

TB6575FNG Usage Considerations

The TB6575FNG provides sensorless commutation and PWM current control for 3-phase full-wave BLDC motors. It is for a fan motor. It can not be applied to the motor which changes the rotation direction between forward and reverse. Please confirm it can be applied to your motor or not by setting the IC because the sensorless drive is weak to a load change. It does not surely start. To start, consider the relation between FG pulse and Vsp and make the motor to detect the abnormal state and restart.

**1. Power Supply Voltage**

**Power Supply Voltage Usage Range**

Characteristic	Symbol	Operating Voltage Range	Unit
Power supply for control block	V <sub>DD</sub>	4.5 to 5.5	V

**2. Control Inputs (LA, CW/CCW, SEL\_LAP, Fmax, Fst, OS and Vsp)**

**(1) Input Method**

When V<sub>DD</sub> is switched off, the LA, CW/CCW, SEL\_LAP, Fmax, Fst, OS, and VSP input signals should be open or low, until V<sub>DD</sub> has settled.

**3. Oscillation Circuit**

**(1) Operating Oscillation Range**

Characteristic	Symbol	Operating Range	Unit
Oscillation frequency	f <sub>osc</sub>	2 to 8	MHz

**(2) Recommended Oscillator**

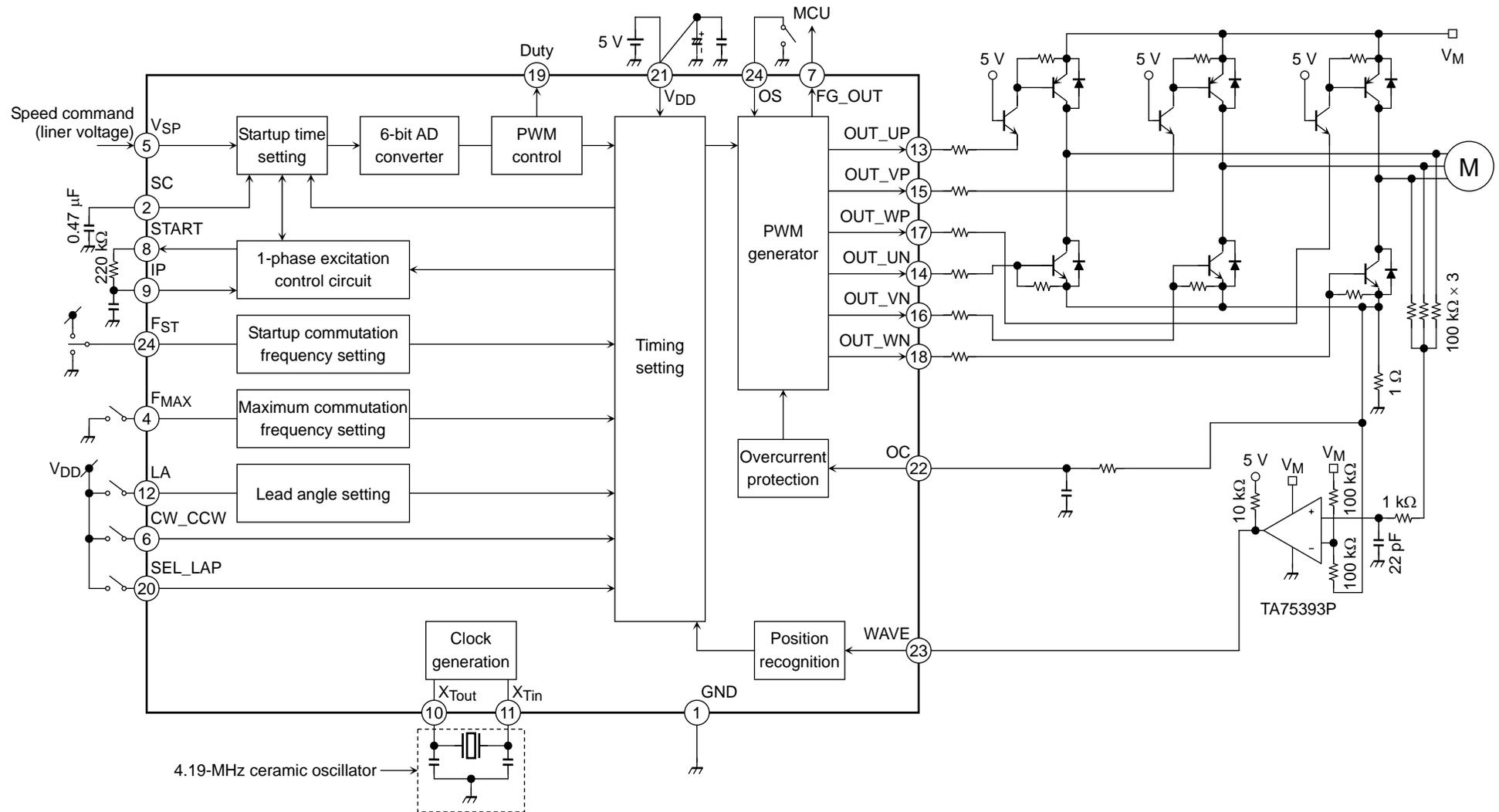
Ceramic Oscillator: 4.19 MHz

- FCR4.19MC5 (TDK Corporation)
- CSTLS4M19G56-B0 (Murata manufacturing Co. Ltd)

**(3) Connection**

Place the oscillator's GND as close as possible to the IC's S-GND pin.

