

For inverter users

1. When studying how to use our inverters

Notes

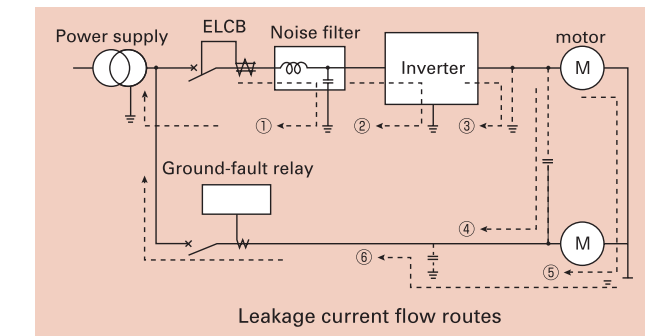
Leakage current

This inverter uses high-speed switching semiconductors for PWM control. When a relatively long cable is used for power supply to an inverter, current may leak from the cable or the motor to the ground because of its capacitance, adversely affecting peripheral equipment. The intensity of such a leakage current depends on the PWM carrier frequency setting, the lengths of the input and output cables, etc., of the inverter. To prevent current leakage, it is recommended to take the following measures.

Effects of leakage current

Leakage current which increases when an inverter is used may pass through the following routes:

- Route (1) ... Leakage due to the capacitance between the ground and the noise reduction filter
 - Route (2) ... Leakage due to the capacitance between the ground and the inverter
 - Route (3) ... Leakage due to the capacitance between ground and the cable connecting the inverter and the motor
 - Route (4) ... Leakage due to the capacitance of the cable connecting the motor and an inverter in another power distribution line
 - Route (5) ... Leakage through the grounding line common to motors
 - Route (6) ... Leakage to another line because of the capacitance of the ground
- Leakage current which passes through the above routes may cause the following trouble.
- Malfunction of a leakage circuit breaker (ELCB) in the same or another power distribution line
 - Malfunction of a ground-relay installed in the same or another power distribution line
 - Noise produced at the output of an electronic device in another power distribution line
 - Activation of an external thermal relay installed between the inverter and the motor, at a current below the rated current



Measures against effects of leakage current

The measures against the effects of leakage current are as follows:

- 1) Measures to prevent the malfunction of leakage circuit breakers (ELCB)
 - (1) Decrease the PWM carrier frequency of the inverter. *Note*
 - (2) Use radio-frequency interference-proof ELCBs as ground-fault interrupters in not only the system into which the inverter is incorporated but also other systems. When ELCBs are used, the PWM carrier frequency needs to be increased to operate the inverter.
 - (3) When connecting multiple inverters to a single ELCB, use an ELCB with a high current sensitivity or reduce the number of inverters connected to the ELCB.
 - 2) Measures against malfunction of ground-fault relay:
 - (1) Decrease the PWM carrier frequency of the inverter. *Note*
 - (2) Install ground-fault relays with a high-frequency protective function in both the same and other lines. When ELCBs are used, the PWM carrier frequency needs to be increased to operate the inverter.
 - 3) Measures against noise produced by other electric and electronic systems:
 - (1) Separate the grounding line of the inverter from that of the affected electric and electronic systems.
 - (2) Decrease the PWM carrier frequency of the inverter. *Note*
 - 4) Measures against malfunction of external thermal relays:
 - (1) Remove the external thermal relay and use the electronic thermal function of the inverter instead of it. (Unapplicable to cases where a single inverter is used to drive more than one motor. Refer to the instruction manual for measures to be taken when thermal relays cannot be removed.)
 - (2) Decrease the PWM carrier frequency of the inverter. *Note*
 - 5) Measures by means of wiring and grounding
 - (1) Use a grounding wire as large as possible.
 - (2) Separate the inverter's grounding wire from that of other systems or install the grounding wire of each system separately to the grounding point.
 - (3) Ground (shield) the main circuit wires with metallic conduits.
 - (4) Use the shortest possible cables to connect the inverter to the motor.
 - (5) If the inverter has a high-attenuation EMC noise reduction filter, change the grounding capacitor switch to reduce the leakage current. Note that doing so leads to a reduction in the noise attenuating effect.
- Note*) In the case of this inverter, the PWM carrier frequency can be decreased to 2.0kHz. Decreasing the carrier frequency results in an increase in electromagnetic noise from the motor.

