TB67S105FTG
Usage considerations

Summary

The TB67S105FTG is a two-phase bipolar stepping motor driver using a PWM chopper control. It has a 8-bit serial control system. Fabricated with the BiCD process, this device is rated at 50 V/3.0 A. It has also a regulator, so that it drives motors using VM power supply only. In this IC, 8-bit shift register is incorporated and it is corresponding to a serial-to-parallel conversion.

The information included in this document is not guaranteed for operations and characteristics (reference data for a test only). For details such as electric characteristics, refer to the technical datasheet.

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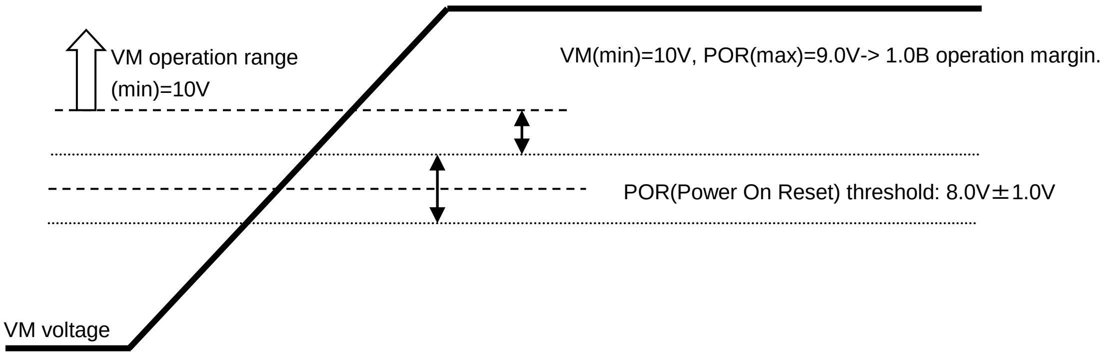
1. Power supply voltage

1.1 Power supply voltage and usage range

In using the TB67S105FTG, the voltage should be applied to the VM, VREFA, and VREFB pins.

The maximum rating of VM supply voltage is 50V. Usage range of the power supply is 10 to 40V.
The maximum rating of VREF voltage is 5V. Usage range of the voltage is 0 to 3.6V.
The regulator voltage (VCC) can be also used for the VREF voltage. (If the current is led beyond the capability of the internal regulator, the regulation of the VCC may not hold. When the VCC voltage is divided and used for the VREF voltage, be careful that the total dividing resistors is not less than 10 kΩ.)



1.2 Power supply sequence

There are no special requirements for power-on and power-off sequence because the TB67S105FTG incorporates the power on reset (POR). However, under the unstable state of applying the power supply (VM) and shutdown, it is recommended to turn off the motor operation. The motor should be operated by switching the input signal after the power supply becomes in the stable state.

2. Motor current

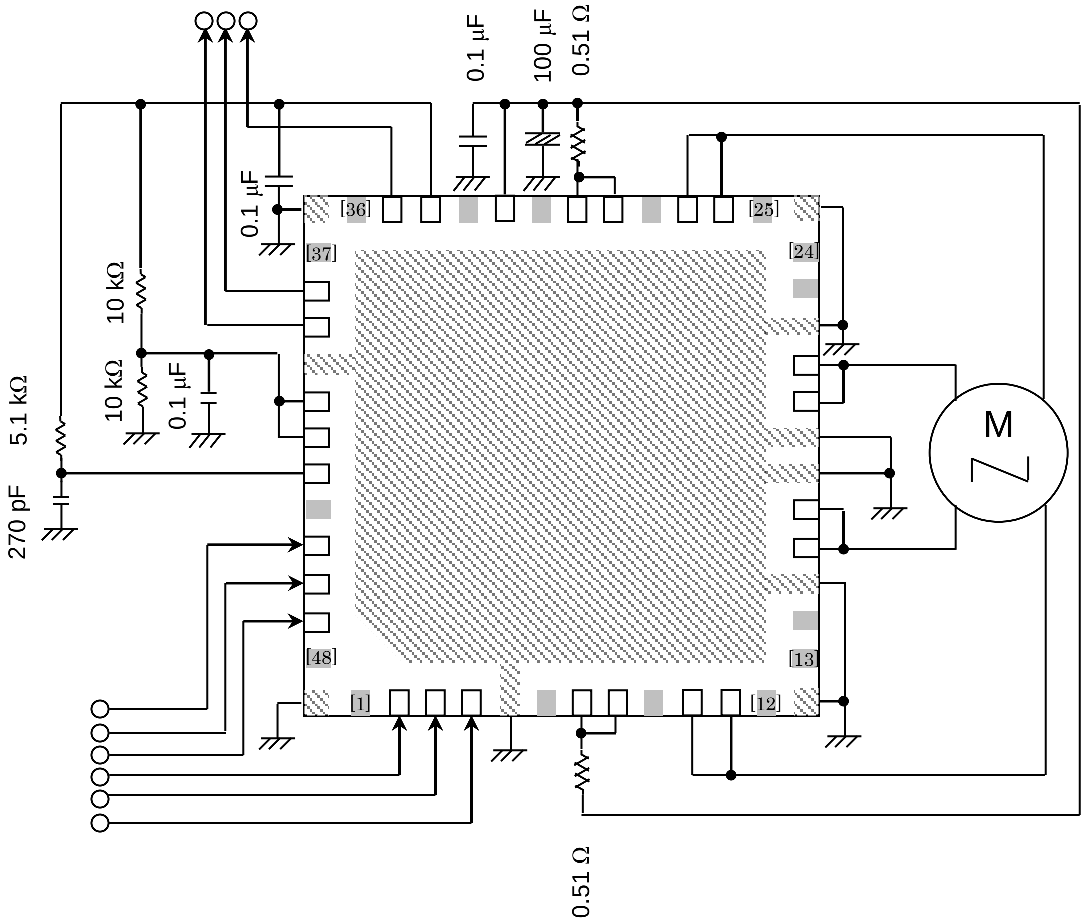
Motor usage current should be 2.4A or less. Also, note that the peak current may be limited due to usage conditions (such as ambient temperature, PCB layout pattern, heat issue, step resolution setting). The most appropriate current value should be set after calculating the heat and evaluating the board under the operating environment.

