



SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

STK672-050-E — Thick-Film Hybrid IC Unipolar Constant-current Chopper (external excitation PWM) Circuit with Built-in Microstepping Controller Stepping Motor Driver (sine wave drive) Output Current 3.0A (no heat sink*)

Overview

The STK672-050-E is a stepping motor driver hybrid IC that uses power MOSFETs in the output stage. It includes a built-in microstepping controller and is based on a unipolar constant-current PWM system. The STK672-050-E supports application simplification and standardization by providing a built-in 4 phase distribution stepping motor controller. It supports five excitation methods: 2 phase, 1-2 phase, W1-2 phase, 2W1-2 phase, and 4W1-2 phase excitations, and can provide control of the basic stepping angle of the stepping motor divided into 1/16 step units. It also allows the motor speed to be controlled with only a clock signal.

The use of this hybrid IC allows designers to implement systems that provide high motor torques, low vibration levels, low noise, fast response, and high-efficiency drive.

Applications

- Facsimile stepping motor drive (send and receive)
- Paper feed and optical system stepping motor drive in copiers
- Laser printer drum drive
- Printer carriage stepping motor drive
- X-Y plotter pen drive
- Other stepping motor applications

Note*: Conditions: $V_{CC1} = 24V$, $I_{OH} = 2.0A$, 2W1-2 excitation mode.

■ Any and all SANYO Semiconductor Co.,Ltd. products described or contained herein are, with regard to "standard application", intended for the use as general electronics equipment (home appliances, AV equipment, communication device, office equipment, industrial equipment etc.). The products mentioned herein shall not be intended for use for any "special application" (medical equipment whose purpose is to sustain life, aerospace instrument, nuclear control device, burning appliances, transportation machine, traffic signal system, safety equipment etc.) that shall require extremely high level of reliability and can directly threaten human lives in case of failure or malfunction of the product or may cause harm to human bodies, nor shall they grant any guarantee thereof. If you should intend to use our products for applications outside the standard applications of our customer who is considering such use and/or outside the scope of our intended standard applications, please consult with us prior to the intended use. If there is no consultation or inquiry before the intended use, our customer shall be solely responsible for the use.

■ Specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein stipulate the performance, characteristics, and functions of the described products in the independent state, and are not guarantees of the performance, characteristics, and functions of the described products as mounted in the customer's products or equipment. To verify symptoms and states that cannot be evaluated in an independent device, the customer should always evaluate and test devices mounted in the customer's products or equipment.

SANYO Semiconductor Co., Ltd.

<http://semicon.sanyo.com/en/network>

Features

- Can implement stepping motor drive systems simply by providing a DC power supply and a clock pulse generator.

<Control Block Features>

- One of five drive types can be selected with the drive mode settings (M1, M2, and M3)
 - 1) 2 phase excitation drive
 - 2) 1-2 phase excitation drive
 - 3) W1-2 phase excitation drive
 - 4) 2W1-2 phase excitation drive
 - 5) 4W1-2 phase excitation drive
- Provides four freely selectable modes for the vector locus during microstepping drive: circular mode, one inside mode, and two outside modes.
- Phase retention even if excitation is switched.
- The excitation phase state can be verified in real time using the MO1, MO2, and MOI signal output pins.
- The CLK input counter block can be selected to be one of the following by the high/low setting of the M3 input pin.
 - 1) Rising edge only
 - 2) Both rising and falling edges
- The CLK and RETURN input pins include built-in malfunction prevention circuits for external pulse noise.
- ENABLE and RESET pins provided. These are Schmitt trigger inputs with built-in 20kΩ (typical) pull-up resistors.
- No noise generation due to the difference between the A and B phase time constants during motor hold since external excitation is used.
- Microstepping operation supported even for small motor currents, since the reference voltage Vref can be set to any value between 0V and 1/2V_{CC2}.

<Driver Block>

- External excitation PWM drive allows a wide operating supply voltage range (V_{CC1} = 10 to 45V) to be used.
- Current detection resistor (0.2Ω) built-in the hybrid IC itself.
- Power MOSFETs adopted for low drive loss.
- Provides a motor output drive current of I_{OH} = 3.0A.

Specifications

Absolute Maximum Ratings at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|---------------------------------|----------------------|---|--------------|------|
| Maximum supply voltage 1 | V _{CC1} max | No signal | 52 | V |
| Maximum supply voltage 2 | V _{CC2} max | No signal | -0.3 to +7.0 | V |
| Input voltage | V _{IN} max | Logic input pins | -0.3 to +7.0 | V |
| Output current | I _{OH} max | 0.5s, 1 pulse, when V _{CC1} applied. Load: R = 5Ω, L = 10mH for each phase. | 4.0 | A |
| Repeated avalanche capacity | E _{ar} max | | 38 | mJ |
| Allowable power dissipation | P _d max | θ _{c-a} = 0 | 25 | W |
| Operating substrate temperature | T _c max | | 105 | °C |
| Junction temperature | T _J max | | 150 | °C |
| Storage temperature | T _{stg} | | -40 to +125 | °C |

Allowable Operating Ranges at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|--------------------------------|------------------|--|-----------------------|------|
| Supply voltage 1 | V _{CC1} | With signals applied | 10 to 45 | V |
| Supply voltage 2 | V _{CC2} | With signals applied | 5 ± 5% | V |
| Input voltage | V _{IH} | | 0 to V _{CC2} | V |
| Phase driver withstand voltage | V _{DSS} | Tr1, 2, 3, and 4 (the A, \bar{A} , B, and \bar{B} outputs) | 100 (min) | V |
| Output current | I _{OH} | Duty 50% | 3.0 | A |

STK672-050-E

Electrical Characteristics at $T_c = 25^\circ\text{C}$, $V_{CC1} = 24\text{V}$, $V_{CC2} = 5\text{V}$

| Parameters | Symbols | Conditions | Rating | | | unit |
|------------------------------------|------------|---|--------|------|------|---------------|
| | | | min | typ | max | |
| Control supply current | I_{CC} | Pin 7, with ENABLE pin held low. | | 4.5 | 15 | mA |
| Output saturation voltage | V_{sat} | $R_L = 7.5\Omega$ ($I \approx 3\text{A}$) | | 1.4 | 2.6 | V |
| Average output current | I_{oave} | Load: $R = 3.5\Omega$ / $L = 3.8\text{mH}$ For each phase, $V_{ref} \approx 0.6\text{V}$ | 0.45 | 0.50 | 0.55 | A |
| FET diode forward voltage | V_{df} | $I_f = 1\text{A}$ | | 1.2 | 1.8 | V |
| [Control Inputs] | | | | | | |
| Input voltage | V_{IH} | Except for the V_{ref} pin | 4 | | | V |
| | V_{IL} | Except for the V_{ref} pin | | | 1 | V |
| Input current | I_{IH} | Except for the V_{ref} pin | 0 | 1 | 10 | μA |
| | I_{IL} | Except for the V_{ref} pin | 125 | 250 | 510 | μA |
| [Vref Input Pin] | | | | | | |
| Input voltage | V_I | Pin 8 | 0 | | 2.5 | V |
| Input current | I_I | Pin 8 | | 1 | | μA |
| [Control Outputs] | | | | | | |
| Output voltage | V_{OH} | $I = -3\text{mA}$, pins MOI, MO1, MO2 | 2.4 | | | V |
| | V_{OL} | $I = +3\text{mA}$, pins MOI, MO1, MO2 | | | 0.4 | V |
| [Current Distribution Ratio (A-B)] | | | | | | |
| 2W1-2, W1-2, 1-2 | V_{ref} | $\theta = 1/8$ | | 100 | | % |
| 2W1-2, W1-2 | V_{ref} | $\theta = 2/8$ | | 92 | | % |
| 2W1-2 | V_{ref} | $\theta = 3/8$ | | 83 | | % |
| 2W1-2, W1-2, 1-2 | V_{ref} | $\theta = 4/8$ | | 71 | | % |
| 2W1-2 | V_{ref} | $\theta = 5/8$ | | 55 | | % |
| 2W1-2, W1-2 | V_{ref} | $\theta = 6/8$ | | 40 | | % |
| 2W1-2 | V_{ref} | $\theta = 7/8$ | | 20 | | % |
| 2 | V_{ref} | | | 100 | | % |
| PWM frequency | f_c | | 37 | 47 | 57 | kHz |

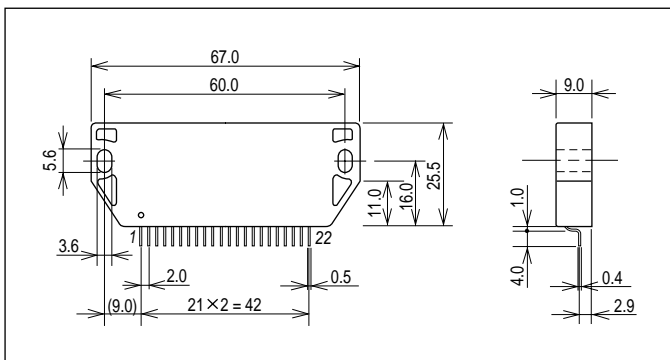
Note: A constant-voltage power supply must be used.

The design target value is shown for the current distribution ratio.