### 4. Application Circuit (example for motor voltage of $\leq 30\text{ V}$ )



### (1) Capacitors for Power Supply

Connect capacitors between  $V_{DD}$  and GND, and between  $V_M$  and GND as near the IC as possible.

#### Recommended Values

Characteristic	Recommended Value	Remarks
$V_{DD} - GND$	10 $\mu F$ to 33 $\mu F$	Electrolytic capacitor
$V_M - GND$	0.001 $\mu F$ to 0.22 $\mu F$	Ceramic capacitor

### (2) Startup Setting

Please decide the value from the results of your evaluation because it depends on the motors.

#### Conditions of Toshiba's Evaluation

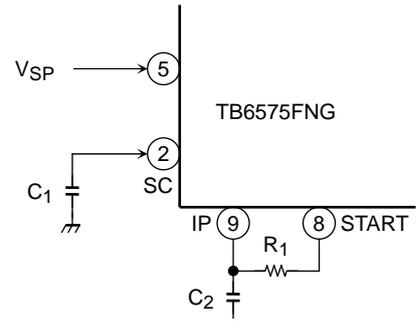
Characteristic	Value	Remarks
SC:C1	0.47 $\mu F$	Ceramic capacitor
START - IP:R1	220 $k\Omega$	Resistor
IP:C2	1 $\mu F$	Ceramic capacitor

Our fan motor for evaluation operates under these conditions.

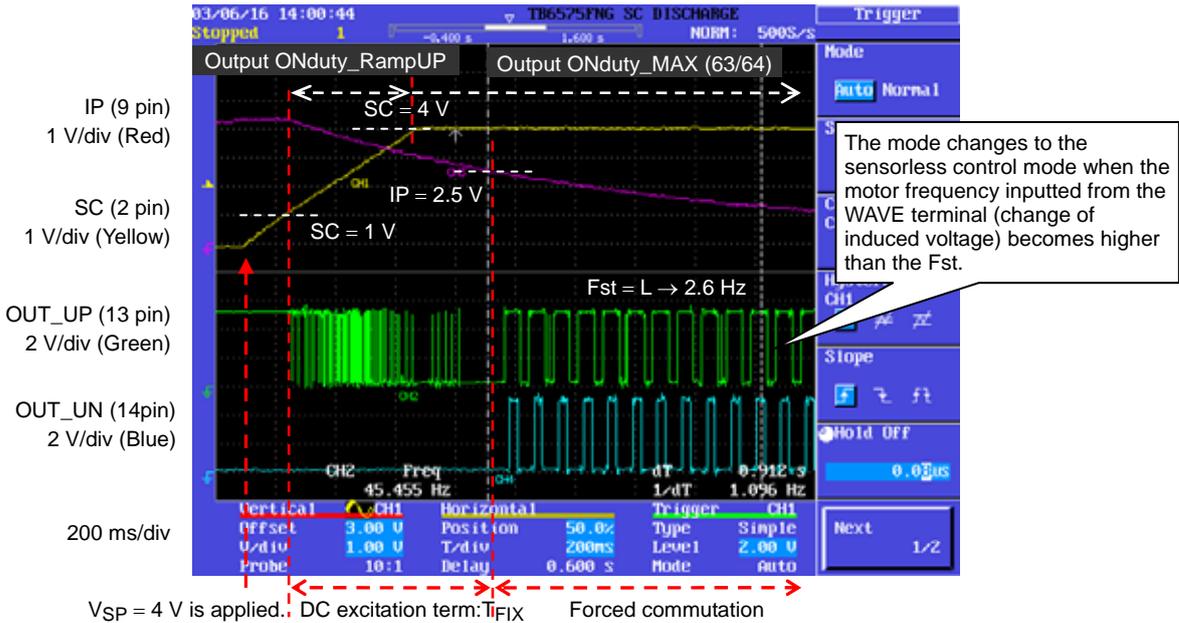
### Output Operating Waveform of the TB6575FNG in Startup Mode (for reference)

The comparison of DC energization term is shown below when the capacitor C2 of 4.7 μF and 1 μF is adopted each. It is important to lock the rotor completely in the DC energization term. ON duty of output PWM in all modes is determined depending on the potential of SC terminal. Slope of SC terminal is determined by the capacitor C1 and the maximum potential is clamped by V<sub>SP</sub>.

The most appropriate conditions for startup must be determined by doing an experiment by changing C1, C2, R1, Fst, and V<sub>SP</sub>.

