TB6608FNG Usage Considerations

The TB6608FNG drives a two-phase stepping motor in bipolar mode.
It achieves a constant-current drive with the PWM control.
The excitation mode is selectable from 2-phase, 1-2-phase, W1-2 phase and 2W1-2 phase modes, and the rotation direction can be selected from clockwise and counterclockwise. The TB6608FNG allows easy motor control by only using the clock signal as an input signal.

1. Power Supply Voltage

(1) Operating Power Supply Voltage Range

Characteristic	Symbol	Operating Voltage Range	Absolute Maximum Rating	Unit
Control power supply voltage	V_{CC}	2.7 to 5.5	6	V
Motor power supply voltage	V_M	2.5 to 13.5	15	V

Note: The maximum ratings are the limits that must not be exceeded, even for an instant, under worst possible conditions.
The TB6608FNG should be used within the rated maximum operating power supply voltage range.

(2) Power-On and Power-Off Sequences

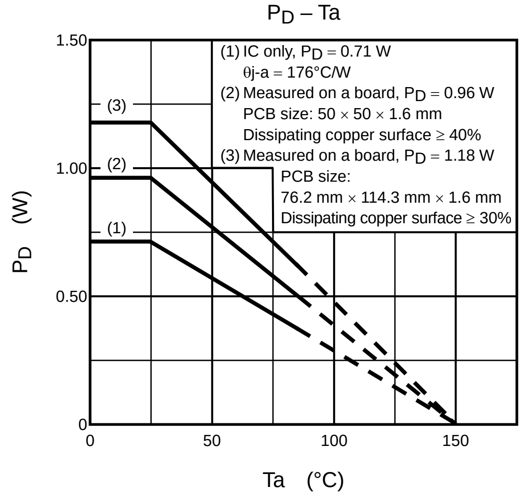
The STBY pin must be set Low upon powering on and off the device. Otherwise, a large current might abruptly flow through the output pins.
Also, at the power-on, V_M must be applied after applying V_{CC}. At the power-off, V_{CC} must be turned off after turning off V_M.

2. Output Current

The absolute maximum rating of the output current is 0.8 A (peak). This rating must not be exceeded even for an instant.
The maximum operating output current varies as follows depending on the V_M operating voltage:
$2.5\ V \le V_M \le 4.8\ V$: 0.35 A (max)
$4.8\ V < V_M \le 13.5\ V$: 0.6 A (max)
The average value of the allowable current is limited by the total power dissipation. The current should be properly regulated so that the power dissipation does not exceed the rated maximum power dissipation.

3. Power Dissipation

The figure below shows the plots of power dissipation versus ambient temperature under each test condition.



When Iout = 0.6 A, the output saturation voltage $V_{SAT\ (U\ +\ L)}$ is 1.2 V (max).
When V_{CC} = 3.3 V, the consumption current I_{CC1} = 6 mA (max).
Also, when V_M = 5 V, the consumption current I_{M1} = 2 mA (max).

- When in 2-phase excitation mode

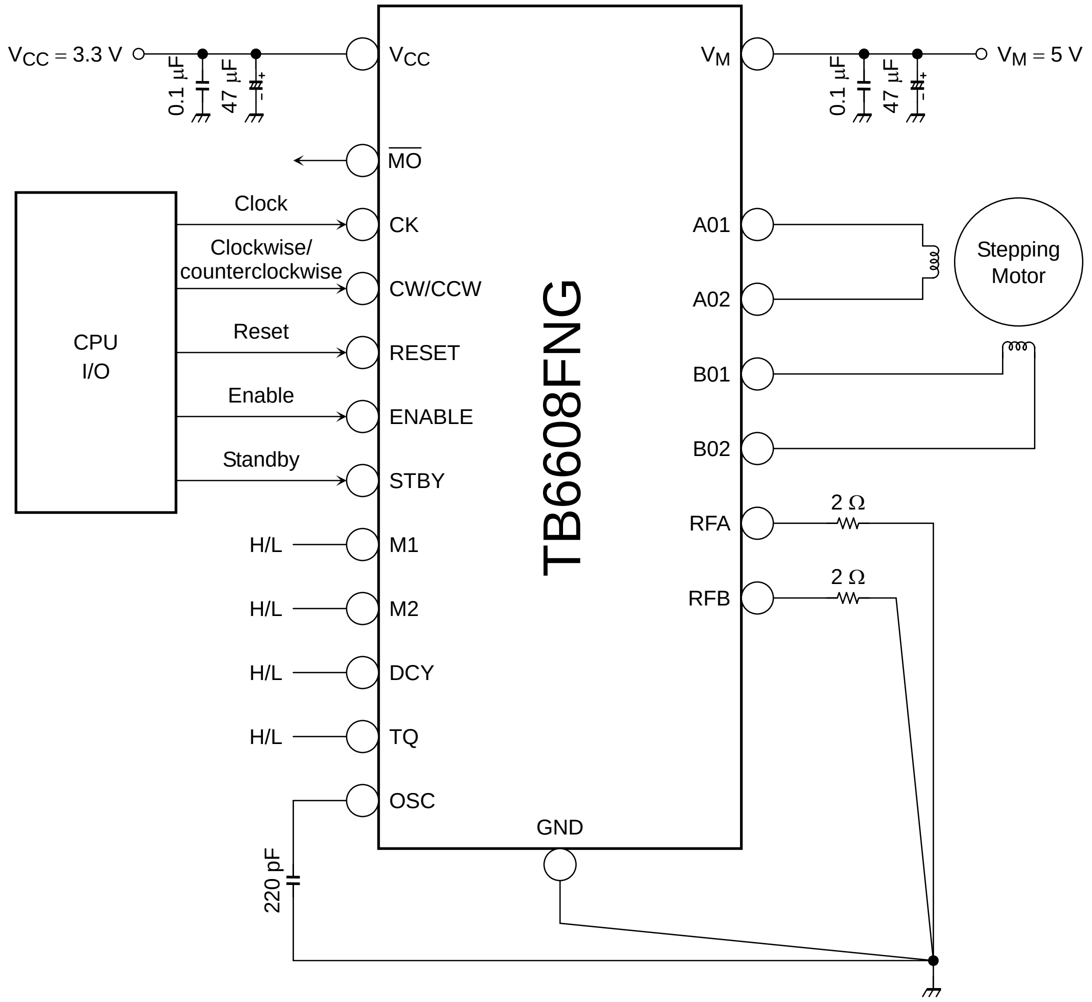
$$P_D = (Iout \times V_{SAT\ (U\ +\ L)}) \times 2 + V_{CC} \times I_{CC1} + V_M \times I_{M1}$$
$$= 0.54 \times 2 + 0.0198 + 0.01$$
$$= 1.11\ W$$