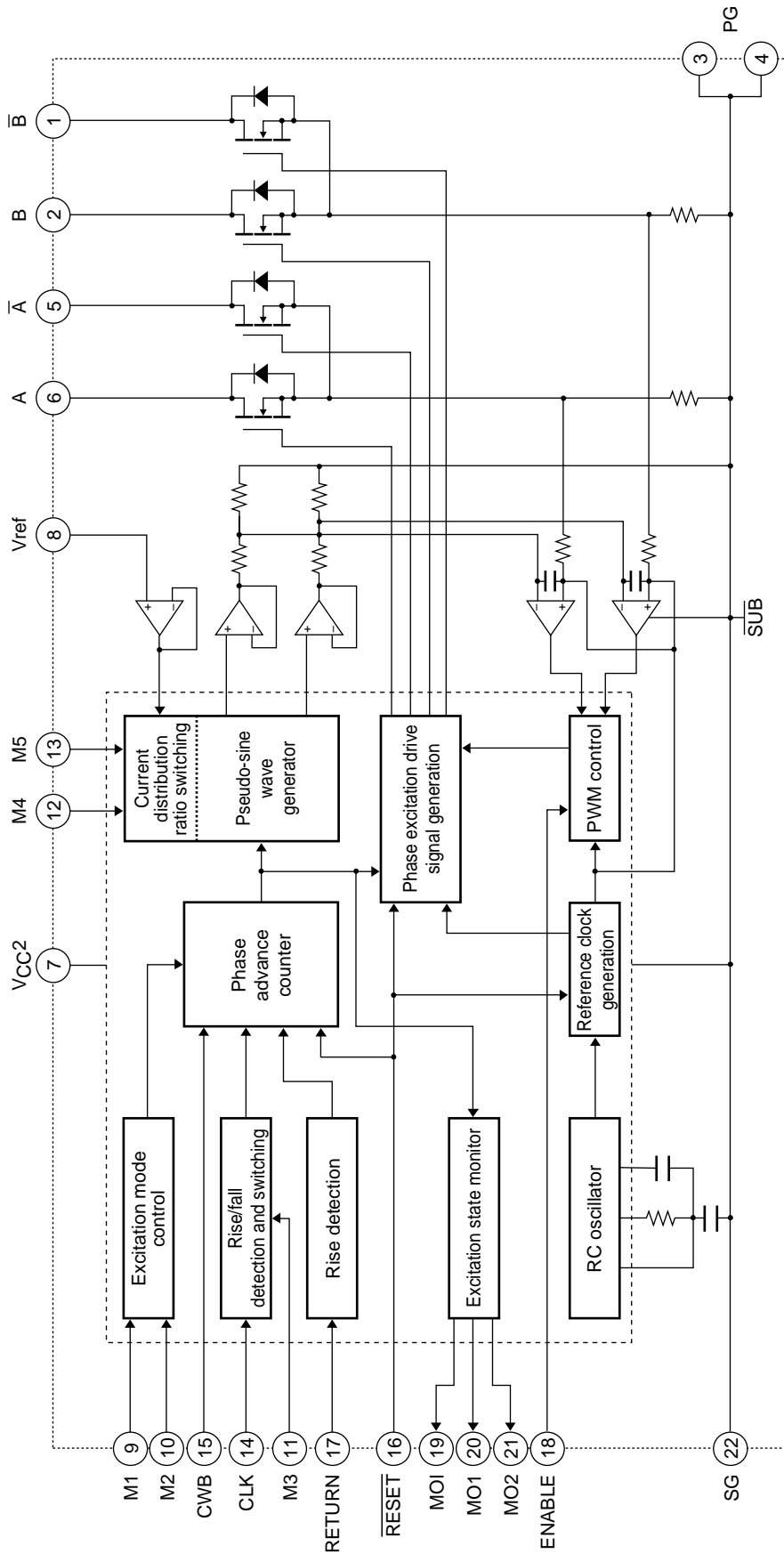
Package Dimensions

unit:mm (typ)

4164



Internal Block Diagram

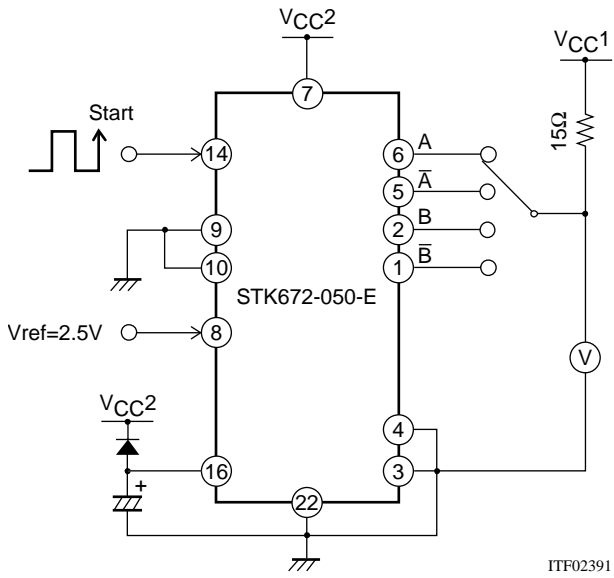


ITF02390

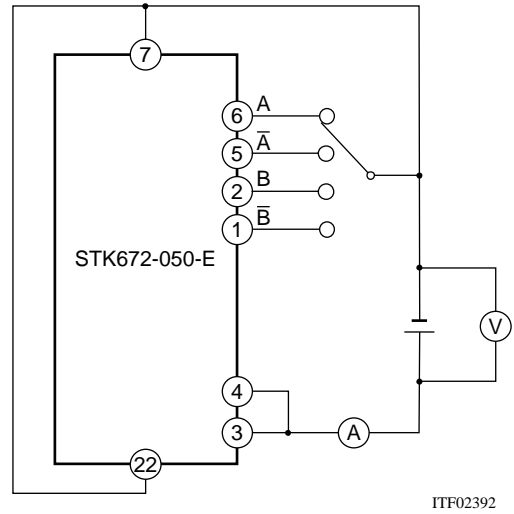
STK672-050-E

Test Circuit Diagrams

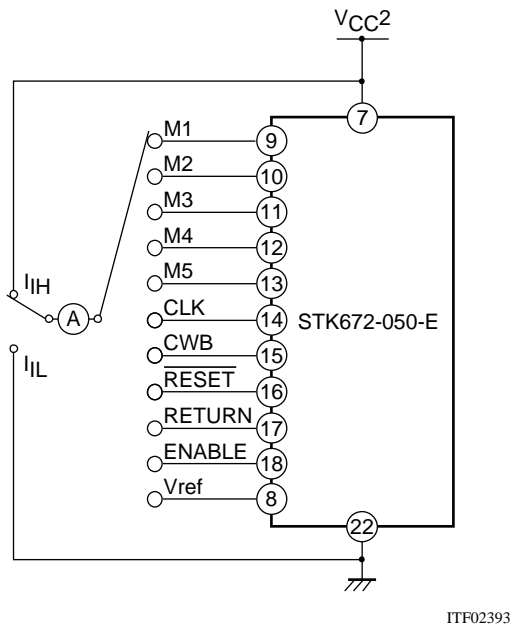
V_{sat}



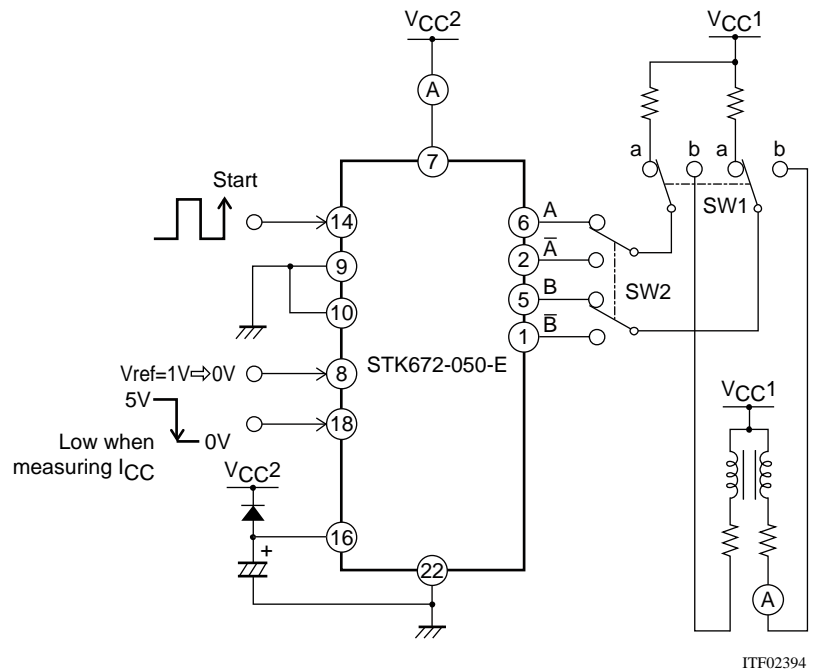
V_{df}



I_{IH}, I_{IL}



I_{oave}, I_{CC}, f_c



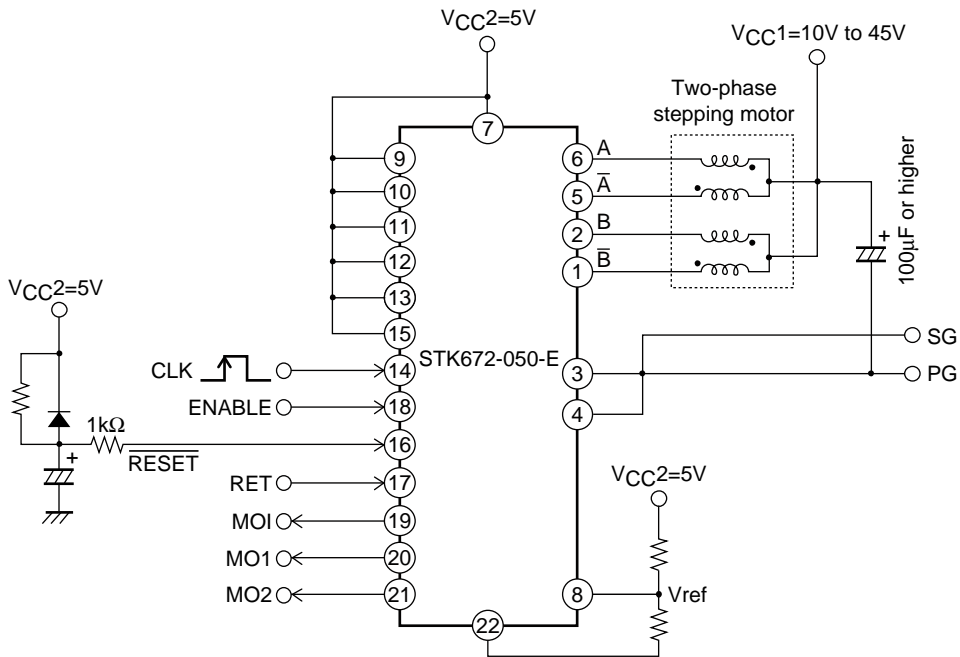
When measuring I_{oave}: With SW1 set to 'a', V_{ref} = 0.6V

When measuring f_c: With SW1 set to 'b', V_{ref} = 0V

When measuring I_{CC}: Set ENABLE low

Power-on Reset

The application must perform a power-on reset operation when VCC2 power is first applied to this hybrid IC. Application circuit that used 2W1-2 phase excitation (microstepping operation) mode.