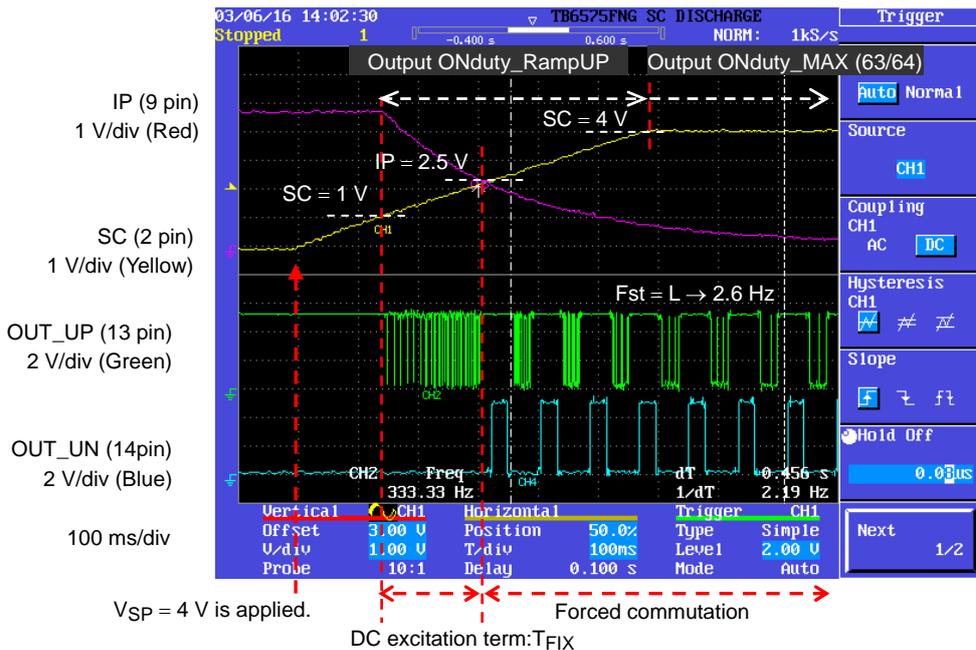


#### 1. Measurement condition: V<sub>DD</sub> = 5.0 V, V<sub>SP</sub> = 4.0 V, FST = "L", R1/C2 = 220 KΩ/4.7 μF



$$T_{FIX} (\text{typ.}) = 0.69 \times C2 \times R1 (\text{s}) = 0.69 \times 4.7 \mu\text{F} \times 220 \text{K} = 0.71 (\text{s})$$

#### 2. Measurement condition: V<sub>DD</sub> = 5.0 V, V<sub>SP</sub> = 4.0 V, FST = "L", R1/C2 = 220 KΩ/1.0 μF



$$T_{FIX} (\text{typ.}) = 0.69 \times C2 \times R1 (\text{s}) = 0.69 \times 1.0 \mu\text{F} \times 220 \text{K} = 0.15 (\text{s})$$

**(3) Protection Filter for Input**

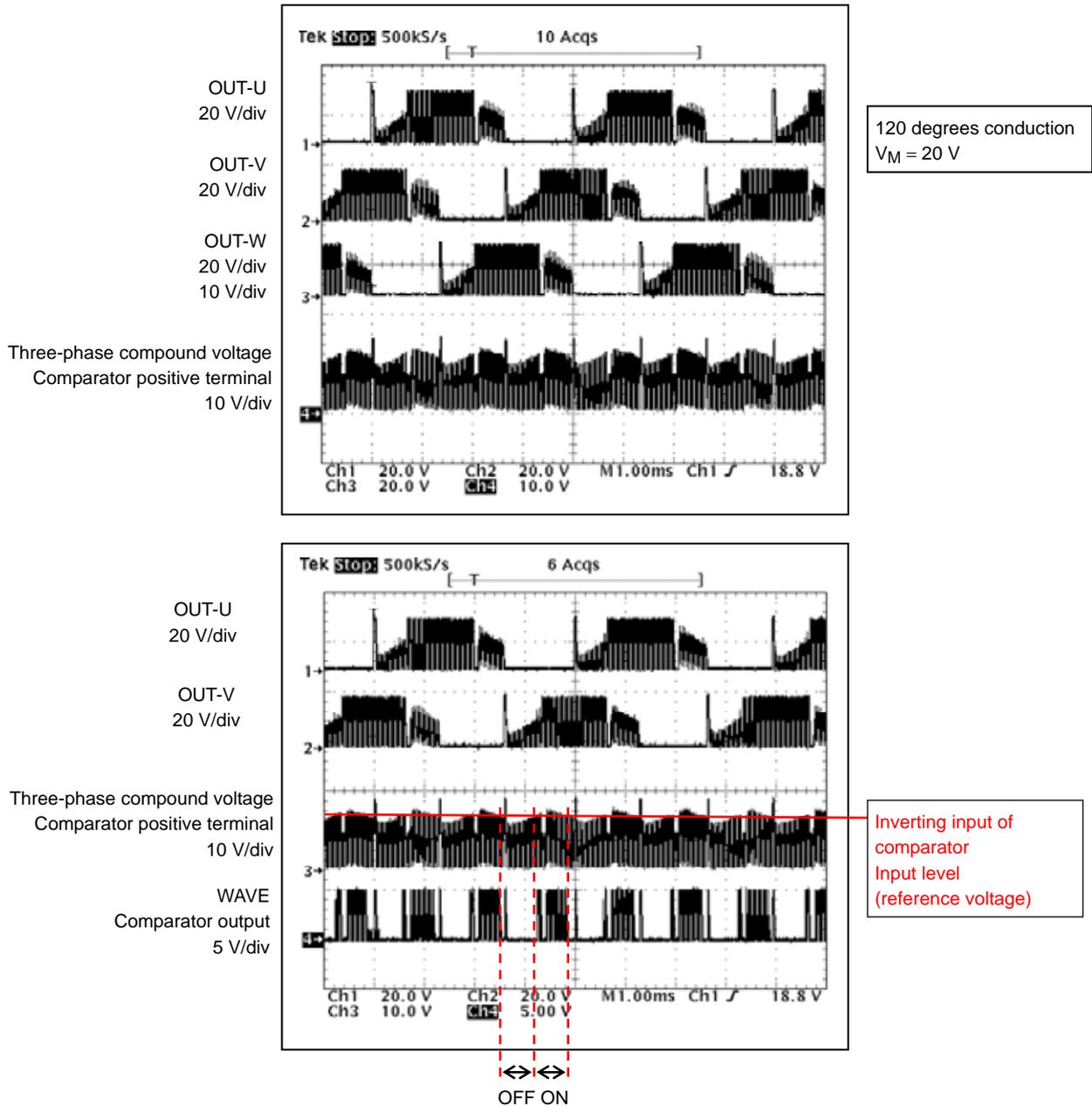
The input pins of over current protection and of position recognition have high impedance and are easily influenced by noise, so it has a possibility to cause a wrong operation. Please provide CR filter not to let it operate wrongly. Please decide the value of the filter from the noise frequency.

