A - phase output 1	Connect AO1 to a motor coil pin.	Output pin for connecting the motor coil. Do not connect the equipment other than motor.
19	RESET	Reset input	See the Input Signal and Operating Modes table.	RESET=L Initial mode (Output is fixed -A -phase current 100%, B -phase current 100%). MO pin is monitored. Motor operates from the initial point of electrical angle by using RESET pin. See the "Relationship between the RESET and the outputs (OUT and MO)" in page 17 of the data sheet.
20, 21	GND	Ground		
22	MO	Monitor output	Initial state: MO = Low (open drain, pulled up by an external resistor)	Motor starts operating by confirming the initial point of the electrical angle by combining the ENABLE pin and the RESET pin in monitoring MO signal. See the "Relationship between the ENABLE and the outputs (OUT and MO)" in page 16 and "Relationship between the RESET and the outputs (OUT and MO)" in page 17 of the datasheet.
23	TQ	Vref setting input	See the Vref Voltage Setting table.	The current of 100% and 25% is set according to the table "Vref setting". The current setting of 25% can be used to fix the rotation axis of the motor without rotating the motor.
1	Vref	External set terminal for A - phase and B - phase reference voltage		IOUT (A) = $1/5 \times Vref(V) / RNF$ () The current is determined when TQ outputs high (torque setting is 100 %). Applied voltage to the power supply pin should be within the operating range.
2	ENABLE	Enable input	See the Input Signal and Operating Modes table.	Whether to apply the current to output pins (AO1, AO2, BO1, and BO2) or not is decided by high or low level of the ENABLE pin. The CLK of the internal IC is counted according to the CK signal when ENABLE is low and output is off. See the "Relationship between the ENABLE and the outputs (OUT and MO)" in page 16 of the data sheet.
3	CK	Clock input		Steps of current level are proceeded by inputting the square wave.

7. Current setting

When the motor supply voltage, the resistance between motor coil pins, the wiring resistance of the PCB board, ON resistance of the motor IC are assumed V_M , R_m , R_p , and R_{on} each, conducting maximum current (I_{max}) is 60% to 80% of the value which is calculated from $V_M \div (R_m + R_p + R_{on})$.

When setting of I (Limit) which is written in page 4 exceeds this I_{max} , its output current waveform corresponds to the pseudo sine wave without peak in saturated. Though motor can rotate, its operating performance falls because the pseudo sine waveform of the output current is not clear and the rotating step angle has variability.

To solve this problem, increase V_M or decrease R_m .

As for our other stepping motor driver ICs, I_{max} is usually 90% to 95% of the value which is calculated from $V_M \div (R_m + R_p + R_{on})$. This IC realizes the stabilization of the PWM frequency and the equalizing of the pulse flow of the current waveform by making discharge a priority for PWM control. So, above phenomenon occurs because of charge deficiency.

When V_M exceeds 12 V, the current waveform might be disordered. It does not influence on the motor operation. To confirm the silent operation, please examine it under the usage condition.

8. Test of short-circuiting

(1)Test of short-circuiting between outputs, air contamination faults, or faults due to improper grounding

The results of the test are shown below. There is no problem.

Test conditions: VCC = 5V, VM = 12V, Vref = 1V
 RFA = RFB = 1.5Ω
 STBY = RESET = ENABLE = TQ = M1 = M2 = CW/CCW= H
 OSC = 220pF, CK = 1 kHz, Motor load

Test results of short-circuiting between outputs, air contamination faults, or faults due to improper grounding