3. Control input

If the control input signal is asserted when VM is set off, the device will not malfunction. But, for safe use, please see the “1.2 Power supply sequence” for reference, and set the input signals to Low.

4. Example of application circuit

(Constants of each element are reference values.)



* The shadow area in the figure shows GND pin / Area, the gray colored area shows NC pin.

Note: Addition of the by-pass capacitor is recommended as necessary. The GND wiring should be a one-point grounding as possible. Since the OUT pin (A+,A-,B+,B-) and RS pin (RSA,RSB) have 2 pins respectively, the same pin should be used short-circuiting surely.

Note: Four corners of the package (corner PAD) should be grounded to the GND pattern surely.

The application circuit example is for reference only, and does not guarantee the mass production design of the device.

(1) Capacitor for VM power supply

To stabilize the voltage of the power supply, and also to reject any incoming noise, we recommend connecting the proper value capacitor to the VM power line (near the device). Especially the ceramic capacitor should be placed near the device as close as possible, to reject high frequency incoming noise.

Recommended values

Item	Parts	Typ.	Recommended range
VM - GND	Electrolytic capacitor	100 μF	47 to 100 μF
	Ceramic capacitor	0.1 μF	0.01 to 1 μF
VCC - GND	Ceramic / Electrolytic capacitor	0.1 μF	0.01 to 1 μF
(VREF - GND)	Ceramic capacitor	0.1 μF	0.01 to 1 μF

* VREF to GND: The capacitor connection should be considered according to the usage environment.

* The values shown in the table is for reference only, therefore components outside the recommended range can also be used, depending on the motor load condition and the design pattern of the PCB.

(2) Resistance of current detection

This IC configures the threshold of the constant current detection by connecting the resistance of current detection between VM and RS terminals. The detection resistance is recommended to connect near the IC. (The motor can be controlled with the accurate current because the influence of the wire resistance of the board can be reduced.)

Recommended values

Item	Parts	Typ.	Recommended range
VM - RS	Chip or lead type resistance	0.22 Ω (1.2 A to 2.4 A)	0.22 to 1.0 Ω
VM - RS	Chip or lead type resistance	0.51 Ω (0 A to 1.2 A)	0.22 to 1.0 Ω

The relation equation of the threshold of the constant current detection, Vref voltage, and the resistance of RS detection is as follows;

$$\mathrm{Iout(max)} = \mathrm{Vref(gain)} \times \frac{\mathrm{Vref(V)}}{\mathrm{RRS}(\Omega)}$$

Vref(gain): Vref decay ratio is 1 / 5.0 (typ.)

As for the resistance of current detection, the constant number which is out of recommended range can be adopted. In this case, please pay attentions to the followings when the used resistance is high and low.

- When the detection resistance is low, the difference voltage between VM and RS comparing to the internal reference voltage becomes small. So, the current may be largely different from the configured current value.
- When the detection resistance is high, the power applied to the detection resistance increases in motor operation (P=I^2×R). So, in case the same current flows as the case of low resistance, the power dissipation should be larger.