We recommend to set the capacity of 0.001  $\mu$ F to 0.1  $\mu$ F.

**(4) Comparator**

The standard voltage of inverting terminal is based on the middle voltage of VM and the voltage in front of the over current detective resistor that exists between output Tr and GND. A minute adjusting is needed depending on the conditions of noise and the motor because it detects the introducing voltage of OFF phase. VM is limited by withstand voltage of this comparator, so when you use it at more than 30 V, please refer "7. Level shift" written later.

**TB6575FNG + MP6404 Driving Wave (for reference)**



Inverting input of comparator (reference voltage) should be adjusted to make the ratio of OFF and ON for comparator output (WAVE terminal) 50% duty.

### 5. Lead angle controller

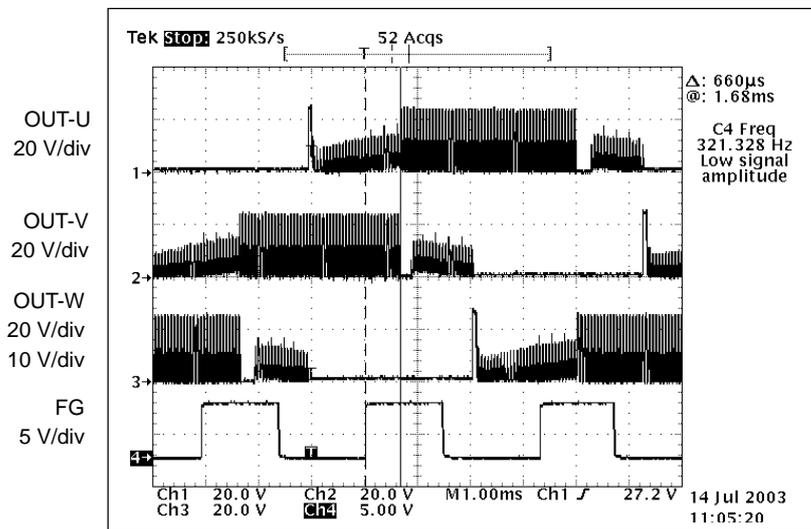
It can operate the driving signal electrically in the range of 7.5 to 15 degrees against introducing voltage. However, when it is in the DC excitation mode or in the forced commutation mode just after startup, it operates with zero degree.

After it detects the introducing voltage and moves to the sensor less mode, it drives at the lead angle according to the LA pin.

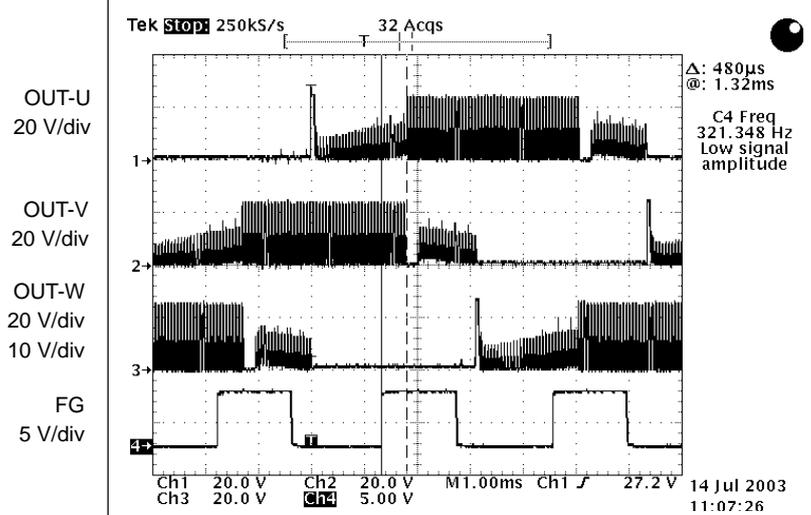
LA	Lead Angle (°)
LOW or OPEN	7.5
HIGH	15

The setting of lead angle depends on the motor and the numbers of spin, so please decide it by doing experiments.