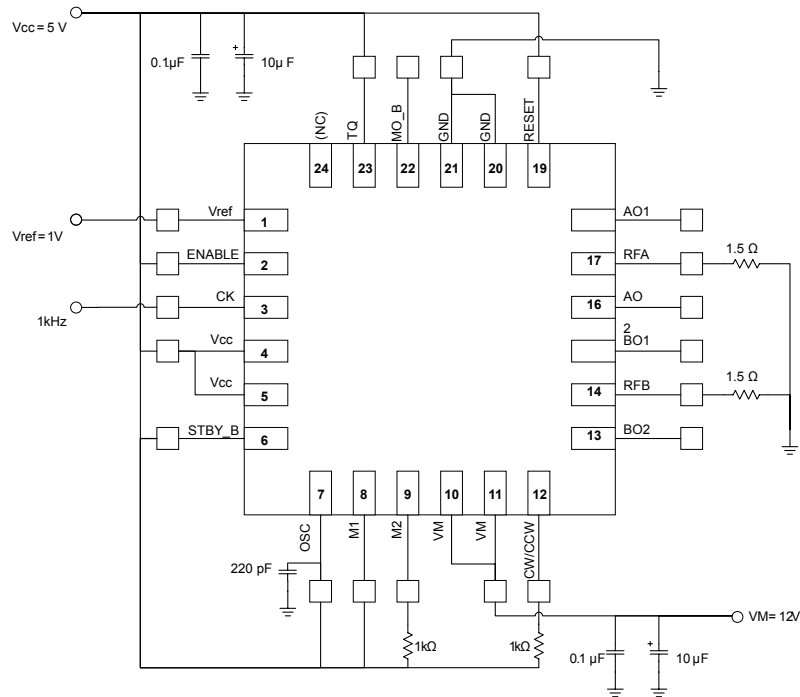
Pin	Result	Judgment
AO1 AO2	Normal appearance, no smoke, normal operation after test	Pass
AO1 VM	Normal appearance, no smoke, normal operation after test	Pass
AO1 GND	Normal appearance, no smoke, normal operation after test	Pass
AO2 VM	Normal appearance, no smoke, normal operation after test	Pass
AO2 GND	Normal appearance, no smoke, normal operation after test	Pass
BO1 BO2	Normal appearance, no smoke, normal operation after test	Pass
BO1 VM	Normal appearance, no smoke, normal operation after test	Pass
BO1 GND	Normal appearance, no smoke, normal operation after test	Pass
BO2 VM	Normal appearance, no smoke, normal operation after test	Pass
BO2 GND	Normal appearance, no smoke, normal operation after test	Pass

ISD (over current detection) is operating.

(2)Test of short-circuiting between contiguous pins

Test conditions: VCC = 5V, VM = 12V, Vref = 1V
 RFA = RFB = 1.5Ω
 STBY = RESET = ENABLE = TQ = M1 = M2 = CW/CCW= H
 OSC = 220pF, CK = 1 kHz, Motor load
 Resistance of 1kΩ is connected between M2 and VCC, CW/CCW and VCC.
 (See below test circuit.)

Test circuit



Test result of short-circuiting between contiguous pins

Pin No.	Pin name	Result	Judgment
1	Vref	Normal appearance, no smoke, normal operation after test	Pass
2	ENABLE		
3	CK	Normal appearance, no smoke, normal operation after test	Pass
4	VCC		
5		Normal appearance, no smoke, normal operation after test	Pass
6	STBY_B		
7	OSC	Normal appearance, no smoke, normal operation after test	Pass
8	M1		
9	M2	Normal appearance, no smoke. Changing excitation mode by M2 pin after test is impossible. Pin is destroyed by round over voltage (12V) from the VM pin.	Pass
10	VM		
11		Normal appearance, no smoke. Changing forward and reverse rotation by CW/CCW pin after test is impossible. Pin is destroyed by round over voltage (12V) from the VM pin.	Pass
12	CW/CCW		
13	BO2	Normal appearance, no smoke, normal operation after test	Pass
14	RFB		
15	BO1	Normal appearance, no smoke, normal operation after test	Pass
16	AO2		
17	RFA	Normal appearance, no smoke, normal operation after test	Pass
18	AO1		
19	RESET	Normal appearance, no smoke, normal operation after test	Pass
20	GND		
21		Normal appearance, no smoke, normal operation after test	Pass
22	MO_B		
23	TQ	---	-
24	(NC)		

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