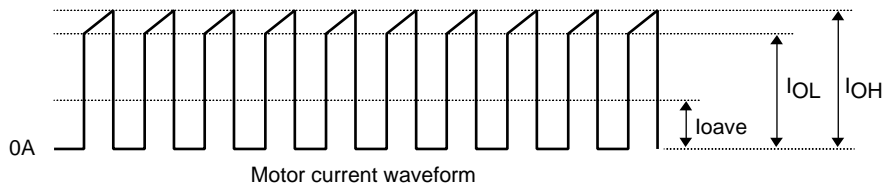
ITF02395

Setting the Motor Current

The motor current I_{OH} is set by the Vref voltage on the hybrid IC pin 8. The following formula gives the relationship between I_{OH} and Vref.

$$I_{OH} = \frac{1}{3} \times V_{ref}/R_s, R_s: \text{The hybrid IC internal current detection resistor } (0.2\Omega \pm 3\%)$$

Applications can use motor currents from the current (0.05 to 0.1A) set by the duty of the frequency set by the oscillator up to the limit of the allowable operating range, $I_{OH} = 3.0A$



A12408

Function Table

| | | | | | | |
|----|---|----------------------|-----------------------|------------------------|-----------------------------------|--------------------------|
| M2 | 0 | 0 | 1 | 1 | Phase switching clock edge timing | |
| M1 | 0 | 1 | 0 | 1 | | |
| M3 | 1 | 2 phase excitation | 1-2 phase excitation | W1-2 phase excitation | 2W1-2 phase excitation | Rising edge only |
| | 0 | 1-2 phase excitation | W1-2 phase excitation | 2W1-2 phase excitation | 4W1-2 phase excitation | Rising and falling edges |

| | | |
|-----|---------|---------|
| | Forward | Reverse |
| CWB | 0 | 1 |

| | |
|--------|-----------------------------------|
| ENABLE | Motor current is cut off when low |
| RESET | Active low |

| | | | | |
|-----|---|-------|---|-------|
| | A | A-bar | B | B-bar |
| MO1 | 1 | 0 | 0 | 1 |
| MO2 | 0 | 0 | 1 | 1 |

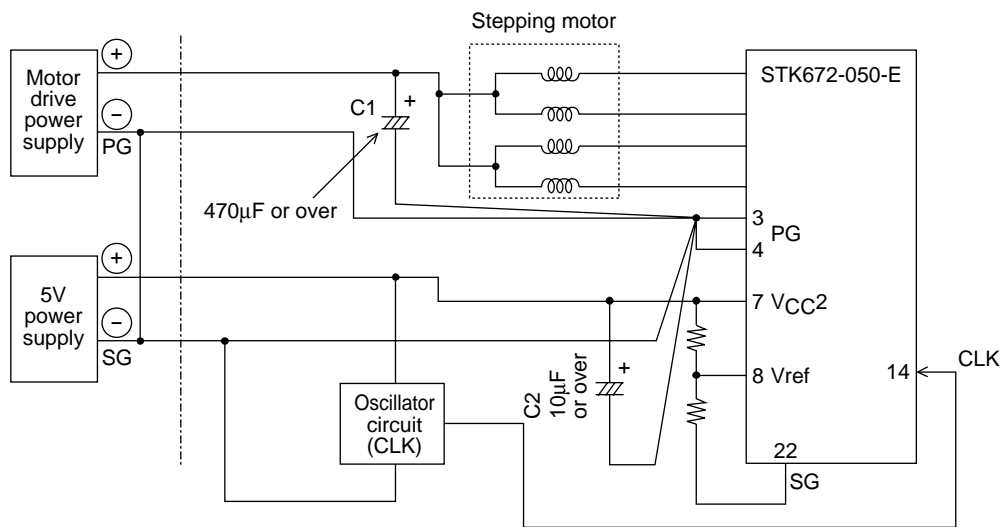
Printed Circuit Board Design Recommendations

This hybrid IC has two grounds, the PG pins (pins 3 and 4) and the SG pin (pin 22). These are connected internally in the hybrid IC.

Two power supplies are required: a motor drive supply and a 5V supply for the hybrid IC itself. If the ground connections for these supplies are not good, the motor current waveforms may become unstable, motor noise may increase, and vibration levels may increase. Use appropriate wiring for these grounds. Here we present two methods for implementing these ground connections.

If the grounds for the motor drive supply and the hybrid IC 5V supply are connected in the immediate vicinity of the power supplies:

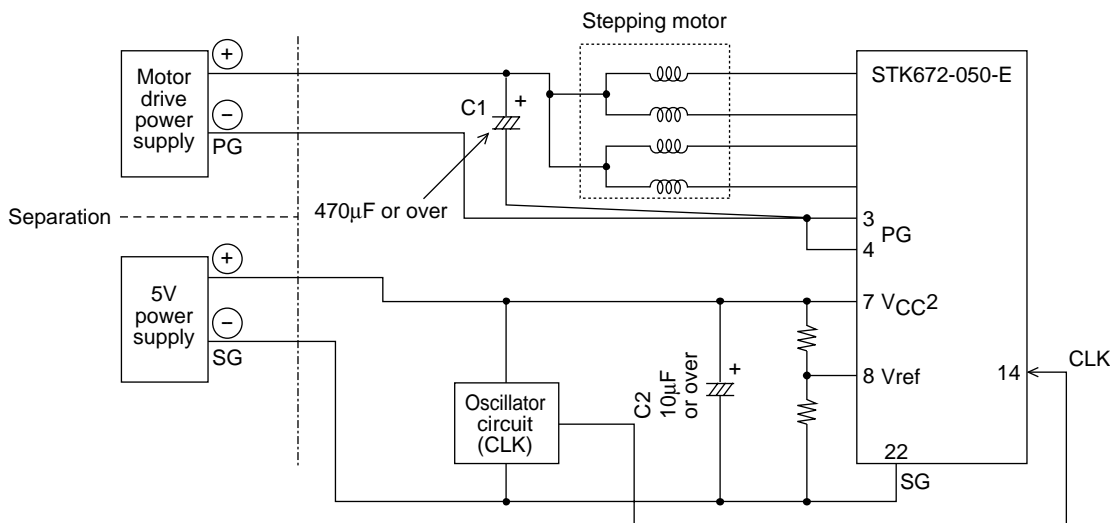
- If PG and SG are shorted at the power supply, connect only the PG line to pins 3 and 4 on the hybrid IC. Also, be sure that no problems occur due to voltage drops due to common impedances. In the specifications, this must be $V_{CC2} \pm 5\%$.
- The current waveforms will be more stable if the Vref ground is connected to pin 22.
- For initial values, use $470\mu\text{F}$ or over for C1 and $10\mu\text{F}$ or over for C2.
Locate C1 as close to the hybrid IC as possible, and the capacitor ground line must be as short as possible.



ITF02396

If the grounds for the motor drive supply and the hybrid IC 5V supply are separated:

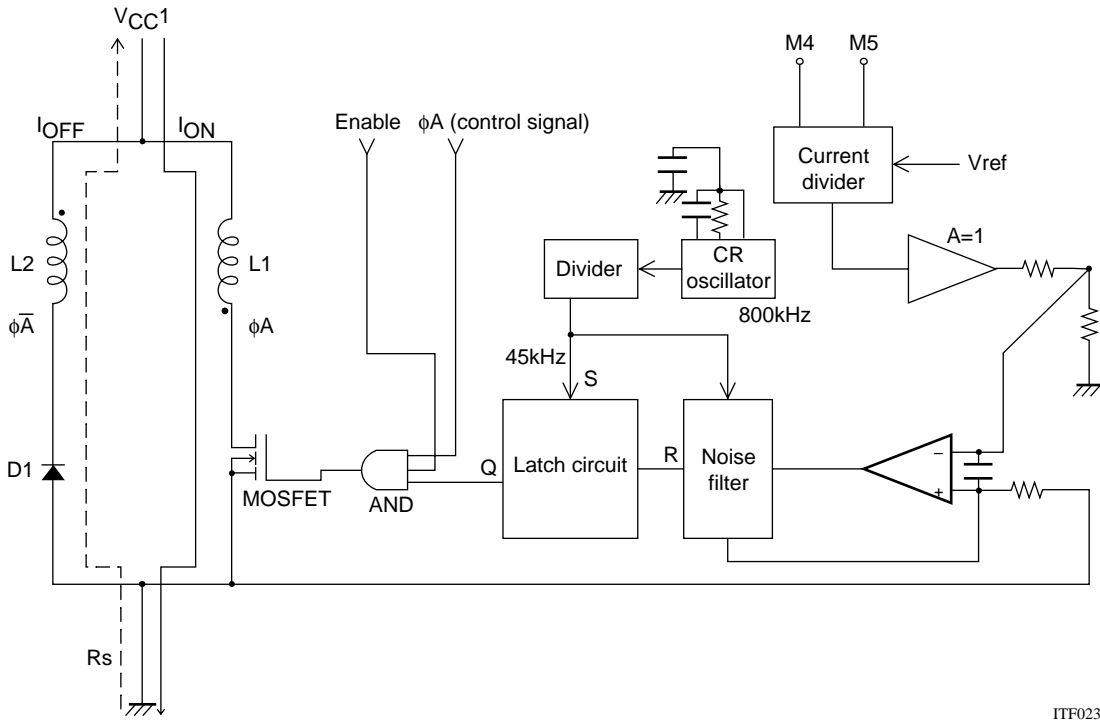
- Insert a capacitor (C1) of $100\mu\text{F}$ or over as close as possible to the hybrid IC. The capacitor ground line must be as short as possible.
The capacitor C2 may be included if necessary. Its ground line should also be as short as possible.



ITF02397

Functional Description

External Excitation Chopper Drive Block Description



ITF02398

Driver Block Basic Circuit Structure

Since this hybrid IC adopts an external excitation method, no external oscillator circuit is required.

When a high level is input to ϕA in the basic driver block circuit shown in the figure and the MOSFET is turned on, the comparator + input will go low and the comparator output will go low. Since a set signal with the PWM period will be input, the Q output will go high, and the MOSFET will be turned on as its initial value.

The current I_{ON} flowing in the MOSFET passes through L1 and generates a potential difference in R_s . Then, when the R_s potential and the V_{ref} potential become the same, the comparator output will invert, and the reset signal Q output will invert to the low level. Then, the MOSFET will be turned off and the energy stored in L1 will be induced in L2 and the current I_{OFF} will be regenerated to the power supply. This state will be maintained until the time when an input to the latch circuit set pin occurs.