### TB6575FNG + MP6404 Driving Wave (for reference)



Lead angle: 7.5 degrees  
120 degrees conduction  
 $V_M = 24\text{ V}$   
 $V_{SP} = 2\text{ V}$



Lead angle: 15 degrees  
120 degrees conduction  
 $V_M = 24\text{ V}$   
 $V_{SP} = 2\text{ V}$

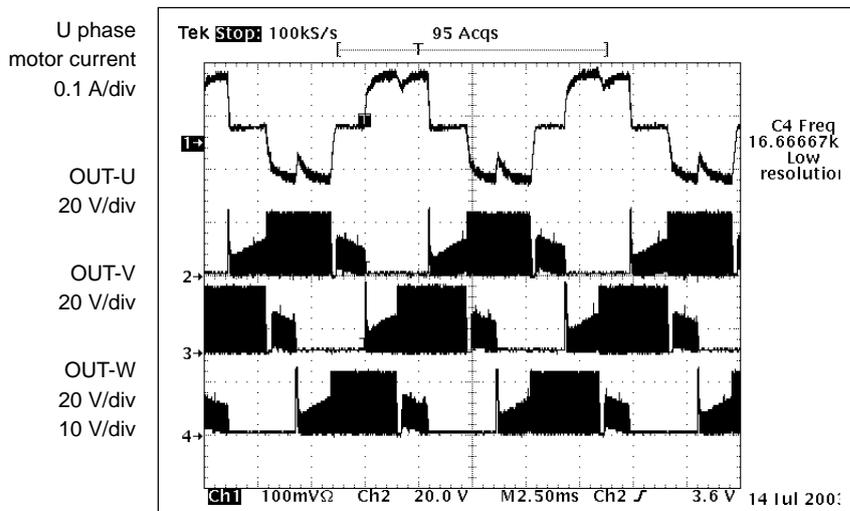
### 6. Lap Conduction

During the lap conduction, it overlaps to other phases by starting the conduction from zero-cross to reduce the noise. This noise is produced in the changing of excitation that arises in the 120 degree conduction.

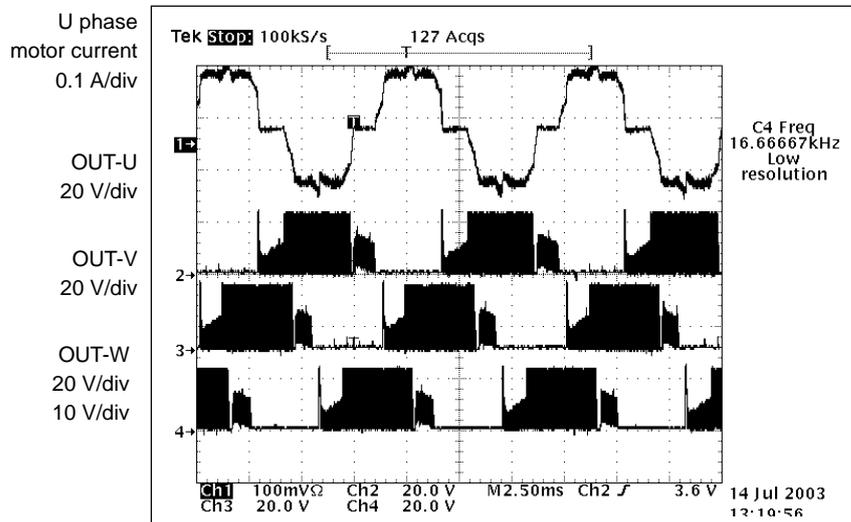
The term of overlap changes depends on the lead angle setting. When the lead angle is 7.5 degrees, it overlaps 22.5 degrees and when the lead angle is 15 degrees, it overlaps 15 degrees.

SEL_LAP	Conduction Method
HIGH or OPEN	120°
LOW	LAP

#### TB6575FNG + MP6404 Driving Wave (for reference)



Lead angle: 7.5 degrees  
120 degrees conduction  
 $V_M = 24\text{ V}$   
 $V_{SP} = 2\text{ V}$

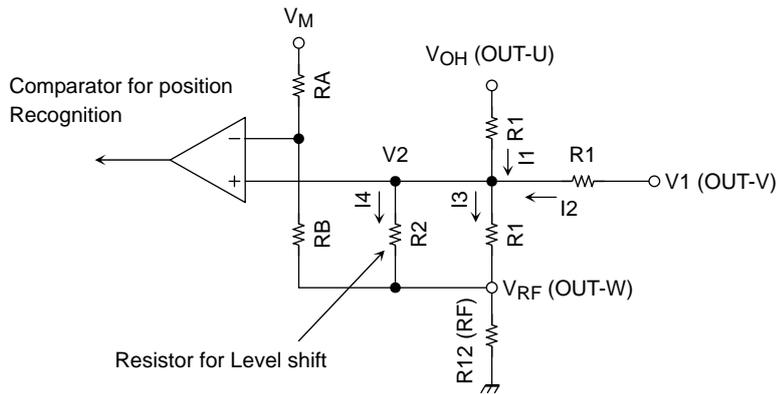


LAP conduction  
 $V_M = 24\text{ V}$   
 $V_{SP} = 2\text{ V}$

**7. Level Shift**

When you use the motor at higher than 30 V, please shift the input voltage of comparator by the method written below.