(3) Frequency setting component

OSCM oscillation frequency (fOSCM) and chopping frequency (fchop) can calculate with the following fomula;

fOSCM = 1 / [0.56 × {C × (R1+ 500)}]
.........C,R1: External constants for OSCM (C = 270 pF , R1 = 5.1 kΩ (reference constants))

fchop = fOSCM / 16

When the chopping frequency is increased, the pulsating current is decreased, so that the reproducibility of the waveform is enhanced. However since the pulsating current is decreased and gate dissipation in the IC is raised, the heat generation is increased.
It is expected that the heat generation may be decreased by reducing the chopping frequency. However the pulsating current may be increased.

Generally, it is recommended to configure the frequency in the range of 50 kHz to 100 kHz on the basis of 70kHz.

(4) Wiring pattern for power supply and GND
Since large current may flow in VM, RS, and GND pattern especially, design the appropriate wiring pattern to avoid the influence of wiring impedance. It is very important for surface mounting package to radiate the heat from the heat sink of the back side of the IC to the GND. So, design the pattern by considering the heat design.

(5) Fuse
Use an appropriate power supply fuse for the power supply line to ensure that a large current does not continuously flow in the 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 the case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

This IC incorporates over current detection circuit (ISD) that turns off the output of the IC when over current is detected in the IC. However, it does not necessarily protect ICs under all circumstances. If the Over current detection 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.
To avoid above IC destruction and malfunctions caused by noise, the over current detection circuit has a dead band time. So, it is concerned that the over current detection circuit may not operate depending on the output load conditions because of the dead band time. Therefore, in order to avoid continuing this abnormal state, use the fuse for the power supply line.

5. Power consumption of IC

Power of the IC is consumed by the transistor of the output block and that of the logic block mainly.

P(total) = P(out) + P(bias)

- Power consumption of the motor output block
  Power of the output block (P(out)) is consumed by MOSFET of upper and lower H-Bridge.

  P (out) = Number of H-Bridge × Iout (A) × VDS (V) = 2 (ch) × Iout (A) × Iout (A) × Ron (Ω) (1)

  When the current waveform of the motor output corresponds to the ideal waveform (2-phase excitation / square wave), average power of output block can be provided as follows;

  When Ron = 0.6Ω , Iout (peak: Max) = 1 A, VM = 24 V
  P(out) = 2 (ch) × 1.0 (A) × 1.0(A) × 0.6(Ω)..(2)
  = 1.2 (W)

- Power consumption of logic and IM systems.
  Power consumptions of logic and IM systems are calculated by separating the states (operating and stopping).

  I (IM3) = 5.5 mA (typ.) : Operating
  I (IM2) = 3.5 mA (typ.) : Stopping

  Output system is connected to VM (24V). (Output system: Current consumed by the circuit connected to VM + Current consumed by switching output steps)

  Power consumption is calculated as follows;

  P(bias) = 24 (V) × 0.0055 (A)...(3)
  = 0.132 (W)