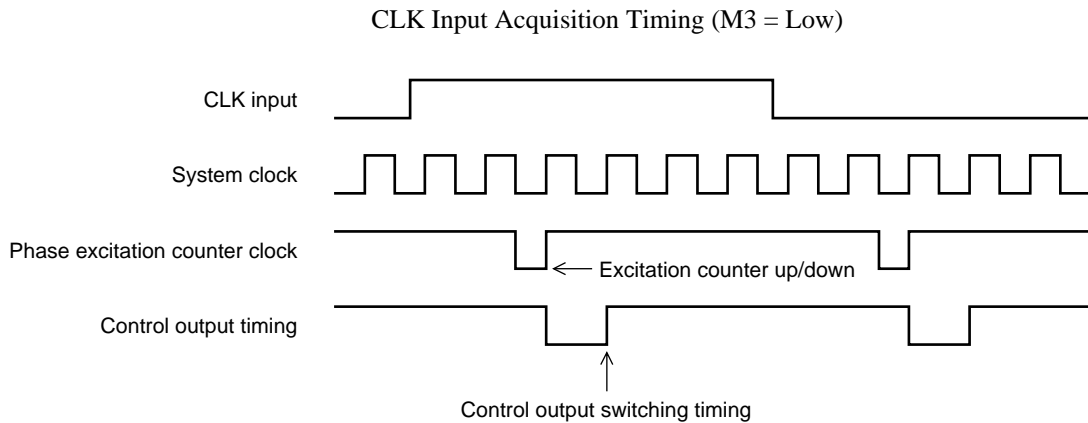
In this manner, the Q output is turned off and on repeatedly by the reset and set signals, thus implementing constant current control. The resistor and capacitor on the comparator input are spike removal circuit elements and synchronize with the PWM frequency. Since this hybrid IC uses a fixed frequency due to the external excitation method and at the same time also adopts a synchronized PWM technique, it can suppress the noise associated with holding a position when the motor is locked.

Input Pin Functions

| Pin No. | Symbol | Function | Pin circuit type |
|-----------|------------|-------------------------------------|--|
| 14 | CLK | Phase switching clock | Built-in pull-up resistor CMOS Schmitt trigger input |
| 15 | CWB | Rotation direction setting (CW/CCW) | Built-in pull-up resistor CMOS Schmitt trigger input |
| 17 | RETURN | Forced phase origin return | Built-in pull-up resistor CMOS Schmitt trigger input |
| 18 | ENABLE | Output cutoff | Built-in pull-up resistor CMOS Schmitt trigger input |
| 9, 10, 11 | M1, M2, M3 | Excitation mode setting | Built-in pull-up resistor CMOS Schmitt trigger input |
| 12, 13 | M4, M5 | Vector locus setting | Built-in pull-up resistor CMOS Schmitt trigger input |
| 16 | RESET | System reset | Built-in pull-up resistor CMOS Schmitt trigger input |
| 8 | Vref | Current setting | Operational amplifier input |

Input Signal Functions and Timing

- CLK (phase switching clock)
 - 1) Input frequency range: DC to 50kHz
 - 2) Minimum pulse width: 10μs
 - 3) Duty: 40 to 60% (However, the minimum pulse width takes precedence when M3 is high.)
 - 4) Pin circuit type: Built-in pull-up resistor (20kΩ, typical) CMOS Schmitt trigger structure
 - 5) Built-in multi-stage noise rejection circuit
 - 6) Function:
 - When M3 is high or open: The phase excited (driven) is advanced one step on each CLK rising edge.
 - When M3 is low: The phase is advanced one step by both rising and falling edges, for a total of two steps per cycle.



A06850

- CWB (Method for setting the rotation direction)
 - 1) Pin circuit type: Built-in pull-up resistor (20kΩ, typical) CMOS Schmitt trigger structure
 - 2) Function:
 - When CWB is low: The motor turns in the clockwise direction.
 - When CWB is high: The motor turns in the counterclockwise direction.
 - 3) Notes: When M3 is low, the CWB input must not be changed for about 6.25μs before or after a rising or falling edge on the CLK input.

- RETURN (Forcible return to the origin for the currently excited phase)
 - 1) Pin circuit type: Built-in pull-up resistor (20kΩ, typical) CMOS Schmitt trigger structure
 - 2) Built-in noise rejection circuit
 - 3) Notes: The currently excited (driven) phase can be forcibly moved to the origin by switching this input from low to high. Normally, if this input is unused, it must be left open or connected to V_{CC2}.

- ENABLE (Controls the on/off state of the A, \bar{A} , B, and \bar{B} excitation drive outputs and selects either operating or hold as the internal state of this hybrid IC.)
 - 1) Pin circuit type: Built-in pull-up resistor (20kΩ, typical) CMOS Schmitt trigger structure
 - 2) Function:
 - When ENABLE is high or open: Normal operating state
 - When ENABLE is low: This hybrid IC goes to the hold state and excitation drive output (motor current) is forcibly turned off. In this mode, the hybrid IC system clock is stopped and no inputs other than the reset input have any effect on the hybrid IC state.

STK672-050-E

- M1, M2, and M3 (Excitation mode and CLK input edge timing selection)

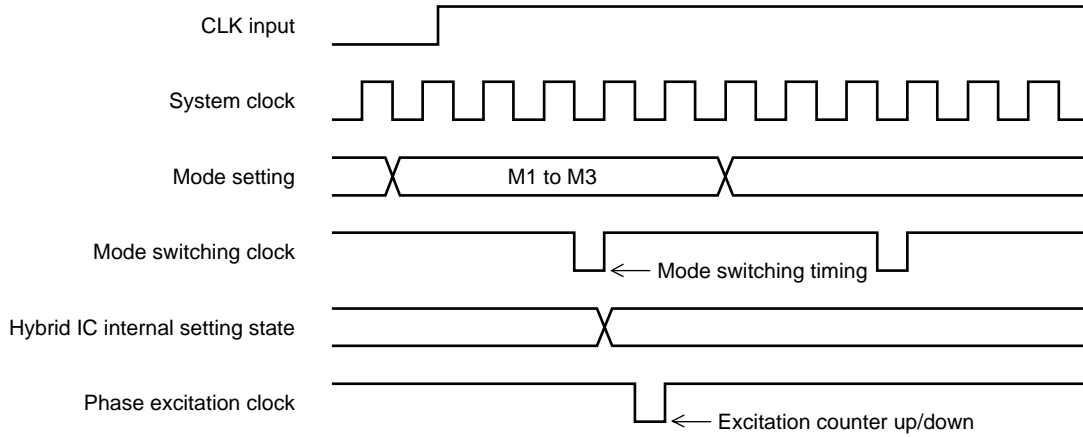
1) Pin circuit type: Built-in pull-up resistor (20kΩ, typical) CMOS Schmitt trigger structure

2) Function:

| | | | | | |
|----|----------------------|-----------------------|------------------------|------------------------|-----------------------------------|
| M2 | 0 | 0 | 1 | 1 | Phase switching clock edge timing |
| M1 | 0 | 1 | 0 | 1 | |
| M3 | 0 | 1 | 0 | 1 | |
| 1 | 2 phase excitation | 1-2 phase excitation | W1-2 phase excitation | 2W1-2 phase excitation | Rising edge only |
| 0 | 1-2 phase excitation | W1-2 phase excitation | 2W1-2 phase excitation | 4W1-2 phase excitation | Rising and falling edges |

3) Valid mode setting timing: Applications must not change the mode in the period 5μs before or after a CLK signal rising or falling edge.

Mode Setting Acquisition Timing

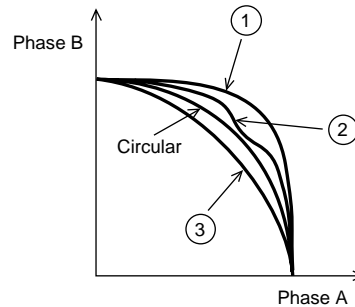


A06851

- M4 and M5 (Microstepping mode rotation vector locus setting)

| | | | | |
|------|----------|---|---|---|
| M4 | 1 | 0 | 1 | 0 |
| M5 | 1 | 0 | 0 | 1 |
| Mode | Circular | ① | ② | ③ |

See page 10 for details on the current division ratio.



ITF02399

- $\overline{\text{RESET}}$ (Resets all parts of the system.)

1) Pin circuit type: Built-in pull-up resistor (20kΩ, typical) CMOS Schmitt trigger structure

2) Function:

- All circuit states are set to their initial values by setting the $\overline{\text{RESET}}$ pin low. (Note that the pulse width must be at least 10μs.)

At this time, the A and $\overline{\text{B}}$ phases are set to their origin, regardless of the excitation mode. The output current goes to about 71% after the reset is released.

3) Notes: When power is first applied to this hybrid IC, Vref must be established by applying a reset. Applications must apply a power on reset when the VCC2 power supply is first applied.

- Vref (Sets the current level used as the reference for constant-current detection.)

1) Pin circuit type: Analog input structure

2) Function:

- Constant-current control can be applied to the motor excitation current at 100% of the rated current by applying a voltage less than the control system power supply voltage VCC2 minus 2.5V.

- Applications can apply constant-current control proportional to the Vref voltage, with this value of 2.5V as the upper limit.

Output Pin Functions

| Pin No. | Symbol | Function | Pin circuit type |
|---------|----------|---------------------------------|-------------------------|
| 19 | MOI | Phase excitation origin monitor | Standard CMOS structure |
| 20, 21 | MO1, MO2 | Phase excitation state monitor | Standard CMOS structure |

Output Signal Functions and Timing

- A, \bar{A} , B, and \bar{B} (Motor phase excitation outputs)

1) Function:

- In the 4 phase and 2 phase excitation modes, a 3.75 μ s (typical) interval is set up between the A and \bar{A} and B and \bar{B} output signal transition times.

- MO1, MO2, and MOI (Phase excitation state monitors)

1) Pin circuit type: Standard CMOS structure

1) Function:

- Output of the current phase excitation output state.

| Phase coordinate | Phase A | Phase B | Phase \bar{A} | Phase \bar{B} |
|------------------|---------|---------|-----------------|-----------------|
| MO1 | 1 | 0 | 0 | 1 |
| MO2 | 0 | 1 | 0 | 1 |

MOI outputs a 0 when each phase is at the origin, and outputs a 1 otherwise.

- Current division ratios set by M3, M4, and M5 Values provided for reference purposes.