- (1) Please put the standard voltage of GND side on the lower resistor (R12).  
Please input the comparator for position recognition on R12, which is a resistor for an overcurrent detector, as a standard. Because the motor is influenced by R12's voltage reducing at startup and this reducing voltage should be canceled each other out.  
When you put it on the GND, there is a possibility that it can not move to sensorless mode because of its errors.
- (2) In calculation, please use the voltage in each phase that connects to the motor. Please do not use  $V_M$ .  
 $V_M$  and the voltage to the motor are different.



It is a circuit diagram for calculation. Keep in mind that it differs that it is actual. Actual circuit is described in the section 8.

$I1 = (V_{OH} - V2)/R1$	Equation (1)
$I2 = (V1 - V2)/R1$	Equation (2)
$I3 = (V2 - V_{RF})/R1$	Equation (3)
$I4 = (V2 - V_{RF})/R2$	Equation (4)
$I1 + I2 = I3 + I4$	Equation (5)

When you substitute the equations (1), (2), (3), and (4) for (5),  
 $(V_{OH} - V2)/R1 + (V1 - V2)/R1 = (V2 - V_{RF})/R1 + (V2 - V_{RF})/R2$

From this equation,  
 $V2 = (V_{OH} + V_{RF} + V1) / (3 + R1/R2)$  Equation (6)

In recognizing V1 as a middle point that is  $((V_{OH} - V_{RF})/2 + V_{RF})$ , Equation (6) becomes as follows:

$$V2 \text{ (middle point)} = \frac{3 \times R2 \times (V_{OH} + V_{RF})}{2 \times (3 \times R2 + R1)}$$

The standard voltage of the comparator is as follows:

$$V_A = (V_M - V_{RF}) \times \frac{R_B}{R_A + R_B} + V_{RF}$$

If recognizing the middle point V2 as VA,

$$(V_M - V_{RF}) \times \frac{R_B}{R_A + R_B} + V_{RF} = \frac{3 \times R_2 \times (V_{OH} + V_{RF})}{2 \times (3 \times R_2 + R_1)}$$

$$\frac{R_B}{R_A + R_B} = \frac{1}{V_M + V_{RF}} \times \left\{ \frac{3 \times R_2 \times (V_{OH} + V_{RF})}{2 \times (3 \times R_2 + R_1)} - V_{RF} \right\}$$

Ex.) If you substitute 40 V for VM, 0.5 V for VRF, 37 V for VOH, 100 kΩ, for R1 and, 30 kΩ for R2, it is concluded that

$$R_B / (R_A + R_B) = 0.2070$$

That is RA: RB = 7930:2070

For example, when RB equals to 10 kΩ, RA becomes 38.3 kΩ.

## 8. Others

### Position recognition

It recognizes the position by comparing the changes of introducing voltage of OFF phase and that of standard value which means postulating middle point.

When it recognizes the position recognizing signal in the IC, it masks opposite startup voltage. This opposite startup voltage equivalents to the Diode-ON time. This masking term changes according to the lead angle as follows;

In recognizing the term of masking after changing, the term written below is masked.

Lead Angle (°)	Masking Term (°)
7.5	22.5
15	30

When Diode-ON time is beyond the masking time written above, it may cause wrong operation and the motor may not work correctly.

In this case, you should change the setting of lead angle, improve the speed of output diode, change the applying conditions, or change the motor it self.

### Maximum Commutation Frequency

If the commutation frequency set up with the FMAX terminal is exceeded, it is judged as the unusual state of a motor and an output is turned off. However, Maximum commutation frequency changes with setup of Forced commutation frequency (Fst terminal), cautions are required.

Commutation frequency means motor current frequency (1 electricity angle).

- Fst = Low

$$F_{MAX} = \text{High or Open, Maximum commutation frequency } f_{MX} = f_{XT} / (6 \times 2^{11})$$

$$F_{MAX} = \text{Low, Maximum commutation frequency } f_{MX} = f_{XT} / (6 \times 2^{12})$$

- Fst = High or Middle

$$F_{MX} = \text{High or Open, Maximum commutation frequency } f_{MX} = f_{XT} / (6 \times 2^8)$$

$$F_{MX} = \text{Low, Maximum commutation frequency } f_{MX} = f_{XT} / (6 \times 2^9)$$

Note: FST = Low, FMAX = Low, since the number of rotations which becomes protection mode becomes low, cautions are required.

Ex.: fxt = 4.19 MHz, in 4pole motor

$$f_{MX} = f_{XT} / (6 \times 2^{12}) = 4.19 \text{ MHz} / (6 \times 2^{12}) = 170.5 \text{ Hz}$$

$$\text{umber of rotations of a motor} = (170.5 \text{ Hz} / 2) * 60 \text{ (s)} = 5115 \text{ rpm}$$

Therefore, if the number of rotations of a motor is set to 5115 rpm, it will become protection mode.