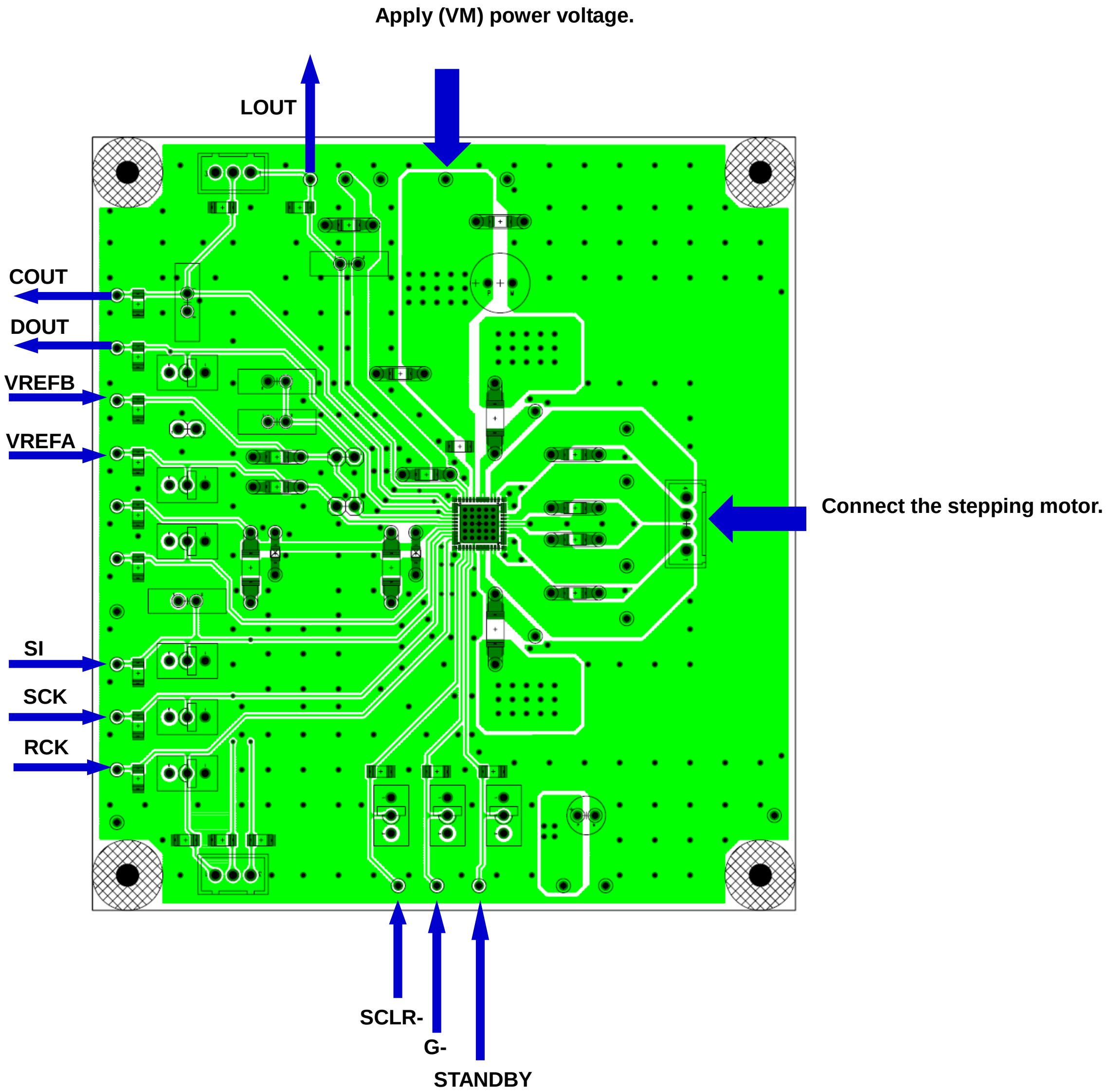
- Power consumption
  Total power consumption P(total) is calculated from the values of formula (2) and (3).

  P(total) = P(out) + P(bias) = 1.2 + 0.132 = 1.332 (W)

  In actual motor operation, the average current becomes lower than the calculated value because of transition time of the current steps and the ripple of the constant current PWM. Refer to the above equations, evaluate the heat design of the board by the actual board enough, and configure the appropriate margin.

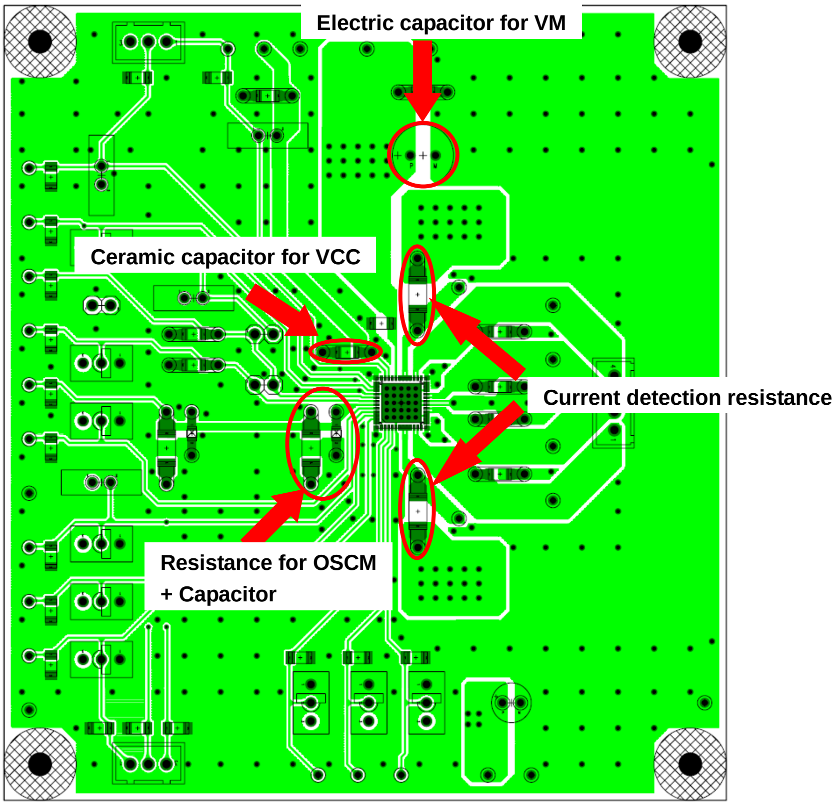
6. Test board dimensions

6.1 Input



Input each power supply and control signals according to the figure shown above.