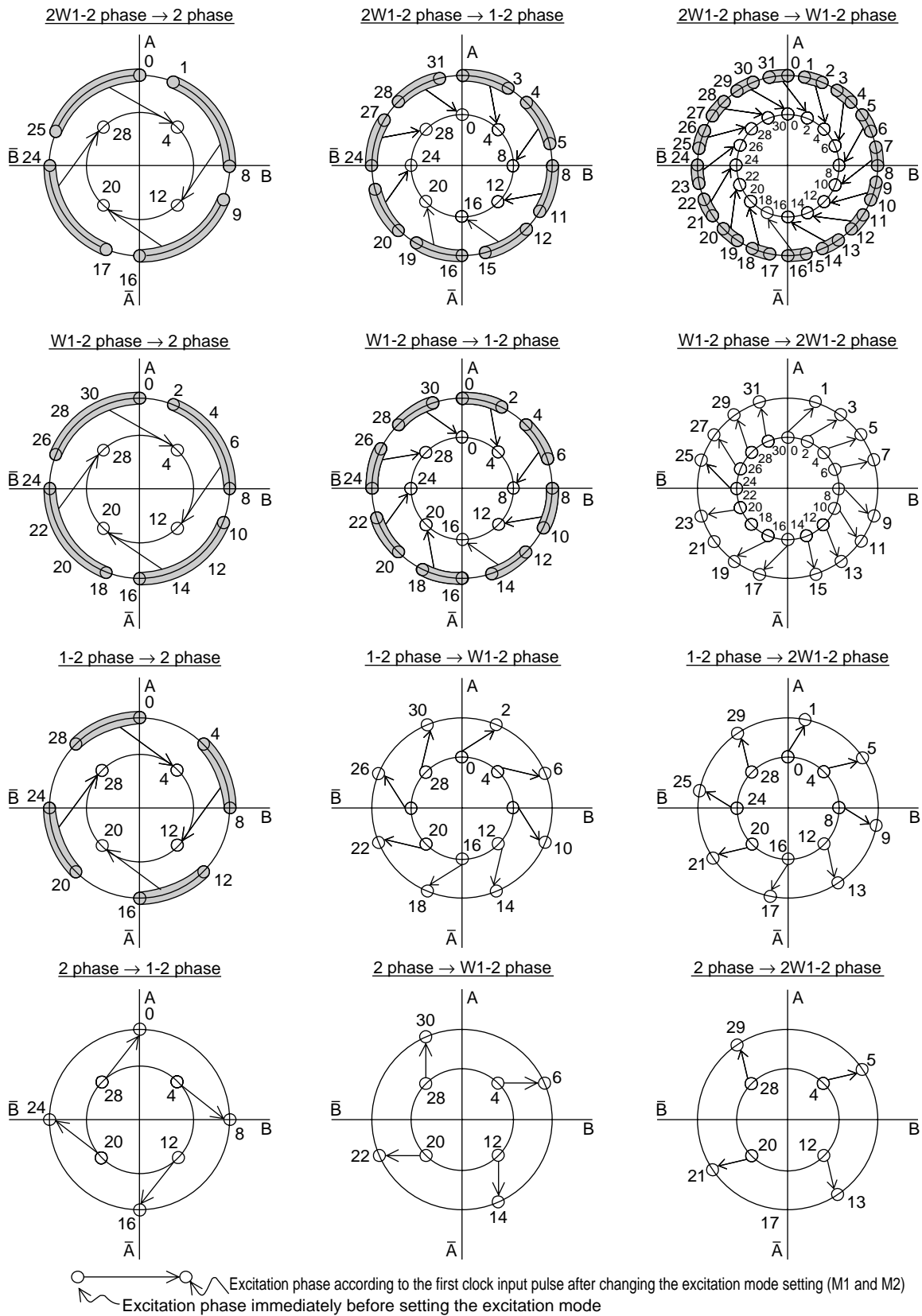
| Mode | | Circular | ① | ② | ③ | Units | Number of steps | | |
|------------------------------|--------|------------------|------------------|------------------|------------------|-------|-----------------|------|-------|
| Setting | M3 = 0 | M4 = 1 M5 = 1 | M4 = 0 M5 = 0 | M4 = 1 M5 = 0 | M4 = 1 M5 = 1 | | | | |
| Current division ratio | 4W1-2 | | 14 | 15 | 15 | % | | 1/16 | |
| | | 2W1-2 | 20 | 25 | 23 | | 19 | 1/8 | 2/16 |
| | | | 31 | 34 | 33 | | 28 | | 3/16 |
| | | 2W1-2 | 40 | 44 | 42 | | 39 | 2/8 | 4/16 |
| | | | 48 | 51 | 49 | | 45 | | 5/16 |
| | | 2W1-2 | 55 | 62 | 57 | | 54 | 3/8 | 6/16 |
| | | | 65 | 69 | 65 | | 62 | | 7/16 |
| | | 2W1-2 | 71 | 77 | 71 | | 69 | 4/8 | 8/16 |
| | | | 77 | 82 | 77 | | 74 | | 9/16 |
| | | 2W1-2 | 83 | 88 | 85 | | 82 | 5/8 | 10/16 |
| | | | 88 | 92 | 89 | | 85 | | 11/16 |
| | | 2W1-2 | 92 | 95 | 95 | | 92 | 6/8 | 12/16 |
| | | | 97 | 98 | 98 | | 94 | | 13/16 |
| | | 2W1-2 | 100 | 100 | 100 | | 100 | 7/8 | 14/16 |

[Load conditions]

V_{CC1} = 24V, V_{CC2} = 5V, R/L = 3.5/3.8mH

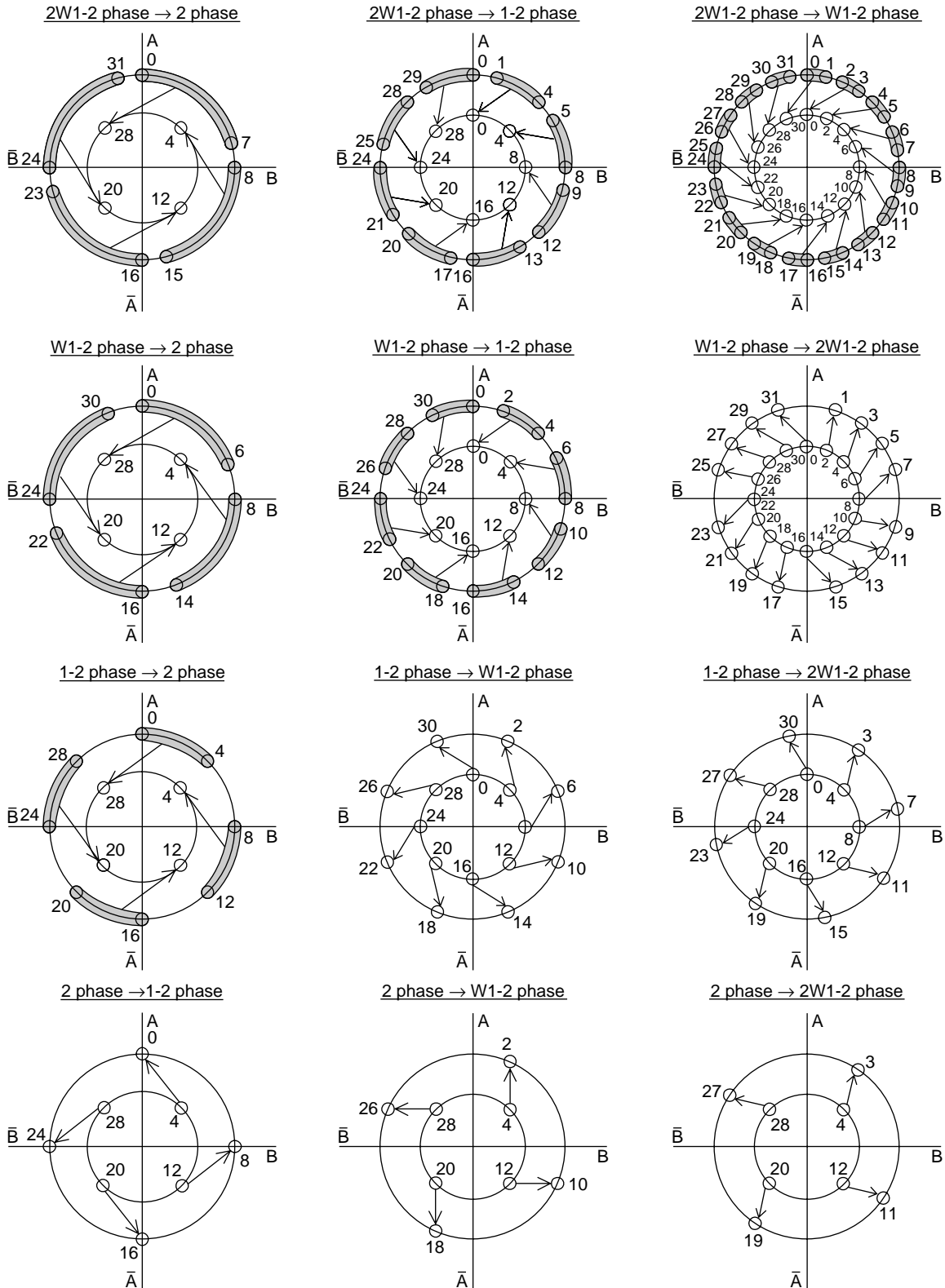
Phase States During Excitation Switching

- Excitation phases before and after excitation mode switching <clockwise direction>