Ground fault

Before beginning operation, thoroughly check the wiring between the motor and the inverter for incorrect wiring or short circuits. Do not ground the neutral point of any star-connected motor.

Radio interference

[Noise produced by inverters]

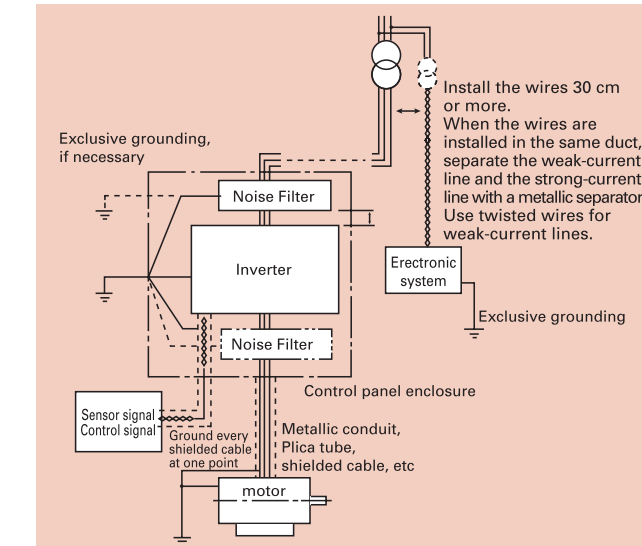
Since this inverter performs PWM control, it produces noise and sometimes affects nearby instrumental devices, electrical and electronic systems, etc. The effects of noise greatly vary with the noise resistance of each individual device, its wiring condition, the distance between it and the inverter, etc.

[Measures against noises]

According to the route through which noise is transmitted, the noises produced by an inverter are classified into transmission noise, induction noise and radiation noise.

[Examples of protective measures]

- Separate the power line from other lines, such as weak-current lines and signal lines, and install them apart from each other.
 - Install a noise reduction filter in each inverter. It is effective for noise prevention to install noise reduction filter in other devices and systems, as well.
 - Shield cables and wires with grounded metallic conduits, and cover electronic systems with grounded metallic cases.
 - Separate the power distribution line of the inverter from that of other devices and systems.
 - Install the input and output cables of the inverter apart from each other.
 - Use shielded twisted pair wires for wiring of the weak-current and signal circuits, and always ground one of each pair of wires.
 - Ground the inverter with grounding wires as large and short as possible, separately from other devices and systems.
- All models, noise can be greatly reduced as they have a built-in EMC noise reduction filter on their input side.**



Power factor improvement capacitors

Do not install a power factor improvement capacitors on the output side of the inverter. Installing a power factor improvement capacitor on the output side causes current containing harmonic components to flow into the capacitor, adversely affecting the capacitor itself or causing the inverter to trip. To improve the power factor, install an input AC reactor or a DC reactor on the primary side of the inverter.

Installation of input AC reactors

These devices are used to improve the input power factor and suppress high harmonic currents and surges. Install an input AC reactor when using this inverter under the following conditions:

- (1) When the power source capacity is 500kVA or more, and when it is 10 times or more greater than the inverter capacity.
- (2) When the inverter is connected the same power distribution system as a thyristor-committed control equipment.
- (3) When the inverter is connected to the same power distribution system as that of distorted wave-producing systems, such as arc furnaces and large-capacity inverters.

2. Selecting the Capacity (model) of the Inverter

Selection

Capacity

Refer to the applicable motor capacities listed in the standard specifications. When driving a high-pole motor, special motor, or multiple motors in parallel, select such an inverter that the sum of the motor rated current multiplied by 1.05 to 1.1 is less than the inverter's rated output current value.

Acceleration/deceleration times

The actual acceleration and deceleration times of a motor driven by an inverter are determined by the torque and moment of inertia of the load, and can be calculated by the following equations.

The acceleration and deceleration times of an inverter can be set individually. In any case, however, they should be set longer than their respective values determined by the following equations.