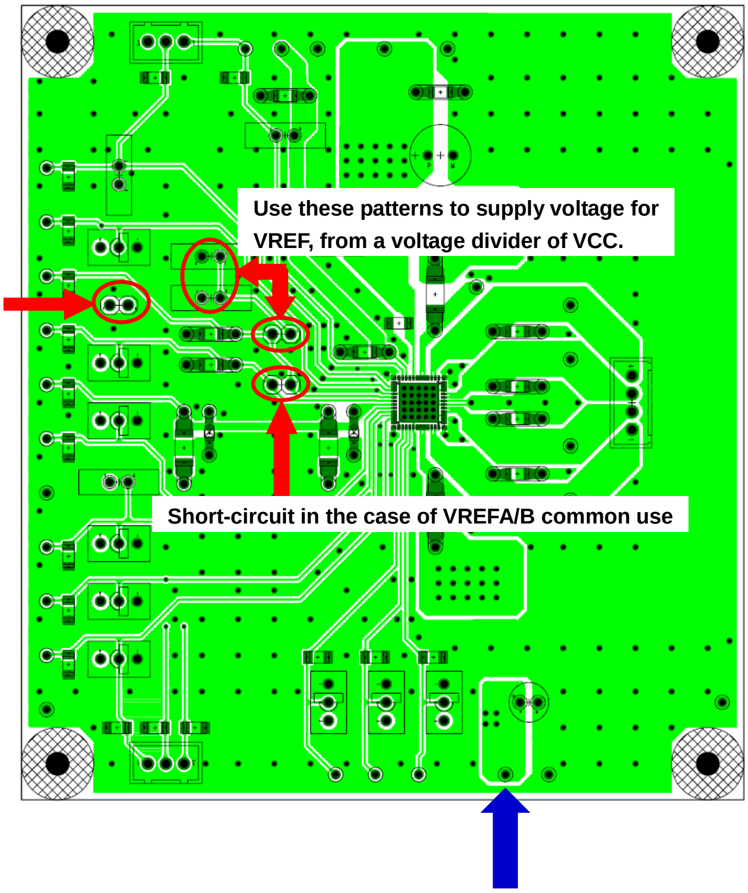
6.2 Main parts



Connect each components to reference for p.10.