- When in 1-2-phase, W1-2-phase or 2W1-2-phase excitation mode

$$P_D = (Iout \times V_{SAT\ (U\ +\ L)}) + V_{CC} \times I_{CC1} + V_M \times I_{M1}$$
$$= 0.54 + 0.0198 + 0.01$$
$$= 0.57\ W$$

Thermal characteristics of the TB6585 may vary greatly depending on the heat dissipation characteristics of the PC board or the transient conditions of the board assembly. Thus, these characteristics must be fully verified in actual operations.

4. Application Circuit Example



(1) Capacitors for the V_{CC} Power Supply Pin

Capacitors should be connected between V_{CC} and GND at locations as close to the TB6608FNG as possible.

Recommended Values

Characteristic	Recommended Value	Remark
Between V_{CC} and GND	10 µF to 100 µF	Electrolytic capacitor
	0.1 µF to 1 µF	Ceramic capacitor

(2) Capacitors for the V_M Power Supply Pin

Capacitors should be connected between V_M and GND at locations as close to the TB6608FNG as possible.

Recommended Values

Characteristic	Recommended Value	Remark
Between V_M and GND	10 µF to 100 µF	Electrolytic capacitor
	0.1 µF to 1 µF	Ceramic capacitor

(3) GND

The GND pin is a part of the leadframe.

Since the chip is mounted on this leadframe, using a wide ground trace aides heat removal. If a large current flows through a ground trace, the ground trace must be designed to be wide.

The ground trace must be as wide as possible.

(4) Capacitor for the OSC Pin

The internal oscillation frequency is determined by the value of the capacitor connected to the OSC pin. When C_{OSC} = 220 pF, the internal oscillation frequency = 460 kHz (typ.)

Then, the oscillation frequency fosc can be calculated as follows:

$$fosc = \frac{I}{2 \times \Delta V_{OSC} \times C_{OSC}}$$

$$= \frac{101\ \mu A}{2 \times (1.1\ V - 0.6\ V) \times C_{OSC}}$$

$$= 1.1 \times 10^{-4} \times \frac{1}{C_{OSC}}$$

(Since this is an approximation formula, the calculation result may not be exactly equal to the actual value.)

(5) Resistors for the RFA and RFB Pins

The value of the resistors connected to the RFA and RFB pins, Rnf, determines the current that flows through A- and B-phases of the motor.

The upper limit of the current across the motor coil (the peak current in each excitation mode), I (Limit), is calculated as:

I (Limit) = Vref/Rnf

Vref is 0.125 V when TQ is Low, while it is 0.5 V when TQ is High.

When Rnf = 2 Ω and Vref = 0.125 V with TQ set Low;

I (Limit) = 62.5 mA

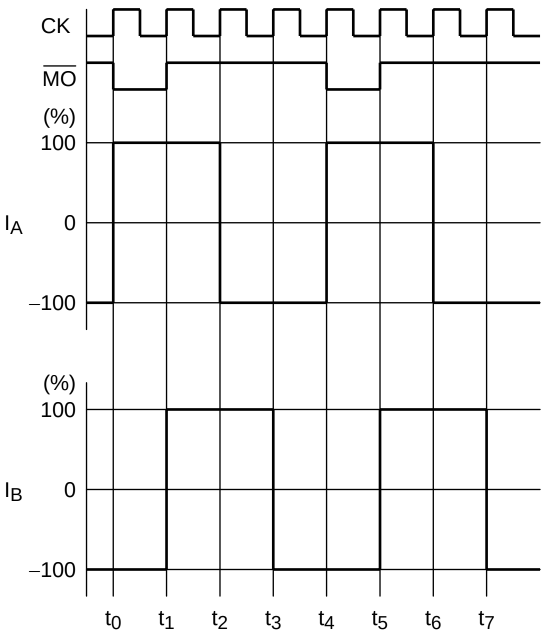
When Rnf = 2 Ω and Vref = 0.5 V with TQ set High;