STK672-050-E

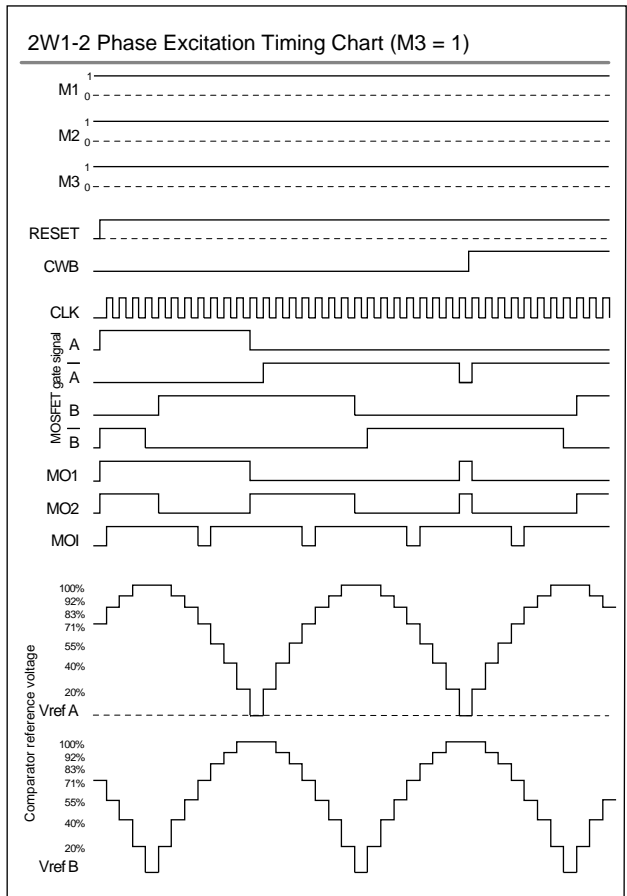
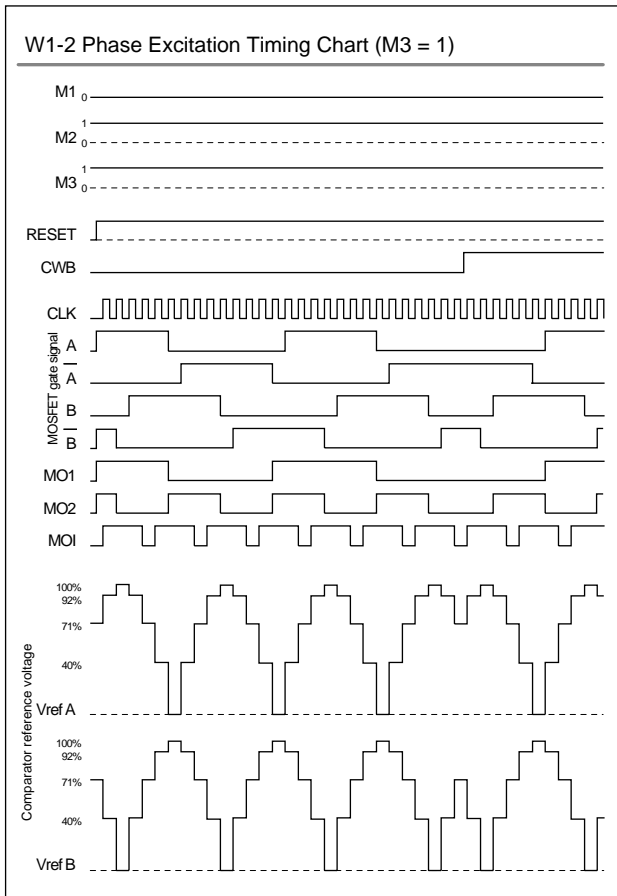
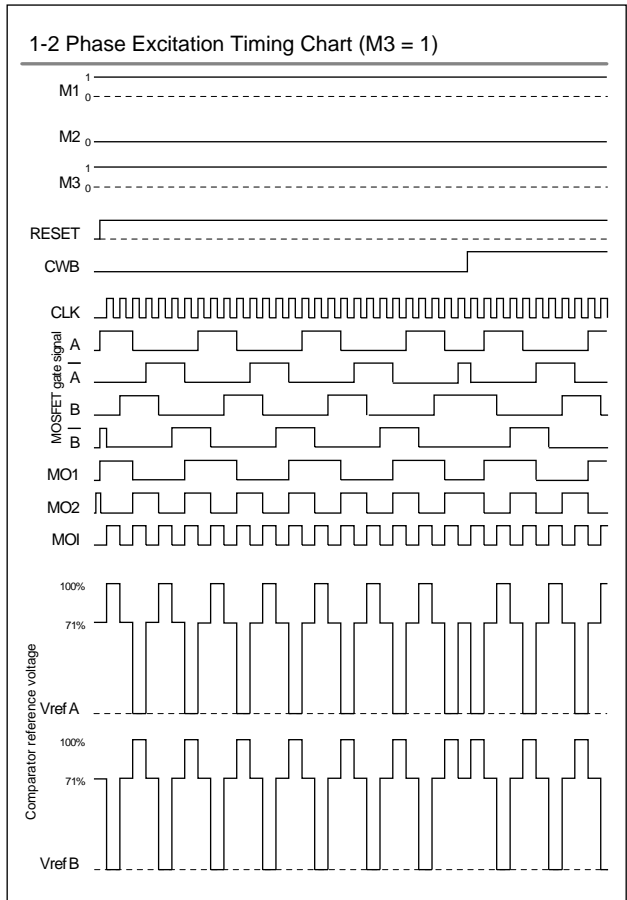
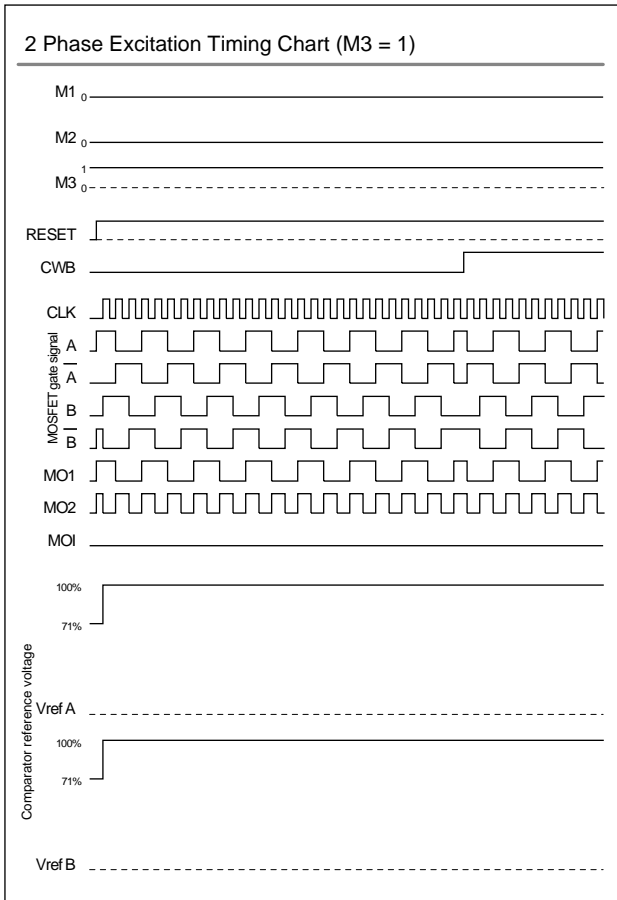
- Excitation phases before and after excitation mode switching <counterclockwise direction>



A12413

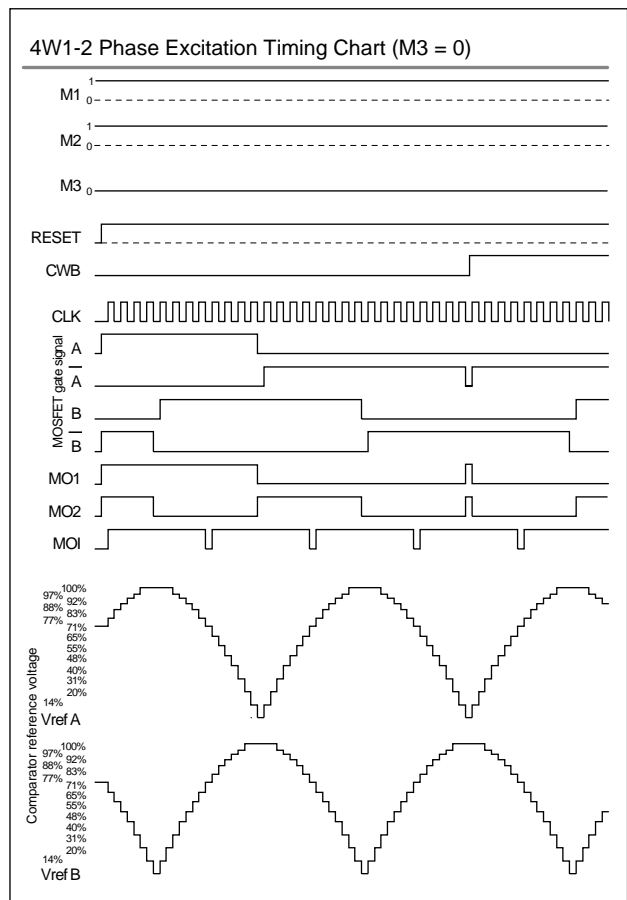
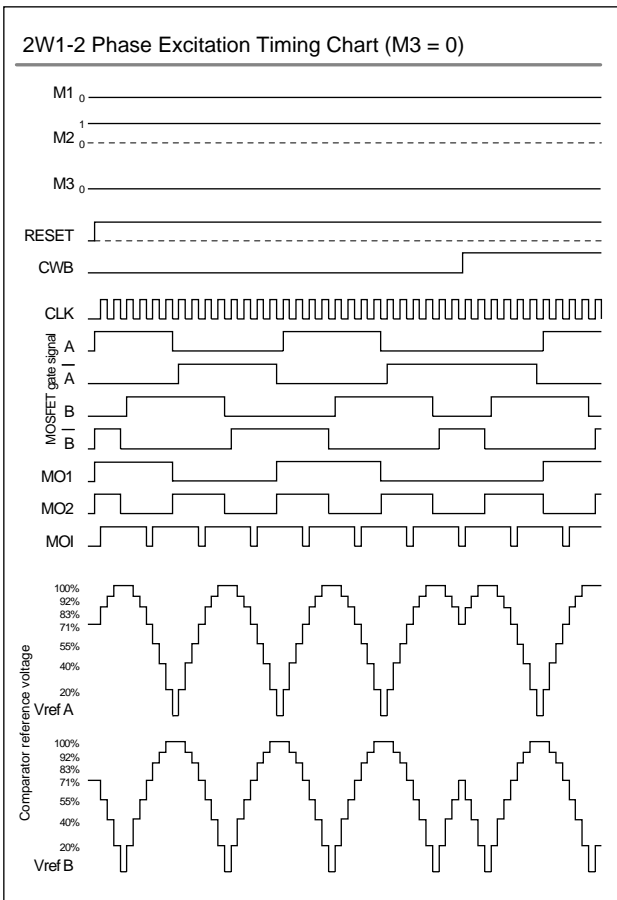
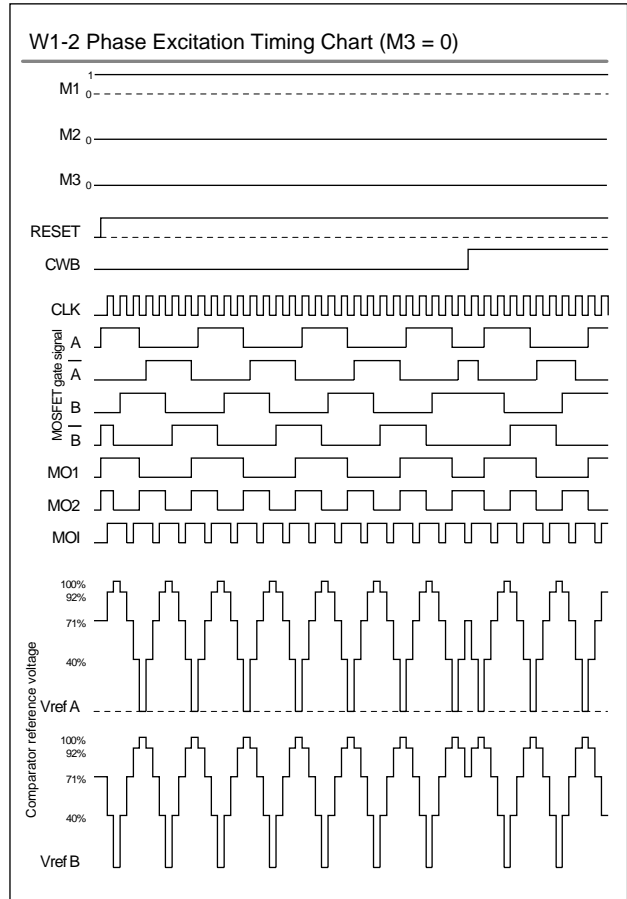
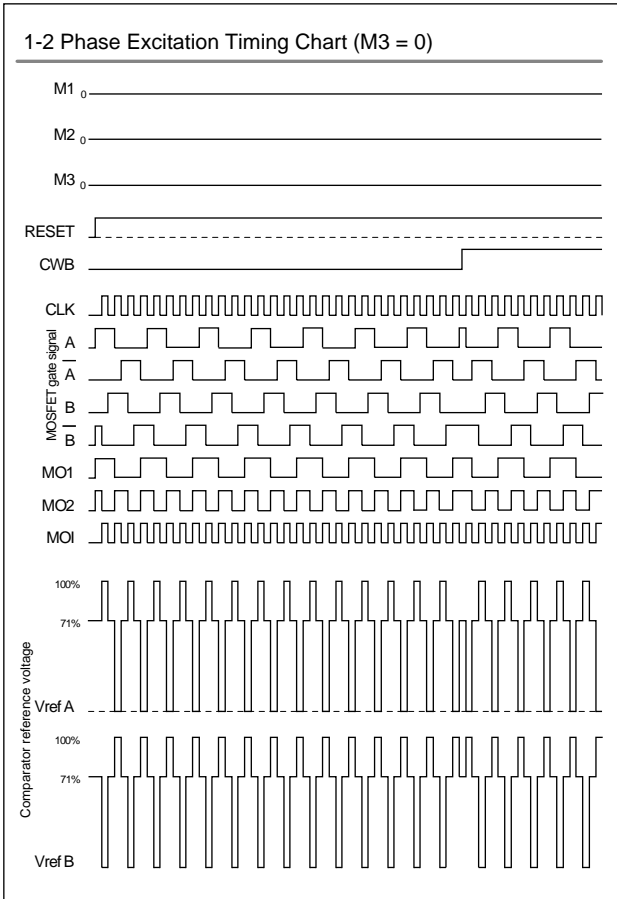
Excitation Time and Timing Charts