**Operation of Over Current Protection**

When voltage of 0.5 V (typ.) or more is applied to OC terminal, output of upper-phase control (OUT\_UP, OUT\_VP, and OUT\_WP) is halted.

The device is not destroyed because of the over current by applying the converted value of current and voltage. This value is set by the motor current detection resistance of the power steps. However, take care not to use this method regularly including startup. Set the current which does not flow in actual operation, and use this method to protect the IC only when the IC operation is in the abnormal state. The operation recovers on the next PWM cycle, so the over current flows at every PWM cycle when the power steps are under controlled. The voltage of 0.5 V or more is applied to OC terminal continuously, the output of the upper phase is halted. In case the over current is estimated to flow, protect the IC by detecting the abnormal state with another system.

The sensorless system of this IC estimates its position by detecting induced voltage (PWM) output. So, when the over current protection works, it cannot estimate the position because output (PWM) stops. As a result, motor has a possibility to become out of control and step-out. To avoid this risk, please recognize this over current protection as one of suggestions to avoid destroying the IC in abnormal state.

**Control Method of V<sub>SP</sub> Terminal in Startup**

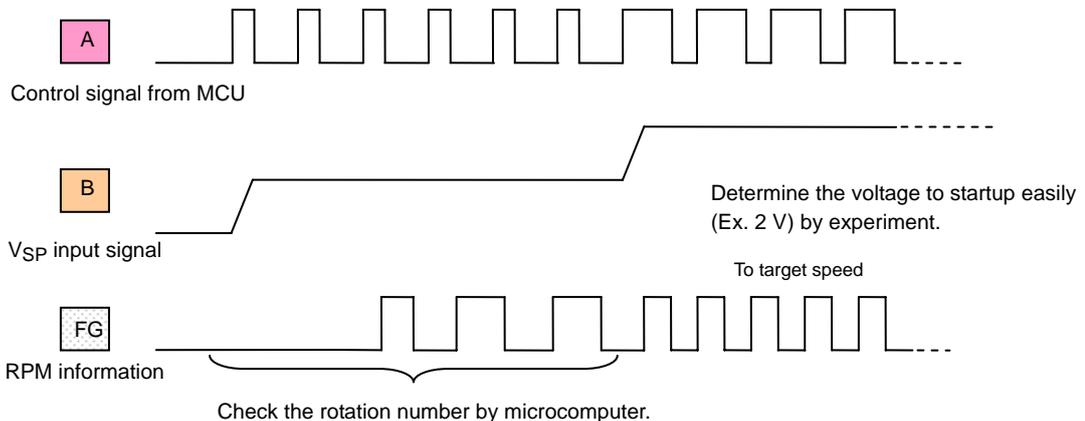
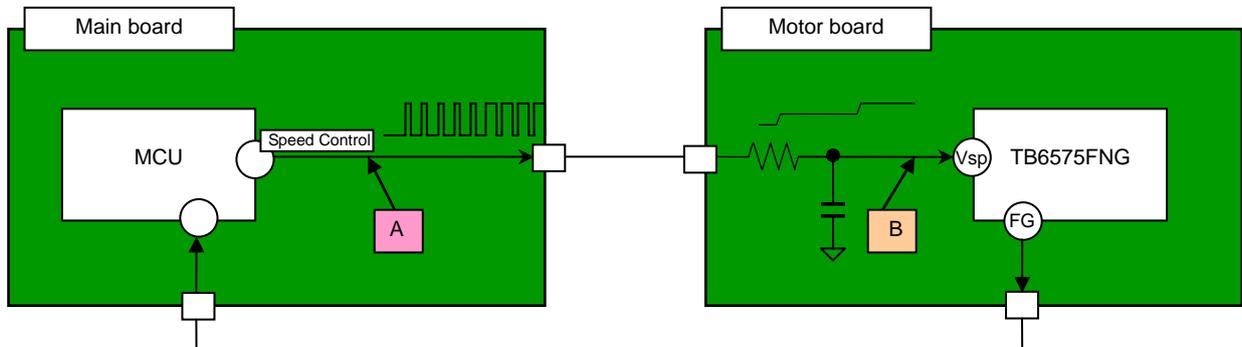
Though DC excitation time and forced commutation are adjusted by experiment, it is difficult to 100% startup because of other conditions including the load.

When the motor does not start, please re-start by checking the motor conditions with microcomputer. Find the best value of V<sub>SP</sub> to start the motor by experiment and apply this V<sub>SP</sub>. To judge whether the motor starts or not, use the microcomputer with FG pulse. When the rotation number corresponding to the V<sub>SP</sub> is gained, change the V<sub>SP</sub> to adjust to the target rotation number. Please check the relation between V<sub>SP</sub> and FG with microcomputer regularly. In the case there is a problem of the condition, please turn on the power again after setting V<sub>SP</sub> zero. If the rotation number is abnormal repeatedly, stop using the motor.

Step 1: Apply V<sub>sp</sub> which is easy to startup.

Step 2: When the motor operates at the appropriate rotation number which corresponds to the V<sub>SP</sub> of Step1, change the V<sub>SP</sub> to gain the target rotation number.