I (Limit) = 250 mA

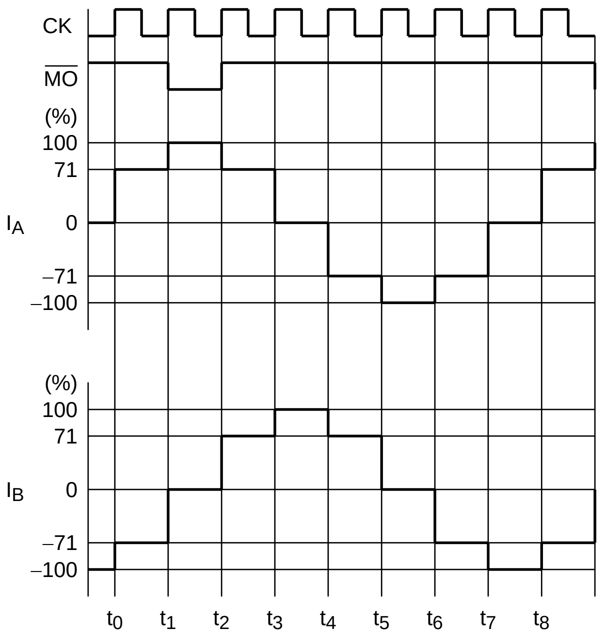
5. Excitation Modes

The excitation mode can be specified by M1 and M2 to either 2-phase, 1-2-phase, W1-2-phase or 2W1-2-phase mode. And the rotation direction can be selected from clockwise and counterclockwise with the CW/CCW pin. The TB6608FNG allows easy motor control by only using the clock signal as an input signal.

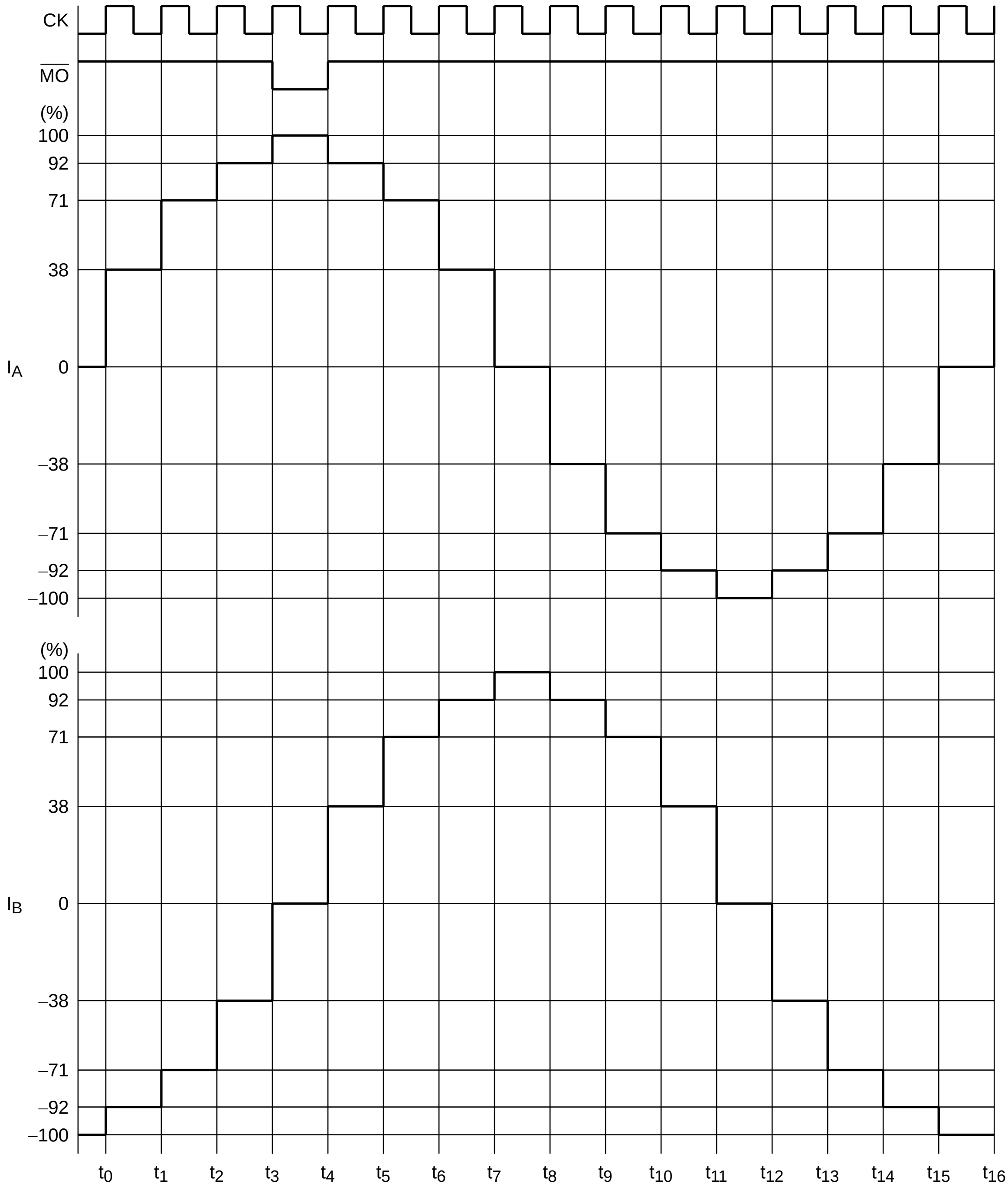
2-PhaseEexcitation (M1: L, M2: L, CW mode)