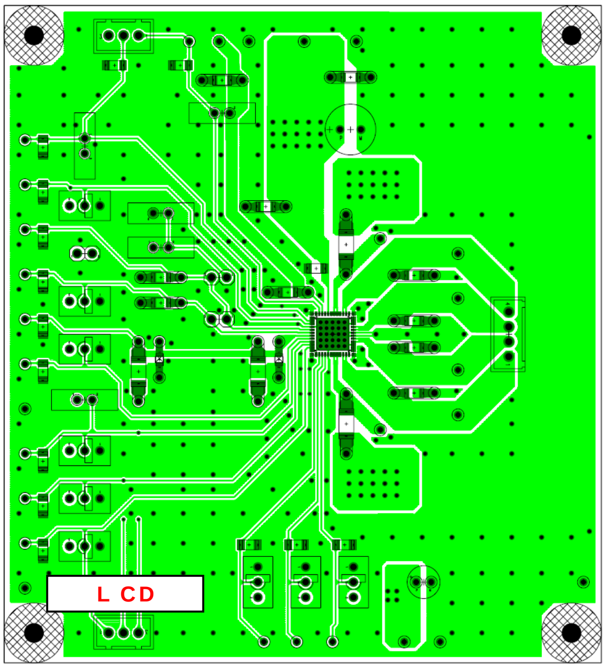
6.3 Board options

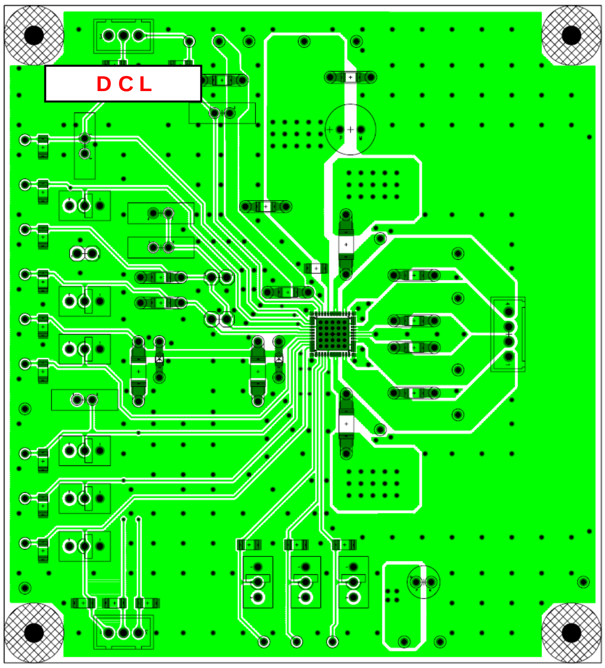
Short the jumper to use the VCC as a power source for the switches.



Power applying pin for switches
(Apply 3.3 V or 5 V if necessary.)
*** When VCC is used for the power supply of the switch, the voltage should not be applied to VDD.**

6.4 Connection between two boards

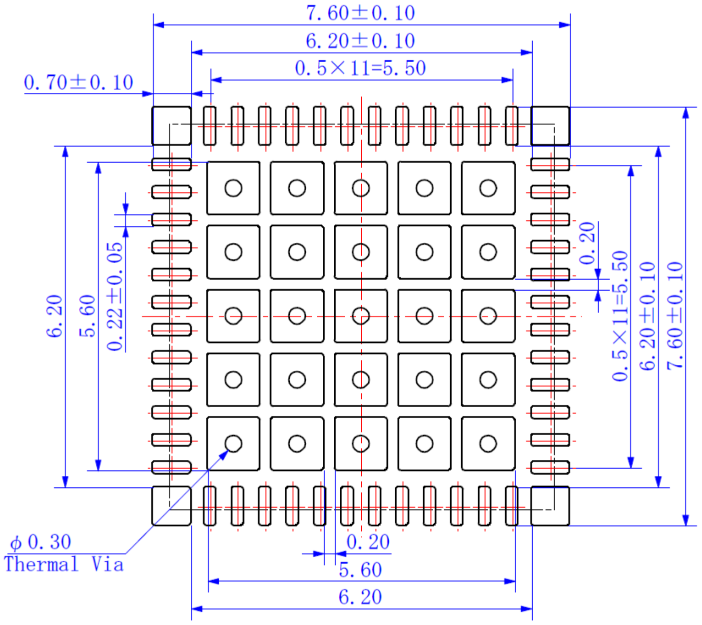




The above figure shows connector positions of D (serial data), C (serial clock), and L (serial latch). When three-line serial output of IC1 is used as three-line serial input of IC2, please connect D, C, and L correctly respectively.