- CLK rising edge operation



ITF02400

• CLK rising and falling edge operation



Thermal Design

<Hybrid IC Average Internal Power Loss Pd>

The main elements internal to this hybrid IC with large average power losses are the current control devices, the regenerative current diodes, and the current detection resistor. Since sine wave drive is used, the average power loss during microstepping drive can be approximated by applying a waveform factor of 0.64 to the square wave loss during 2 phase excitation.

The losses in the various excitation modes are as follows.

2 phase excitation
$$Pd_{2EX} = (V_{sat}+V_{df}) \cdot \frac{f_{clock}}{2} \cdot I_{OH} \cdot t_2 + \frac{I_{OH} \cdot f_{clock}}{2} \cdot (V_{sat} \cdot t_1 + V_{df} \cdot t_3)$$

1-2 phase excitation
$$Pd_{1-2EX} = 0.64 \cdot \{(V_{sat}+V_{df}) \cdot \frac{f_{clock}}{4} \cdot I_{OH} \cdot t_2 + \frac{I_{OH} \cdot f_{clock}}{4} \cdot (V_{sat} \cdot t_1 + V_{df} \cdot t_3)\}$$

W1-2 phase excitation
$$Pd_{W1-2EX} = 0.64 \cdot \{(V_{sat}+V_{df}) \cdot \frac{f_{clock}}{8} \cdot I_{OH} \cdot t_2 + \frac{I_{OH} \cdot f_{clock}}{8} \cdot (V_{sat} \cdot t_1 + V_{df} \cdot t_3)\}$$

2W1-2 phase excitation
$$Pd_{2W1-2EX} = 0.64 \cdot \{(V_{sat}+V_{df}) \cdot \frac{f_{clock}}{16} \cdot I_{OH} \cdot t_2 + \frac{I_{OH} \cdot f_{clock}}{16} \cdot (V_{sat} \cdot t_1 + V_{df} \cdot t_3)\}$$

4W1-2 phase excitation
$$Pd_{4W1-2EX} = 0.64 \cdot \{(V_{sat}+V_{df}) \cdot \frac{f_{clock}}{16} \cdot I_{OH} \cdot t_2 + \frac{I_{OH} \cdot f_{clock}}{16} \cdot (V_{sat} \cdot t_1 + V_{df} \cdot t_3)\}$$

Here, t1 and t3 can be determined from the same formulas for all excitation methods.

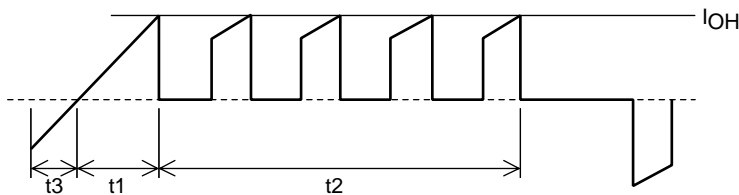
$$t1 = \frac{-L}{R + 0.48} \cdot \ln \left(1 - \frac{R + 0.48}{V_{CC1}} \cdot I_{OH} \right) \qquad t3 = \frac{-L}{R} \cdot \ln \left(\frac{V_{CC1} + 0.48}{I_{OH} \cdot R + V_{CC1} + 0.48} \right)$$

However, the formula for t2 differs with the excitation method.

2 phase excitation
$$t2 = \frac{2}{f_{clock}} - (t1+t3)$$
 1-2 phase excitation
$$t2 = \frac{3}{f_{clock}} - t1$$

W1-2 phase excitation
$$t2 = \frac{7}{f_{clock}} - t1$$
 2W1-2 phase excitation
$$t2 = \frac{15}{f_{clock}} - t1$$

 4W1-2 phase excitation



A12414

Motor Phase Current Model Figure (2 Phase Excitation)

f_{clock} : CLK input frequency (Hz)

V_{sat} : The voltage drop of the power MOSFET and the current detection resistor (V)

V_{df} : The voltage drop of the body diode and the current detection resistor (V)

I_{OH} : Phase current peak value (A)

t₁ : Phase current rise time (s)

V_{CC1} : Supply voltage applied to the motor (V)

t₂ : Constant-current operating time (s)

L : Motor inductance (H)

t₃ : Phase switching current regeneration time (s)

R : Motor winding resistance (Ω)

<Determining the Size of the Hybrid IC Heat Sink>

Determine θ_{c-a} for the heat sink from the average power loss determined in the previous item.

$T_{c \max}$: Hybrid IC substrate temperature ($^{\circ}\text{C}$)

T_a : Application internal temperature ($^{\circ}\text{C}$)

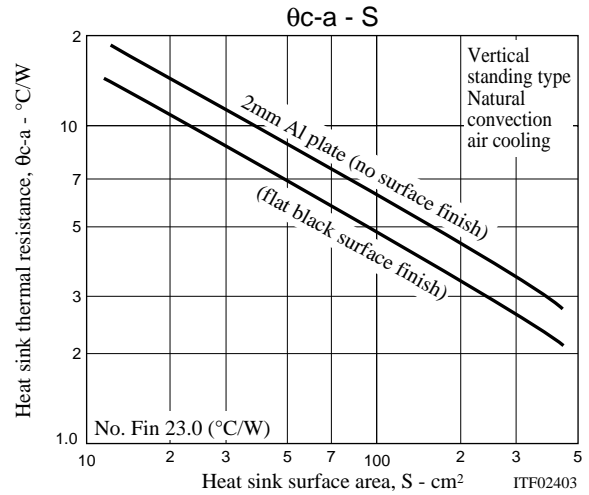
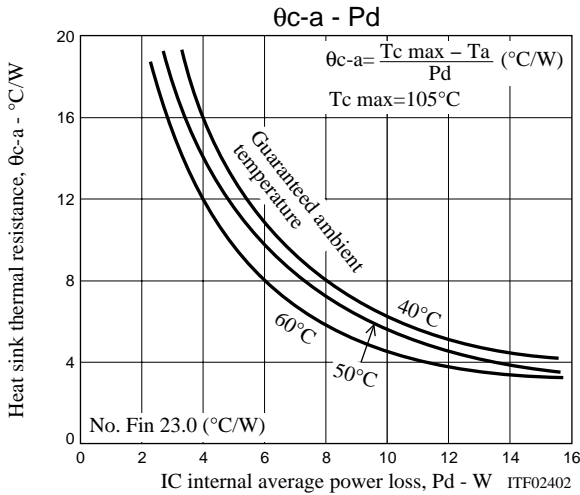
P_{dEX} : Hybrid IC internal average loss (W)

$$\theta_{c-a} = \frac{T_{c \max} - T_a}{P_{dEX}} \quad [^{\circ}\text{C/W}]$$

Determine θ_{c-a} from the above formula and then size S (in cm^2) of the heat sink from the graphs shown below.

The ambient temperature of the device will vary greatly according to the air flow conditions within the application.

Therefore, always verify that the size of the heat sink is adequate to assure that the Hybrid IC back surface (the aluminum plate side) will never exceed a $T_{c \max}$ of 105°C , whatever the operating conditions are.



Next we determine the usage conditions with no heat sink by determining the allowable hybrid IC internal average loss from the thermal resistance of the hybrid IC substrate, namely 18.5°C/W .

For a $T_{c \max}$ of 105°C at an ambient temperature of 50°C $P_{dEX} = \frac{105 - 50}{18.5} = 2.9\text{W}$

For a $T_{c \max}$ of 105°C at an ambient temperature of 40°C $P_{dEX} = \frac{105 - 40}{18.5} = 3.5\text{W}$

This hybrid IC can be used with no heat sink as long as it is used at operating conditions below the losses listed above. (See $\Delta T_c - P_d$ curve in the graph on page 19.)

<Hybrid IC internal power element (MOSFET) junction temperature calculation>

The junction temperature, T_j , of each device can be determined from the loss P_{ds} in each transistor and the thermal resistance θ_{j-c} .