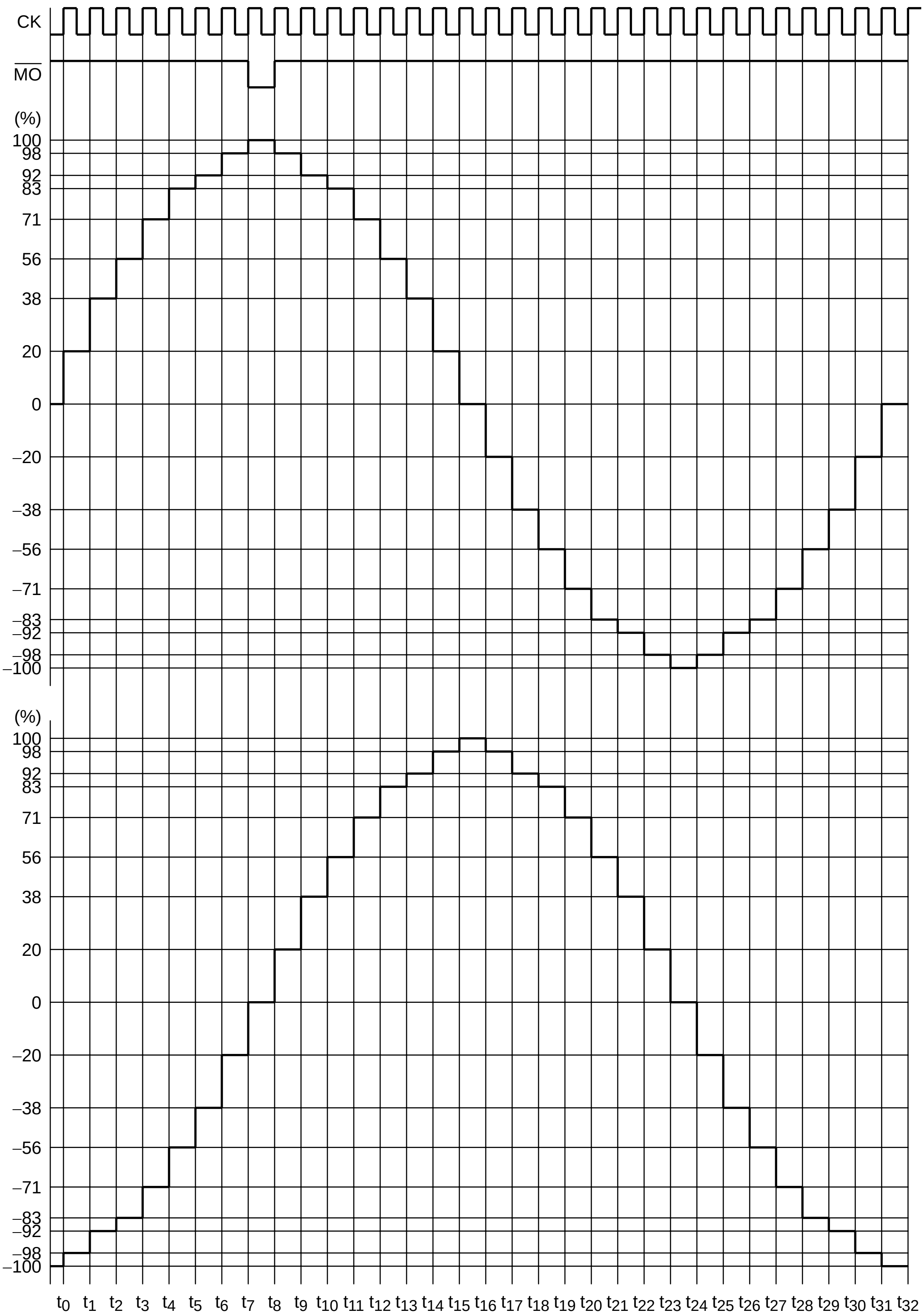
1-2-Phase Excitation (M1: H, M2: L, CW mode)



W1-2-Phase Excitation (M1: L, M2: H, CW mode)



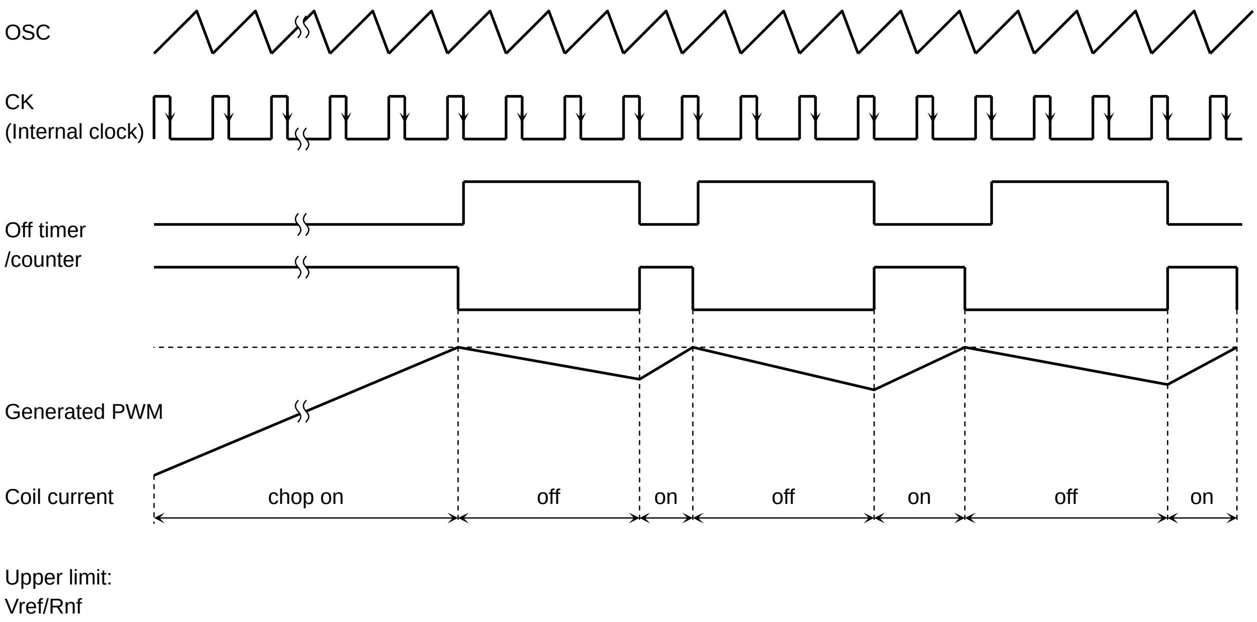
2W1−2-Phase Excitation (M1: H, M2: H, CW mode)