7. Example of reference land pattern

WQFN48 land pattern

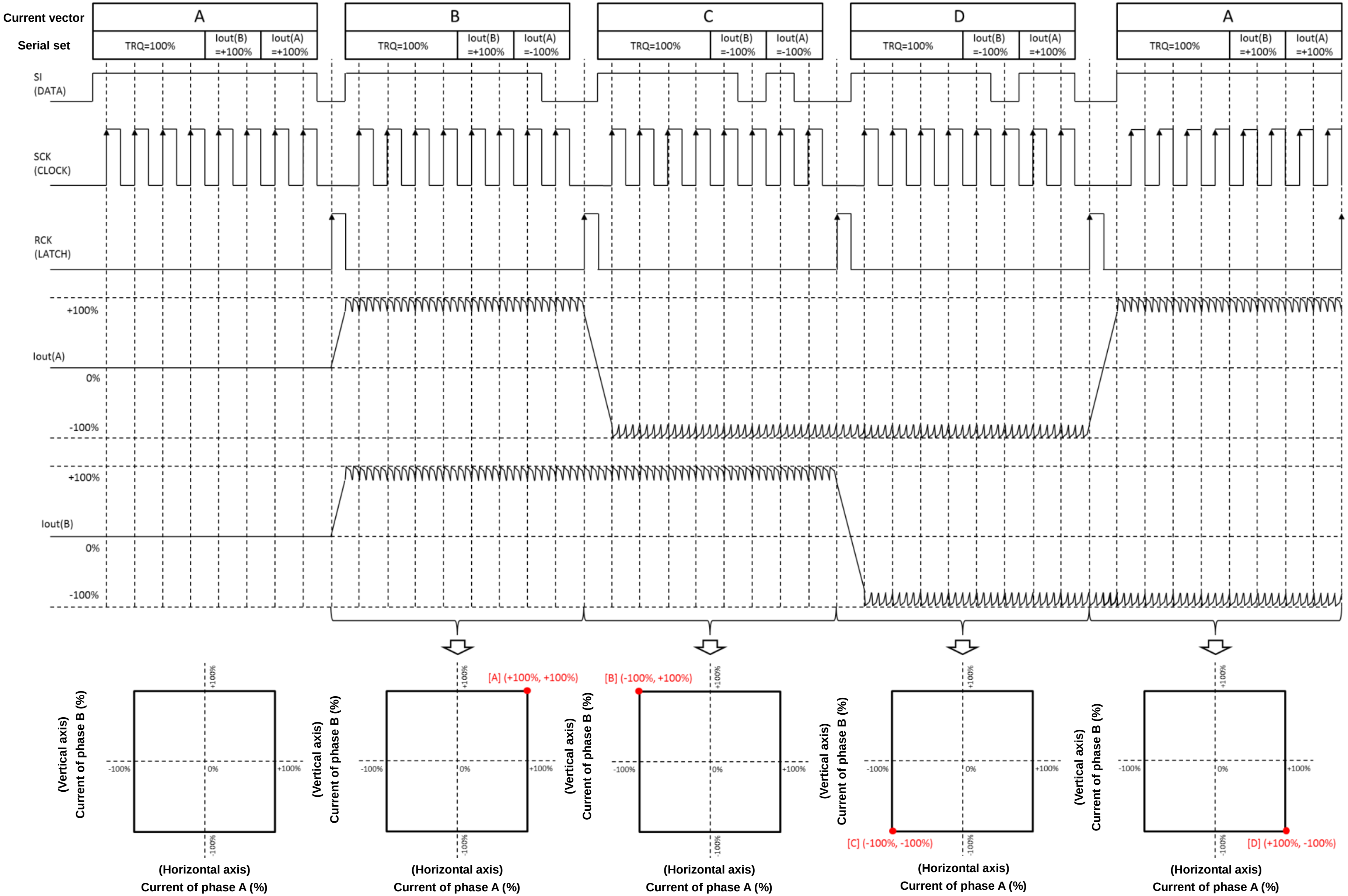


This example of the land pattern is reference only. Toshiba does not guarantee the data for mass production.

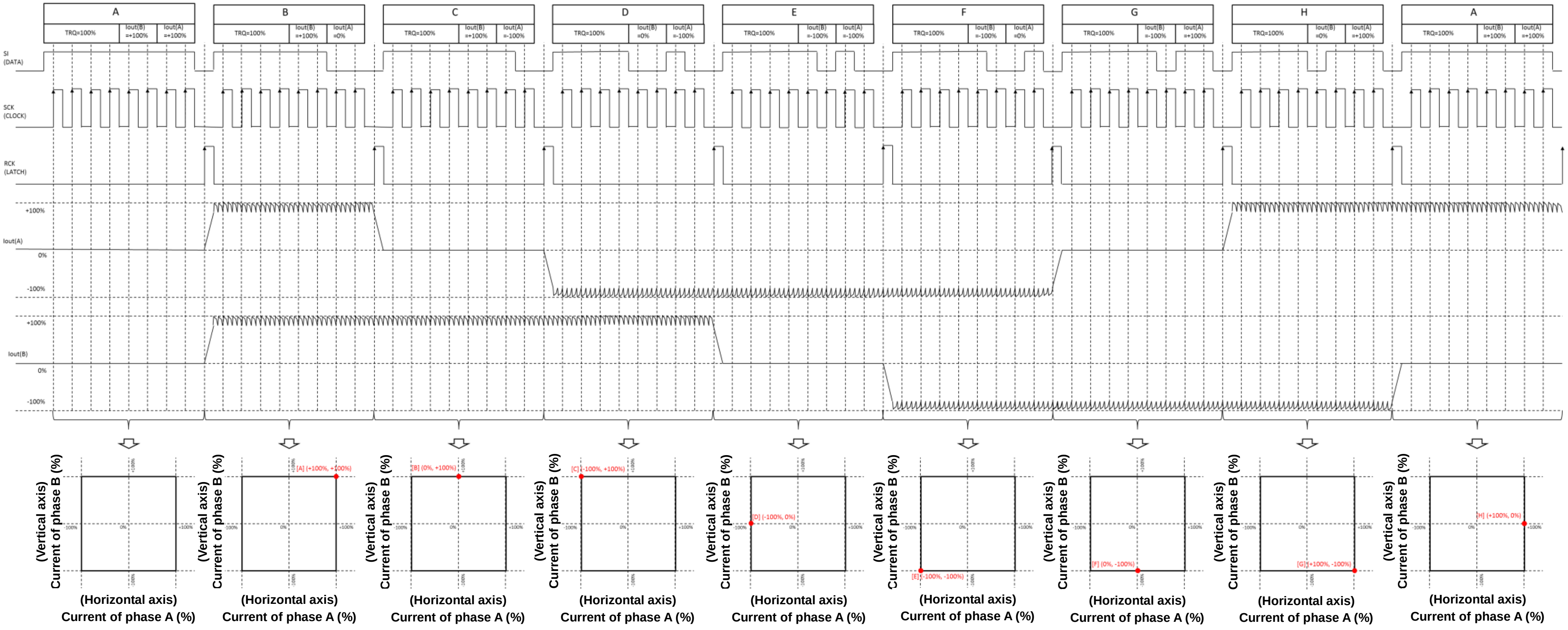
In determining the size of mounting board, design the most appropriate pattern by considering the solder bridge, the solder connecting strength, the pattern accuracy in making board, the heat sink of leads, and the mounting accuracy of the IC board.