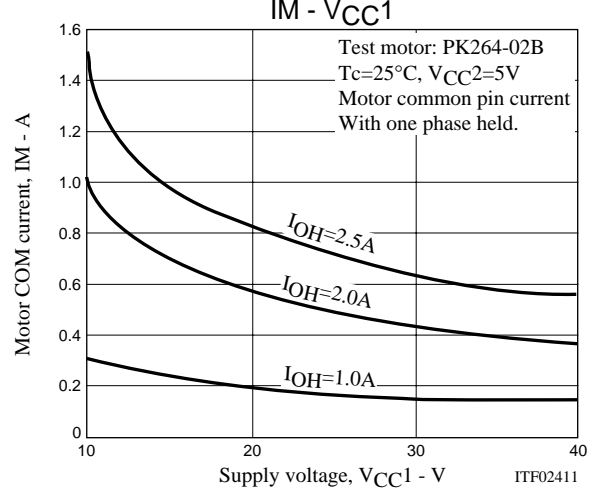
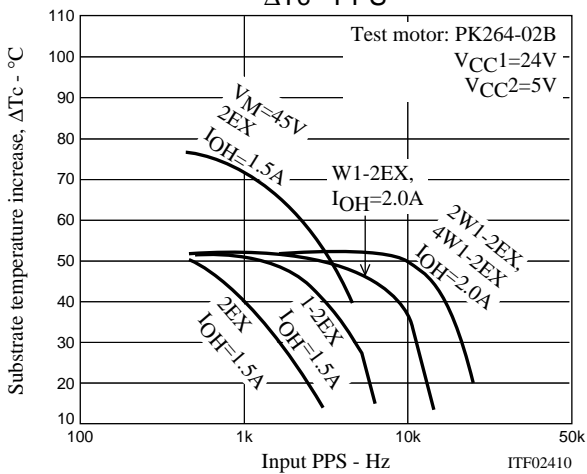
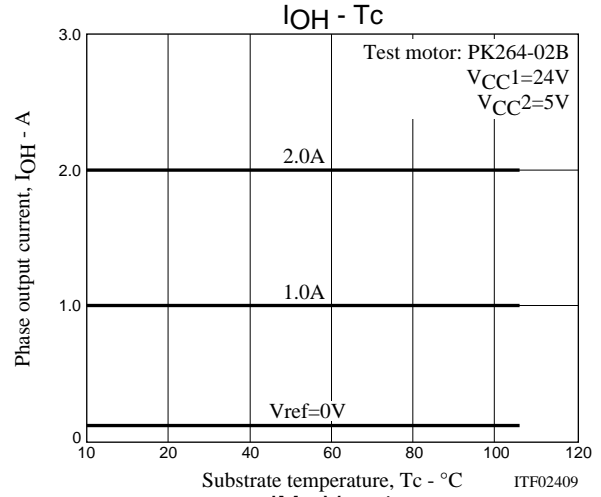
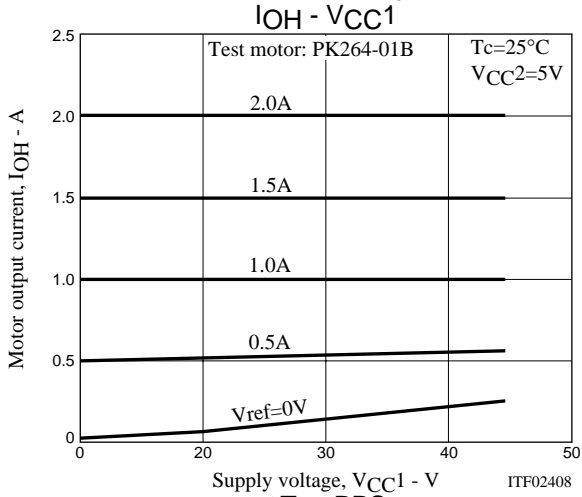
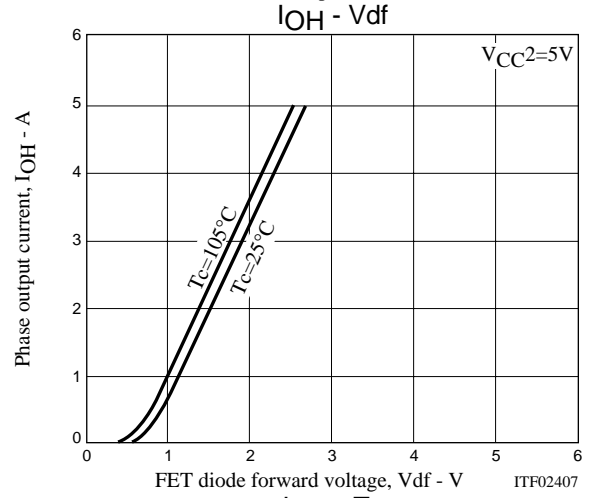
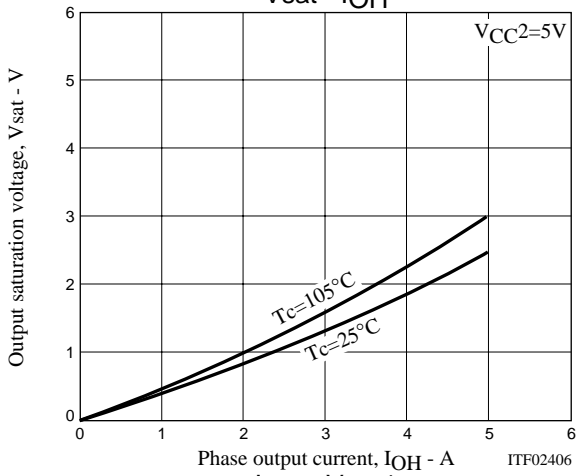
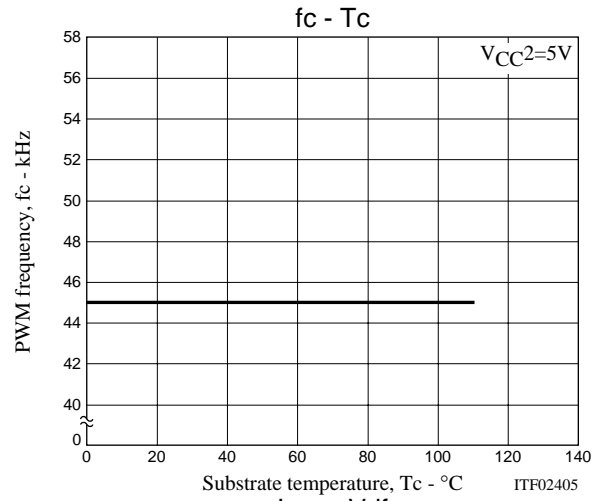
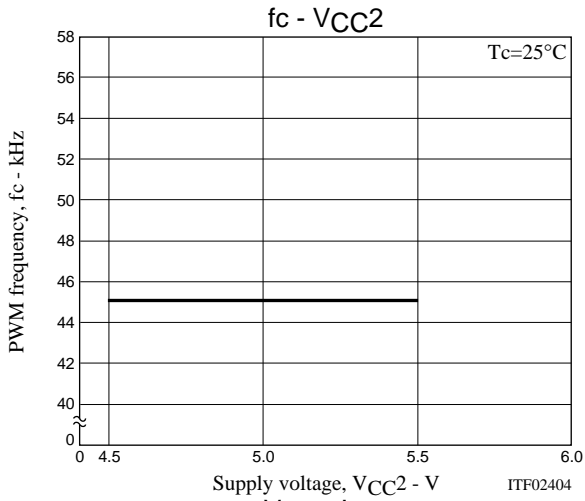
$$T_j = T_c + \theta_{j-c} \times P_{ds} \quad (^{\circ}\text{C})$$

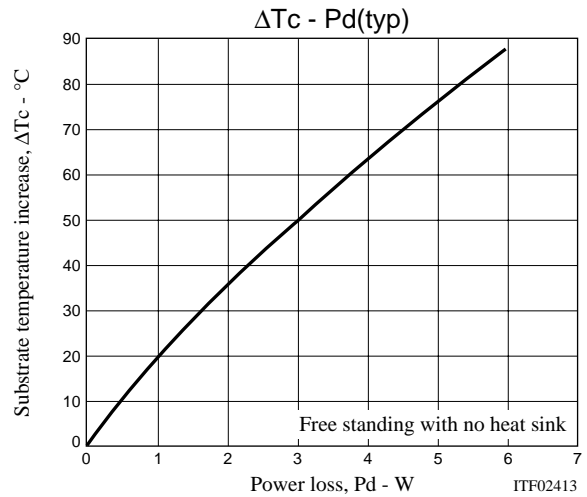
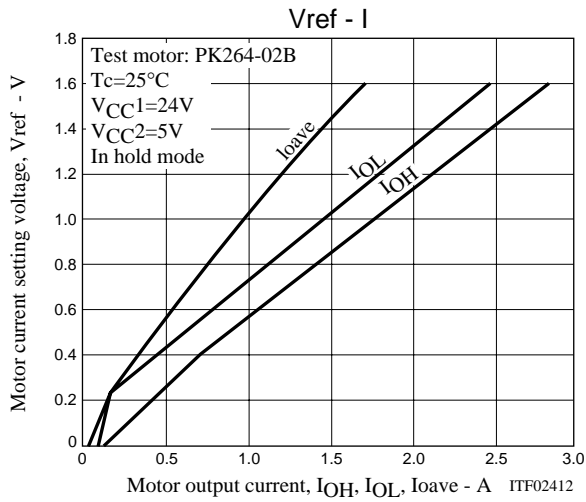
Here, we determine P_{ds} , the loss for each transistor, by determining P_{dEX} in each excitation mode.

$$P_{ds} = P_{dEX}/4$$

The steady-state thermal resistance θ_{j-c} of a power MOSFET is 5°C/W .

STK672-050-E





- SANYO Semiconductor Co.,Ltd. assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein.
- SANYO Semiconductor Co.,Ltd. strives to supply high-quality high-reliability products, however, any and all semiconductor products fail or malfunction with some probability. It is possible that these probabilistic failures or malfunction could give rise to accidents or events that could endanger human lives, trouble that could give rise to smoke or fire, or accidents that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.
- In the event that any or all SANYO Semiconductor Co.,Ltd. products described or contained herein are controlled under any of applicable local export control laws and regulations, such products may require the export license from the authorities concerned in accordance with the above law.
- No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or any information storage or retrieval system, or otherwise, without the prior written consent of SANYO Semiconductor Co.,Ltd.
- Any and all information described or contained herein are subject to change without notice due to product/technology improvement, etc. When designing equipment, refer to the "Delivery Specification" for the SANYO Semiconductor Co.,Ltd. product that you intend to use.
- Information (including circuit diagrams and circuit parameters) herein is for example only; it is not guaranteed for volume production.
- Upon using the technical information or products described herein, neither warranty nor license shall be granted with regard to intellectual property rights or any other rights of SANYO Semiconductor Co.,Ltd. or any third party. SANYO Semiconductor Co.,Ltd. shall not be liable for any claim or suits with regard to a third party's intellectual property rights which has resulted from the use of the technical information and products mentioned above.

This catalog provides information as of June, 2008. Specifications and information herein are subject to change without notice.