6. Chopper Control System

Turning on the power (chop on) causes a current to flow into the coils. Once the voltage (V_{RF}) reaches Vref, it is detected by the comparator and the power is turned off (chop off).

The off timer/counter counts the number of falling edges of the CK signal, which is derived from the OSC signal. The motor-driving-PWM signal is generated by setting the signal off-time to be four CK cycles.



The upper limit of the current across the motor coil (i.e., the peak current in each excitation mode), I (Limit), can be calculated as follows:

I (Limit) = Vref/Rnf

Vref is 0.125 V when TQ is Low, while it is 0.5 V when TQ is High.

Rnf is the value of resistors used for output current detection. One of those resistors is connected between RFA and GND, and the other is connected between RFB and GND.

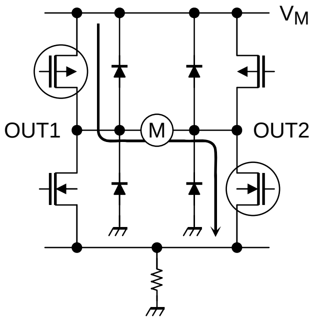
The timing chart may be simplified for the sake of brevity.

7. PWM Control

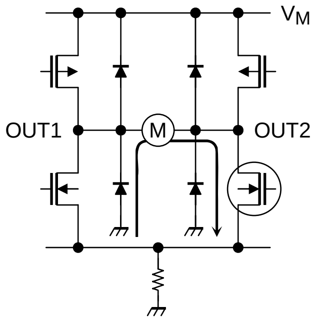
In PWM mode, the motor operating mode changes between CW/CCW and short brake alternately.

To eliminate short-through current due to the simultaneous conduction of high-side and low-side transistors in the bridge output, a dead time of 200 ns (design target value), which is expressed as t2 or t4, are generated in the IC when transistors switch from on to off, or vice versa.

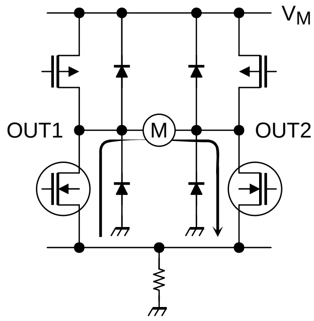
This permits a synchronous rectification PWM operation without controlling the dead time externally.



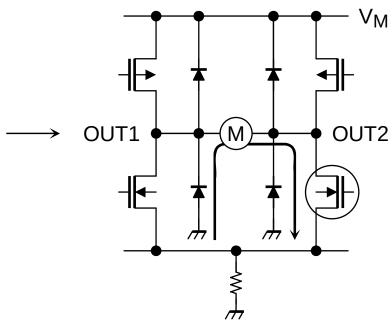
<PWM: ON>
t1



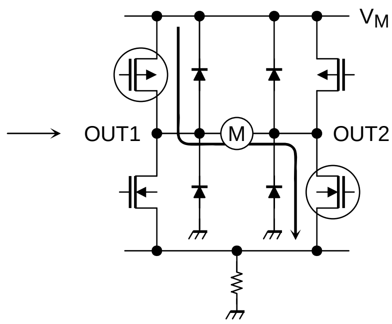
<PWM: ON → OFF>
t2 = 200 ns (typ.)



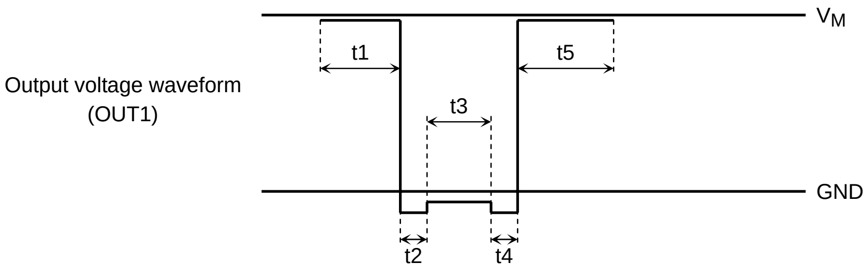
<PWM: OFF>
t3



<PWM: OFF → ON>
t4 = 200 ns (typ.)