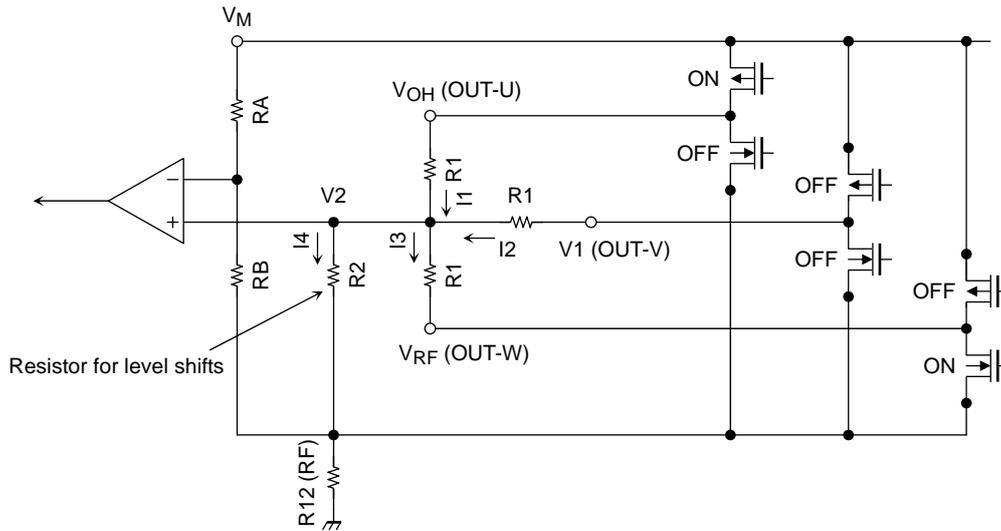
\*: If you cannot have the rotation number which corresponds to the V<sub>SP</sub> of Step1, lower the V<sub>SP</sub> to 1 V and start again.



**TB6575FNG Startup method**

**True circuit diagram (level shift)**

The connection between the external circuit and the power device is shown below.



Induced voltage is supposed to generate under below conditions and output loss is ignored ( $V_{OUT-W}$  is boarded upon  $V_{RF}$ .) in calculating.

- OUT-W ... Low Side: ON
- OUT-U ... High side: ON
- OUT-V ... OFF (BEMF)

**9. Q & A (For your reference)**

(1) What is DC excitation term (TFIX)? How to determine the appropriate term?

Fix the rotor to the initial position. (In CW: the current direction is from U phase to V phase)  
 Time of fixing the rotor is necessary in this term.  
 Conform that the rotor is fixed completely by setting the long time. After that, shorten the fixing time as needed.  
 If the mode is changed to the forced commutation before fixing the rotor, the motor might not startup normally.

(2) What is forced commutation? How to determine the appropriate time?

Forced commutation mode operates the rotor forcibly and generates the induced voltage.  
 When the rotation number of the rotor exceeds the rating determined by  $F_{st}$ , the operation shifts to the normal mode. And so, setting the time is impossible.

(3) In startup, how to input  $V_{SP}$ ?

Find the voltage which is easy to startup the motor operation. Then, apply the fixed voltage (Refer to page 10).  
 After that, conform that rotating number of FG pulse reaches within the rating (rotating number of  $V_{SP}$  conformed in the experiment). Change the  $V_{SP}$  to adjust the rotating number.

(4) In startup, the motor vibrates at first before rotating normally. How to startup the motor smoothly?

The motor vibrates a little at starting because the mode moves from DC exciting to forced commutation. However, it is possible to lighten up the vibration by rising  $V_{SP}$  slowly.

(5) In using the function of over current detection, how to calculate the value of resistance?

The resistance is determined from the formula below.

Detecting resistance  $R (\Omega) = V_{OC} (0.5 (V)) / I_{OUT} (A)$

(Example) In the case current limit is set 1 A:

Spec. of  $V_{OC}$  : 0.46 to 0.54 V

$R = 0.54 \text{ V} / 1 \text{ A} = 0.54 \Omega$

In actual use, if resistance of  $0.54 \Omega$  is used,

$V_{OC}$  (typ.) is 0.5 V and the current is limited at 0.93 A\*.

\* $I_{OUT(limit)} = 0.5 \text{ V} / 0.54 \Omega = 0.93 \text{ A}$

Please set this function in order to stop the motor operation in abnormal state. Set the appropriate resistance not to operate this function in flowing rush current (ex. in startup).

**RESTRICTIONS ON PRODUCT USE**

- Toshiba Corporation, and its subsidiaries and affiliates (collectively "TOSHIBA"), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively "Product") without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**
- Product is intended for use in general electronics applications (e.g., computers, personal equipment, office equipment, measuring equipment, industrial robots and home electronics appliances) or for specific applications as expressly stated in this document. Product is neither intended nor warranted for use in equipment or systems that require extraordinarily high levels of quality and/or reliability and/or a malfunction or failure of which may cause loss of human life, bodily injury, serious property damage or serious public impact ("Unintended Use"). Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. Do not use Product for Unintended Use unless specifically permitted in this document.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA assumes no liability for damages or losses occurring as a result of noncompliance with applicable laws and regulations.