8. Example of timing chart

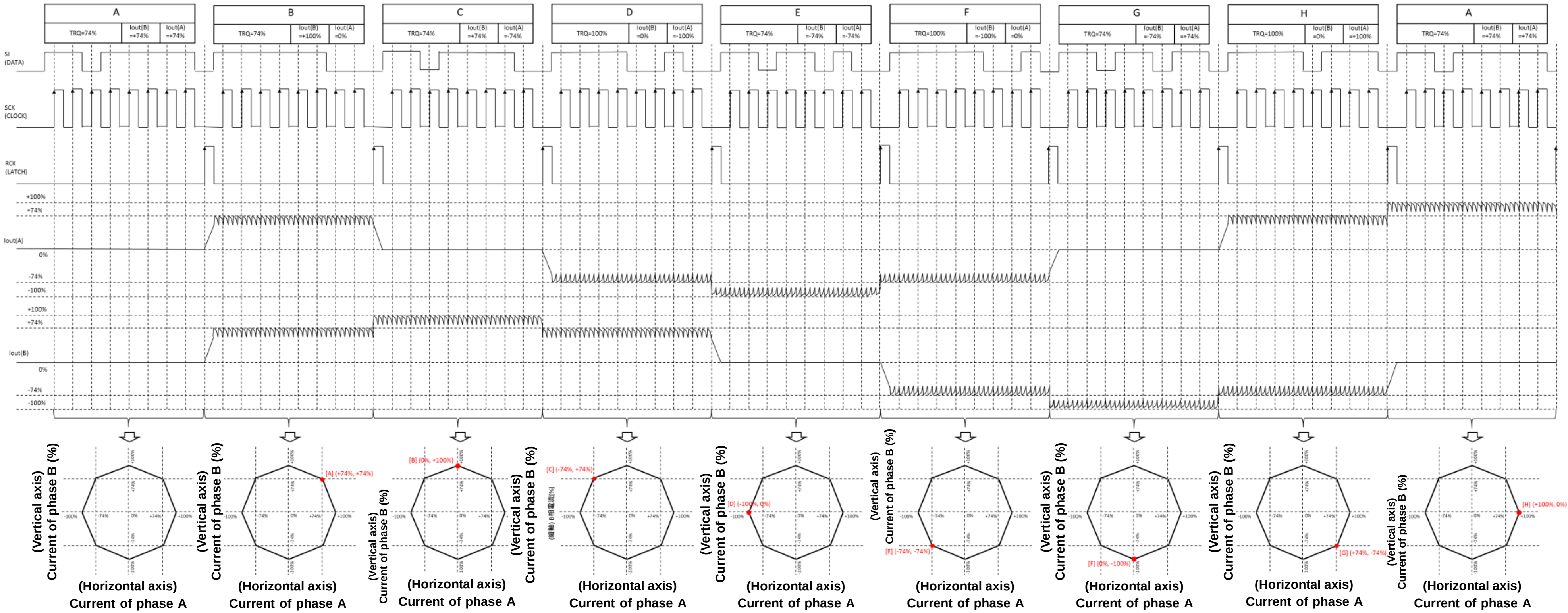
Example of timing chart (Full step resolution, CW control)



Example of timing chart (Half step (a) resolution, CW Control)



Example of timing chart (Half step (b) resolution, CW control)



IC Usage Considerations

Notes on handling of ICs

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 injury by explosion or combustion.

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 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.

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 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.

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.

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, overcurrent 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

Over current Protection Circuit

Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the over current protection circuits operate against the over current, clear the over current status immediately.
Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

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.

Heat Radiation Design

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

Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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