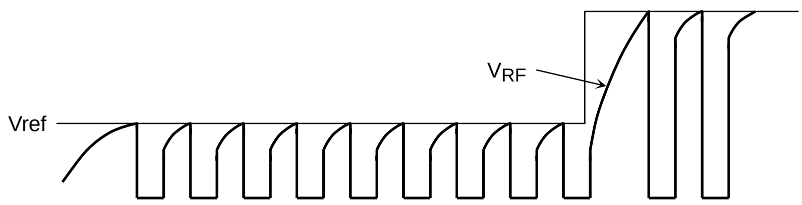
<PWM: ON>
t5

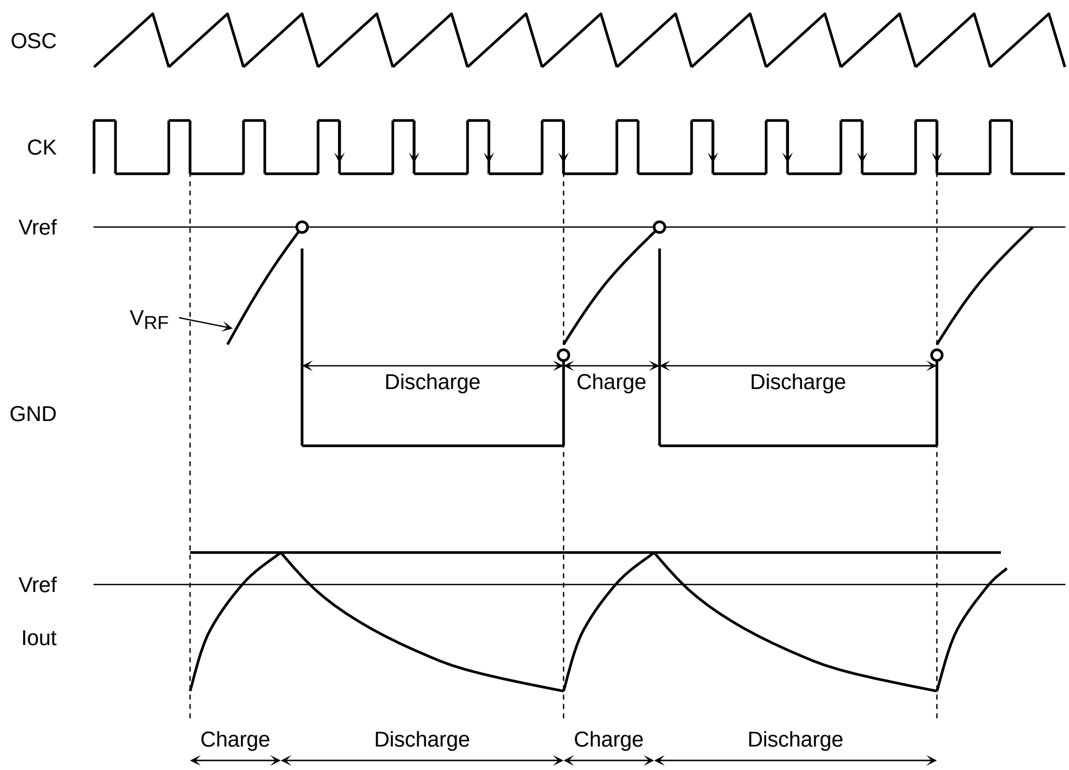


(1) Constant-Current Chopping Mode

When V_{RF} reaches the reference voltage (Vref), the regulator enters Discharge mode.

After four clock cycles of CK, an internal clock generated by OSC, the regulator moves from Discharge mode to Charge mode.

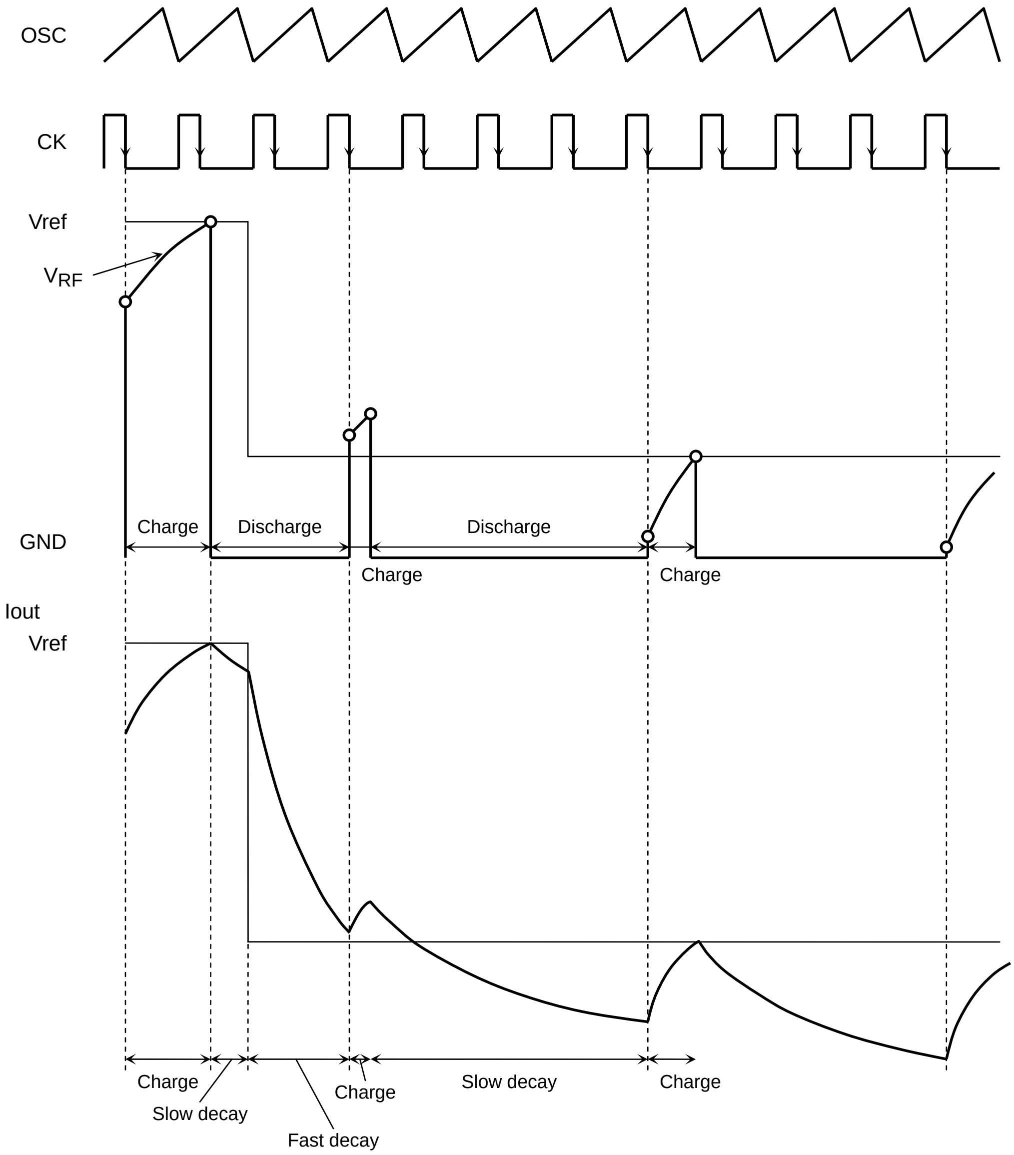




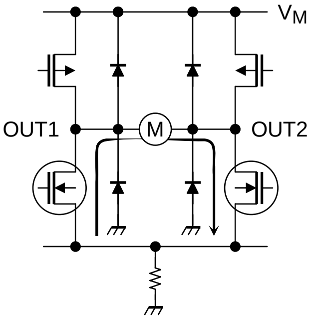
(2) Changing the Predefined Current (during deceleration)

During deceleration, the regulator enters fast-decay mode immediately after the end of the current decay slope of slow-decay mode. The distortion of the current waveform can be reduced by recirculating the coil current to the power supply. Two CK cycles later, the regulator exits fast decay mode and enters Charge mode. (The fast-decay time, which is specified herein as two CK cycles, varies depending on the mode setting. A detailed description of the mode setting is provided in Section 7, Current Decay Mode.)

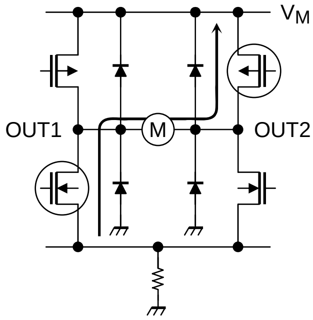
When V_{RF} reaches the reference voltage (Vref), the regulator enters Discharge mode. Four CK cycles later, the regulator exits Discharge mode and enters Charge mode. If V_{RF} > Vref when it enters Charge mode, however, it then reenters Discharge mode. Four CK cycles later, V_{RF} is again compared against Vref. If V_{RF} < Vref, the regulator remains in Charge mode until V_{RF} reaches Vref.



In fast-decay mode, the coil current is recirculated to the power supply as shown below.



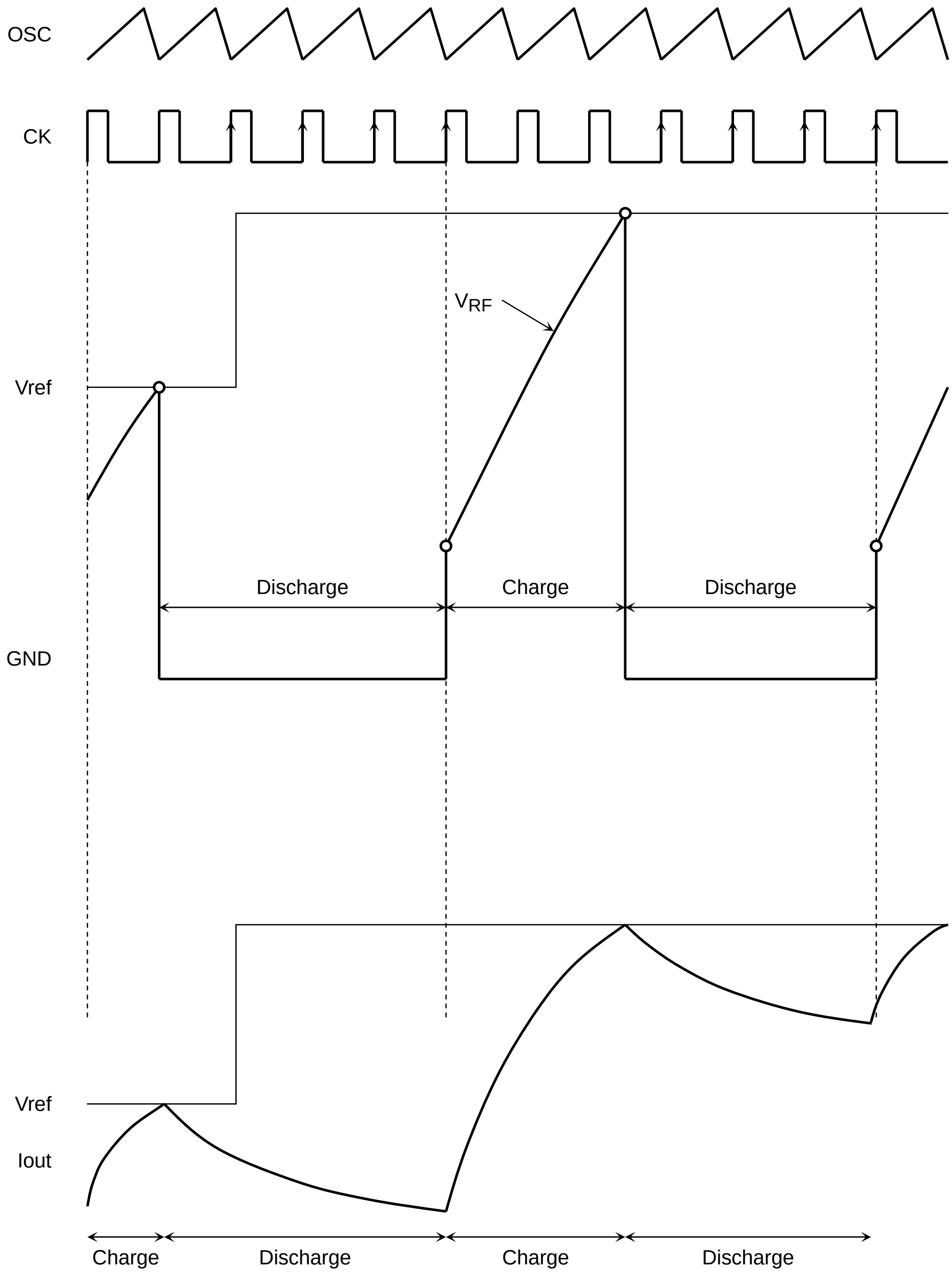
(Slow Decay Mode)



(Fast Decay Mode)

(3) Changing the Predefined Current (during acceleration)

Even when the reference voltage is increased, the regulator remains in Discharge mode for four CK cycles and then enters Charge mode. During acceleration, the current decays only in slow-decay mode.



8. Current Decay Mode

The output current waveform may vary depending on several conditions, such as the motor characteristics, output current and internal oscillation frequency. Thus, these settings should be adjusted properly for each motor by observing the current waveform.

For your reference, the settings for the current decay mode are listed below.

If no distortion can be observed in the output current waveform, the DCY pin should be kept High. The distortion reduction depends on the motor characteristics. If any distortion can be observed, the DCY pin should be kept Low. Also, it is recommended that the DCY input be set High only when the coil of a motor has an inductance of 1.5 mH or higher where fosc is no less than 100 kHz.

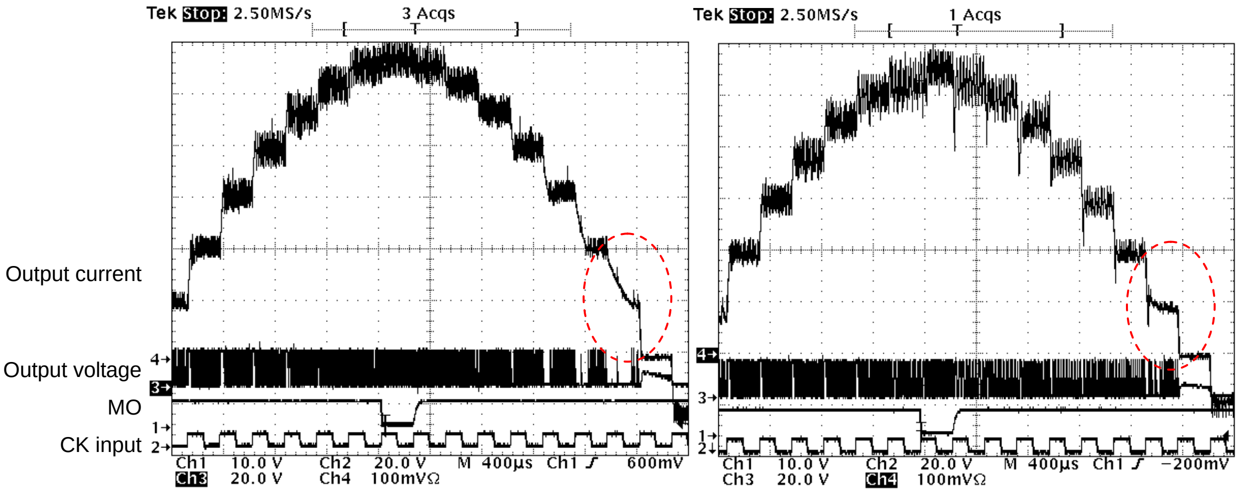
Table Fast-Decay Time Inserted During the Current Decay Period

(which is expressed as number of the CK cycle (an actual value may not exactly equal to the specified value).)

Input	2W1-2-Phase			W1-2-Phase			1-2-Phase		
	Predefined Current	Number of Clock Cycles		Predefined Current	Number of Clock Cycles		Predefined Current	Number of Clock Cycles	
DCY	%	TQ = H	TQ = L	%	TQ = H	TQ = L	%	TQ = H	TQ = L
L	100			100			100		
	98	0	0						
	92	0	0	92	0	0			
	83	0	0						
	71	0	0	71	0	0	71	0	0
	56	0	0						
	38	0	0	38	0	0			
	20	0	0						
	0	0	0	0	0	0	0	0	0
H	100			100			100		
	98	2	1						
	92	2	1	92	2	1			
	83	2	1						
	71	2	1	71	4	2	71	4	2
	56	4	2						
	38	4	2	38	4	2			
	20	4	2						
	0	0	0	0	0	0	0	0	0

As can be seen from the operating waveforms of a motor in the figures below, switching the operating mode from (1) slow decay mode (DCY = Low) to (2) fast decay mode (DCY = High) can reduce the distortion of output waveforms so that the motor can be properly operated.

Operating Waveforms in 2W1-2-Phase Excitation Mode



(1) DCY = L
Slow Decay Mode

(2) DCY = H
Fast Decay Mode

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