Acceleration time	$t_a = \frac{(JM+JL) \times \Delta N}{9.56 \times (TM-TL)}$ (sec.)
Deceleration time	$t_d = \frac{(JM+JL) \times \Delta N}{9.56 \times (TB-TL)}$ (sec.)
Conditions	JM : Moment of inertia of motor (kg·m ²) JL : Moment of inertia of load (kg·m ²) (converted into value on motor shaft) ΔN : Difference in rotating speed between before and after acc. or dec. (min ⁻¹) TL : Load torque (N·m) TM : Motor rated torque × 1.2~1.3 (N·m) ... V/f control TM : Motor rated torque × 1.5 (N·m) ... Vector operation control (In case of variable torque characteristic) TM : Motor rated torque × 1.1 (N·m) ... V/f control TM : Motor rated torque × 1.2 (N·m) ... Vector operation control TB : Motor rated torque × 0.2 (N·m) (When a braking resistor or a braking resistor unit is used: Motor rated torque × 0.8~1.0 (N·m))

Allowable torque characteristics

When a standard motor is combined with an inverter to perform variable speed operation, the motor temperature rises slightly higher than it normally does during commercial power supply operation. This is because the inverter output voltage has a sinusoidal (approximate)

PWM waveform. In addition, the cooling becomes less effective at low speed, so the torque must be reduced according to the frequency. Regarding the allowable torque characteristic, please confirm its motor manufacturer.

When constant-torque operation must be performed at low speeds, use a Toshiba VF motor designed specifically for use with inverters.

Starting characteristics

When a motor is driven by an inverter, its operation is restricted by the inverter's overload current rating, so the starting characteristic is different from those obtained from commercial power supply operation.

Although the starting torque is smaller with an inverter than with the commercial power supply, a high starting torque can be produced at low speeds by adjusting the V/f pattern torque boost amount or by employing vector control. When a larger starting torque is necessary, select an inverter with a larger capacity and examine the possibility of increasing the motor capacity.

3. When installing, wiring and operating the inverter

Installing and wiring

Installing precautions

- (1) Do not install in any location of high temperature, high humidity, moisture condensation and freezing. Do not install the inverter where there are gases that corrode metal or solvents that adversely affect plastic. Avoid locations where there is exposure to water and/or where there may be large amounts of dust and metallic fragments. In this case, please install inverters in the enclosure type cabinet. The cabinet must be considered its size and the cooling method to allow the specifications of an ambient temperature for inverters.
- (2) Must be installed in non-inflammables such as metals. The rear panel gets very hot. If installation is in an inflammable object, this can result in fire.
- (3) Inverters should be arranged in horizontal rows.

Wiring precautions

Installing a molded-case circuit breaker [MCCB]

- (1) Install a molded-case circuit breaker (MCCB) on the inverter's power supply input to protect the wiring.
- (2) Avoid turning the molded-case circuit breaker on and off frequently to turn on/off the motor.
- (3) To turn on/off the motor frequently, close/break the control terminals F (or R)-CC.

Installing a magnetic contactor [MC] [primary side]

- (1) To prevent an automatic restart after the power interruption or overload relay has tripped, or actuation of the protective circuit, install an electro-magnetic contact in the power supply.
- (2) The inverter is provided with a failure detection relay (FL), so that, if its contacts are connected to the operation circuit of the magnetic contactor on the primary side, the magnetic contactor will be opened when the protective circuit of the inverter is activated.
- (3) The inverter can be used without a magnetic contactor. In this case, use an MCCB (equipped with a voltage tripping device) for opening the primary circuit when the inverter protective circuit is activated.
- (4) Avoid turning the magnetic contactor on and off frequently to turn on/off the motor.
- (5) To turn on/off the motor frequently, close/break the control terminals F (or R)-CC.
- (6) Install surge suppressor on any magnetic contactor and relay coils used around the inverter.
- (7) If using a braking resistor, install a magnetic contactor (MC) to the power supply of the inverter, so that the power circuit opens when the internal overload relay of the braking resistor is activated.

Installing a magnetic contactor [MC] [secondary side]

- (1) As a rule, if a magnetic contactor is installed between the inverter and the motor, do not turn on/off while running. (If the secondary-side contactor is turned on/off while running, a large current may flow in the inverter, causing inverter damage and failure.)
- (2) A magnetic contactor may be installed to change the motor or change to the commercial power source when the inverter is stopped. Always use an interlock with the magnetic contactor in this situation so that the commercial power supply is not applied to the inverter's output terminals.

External signal

- (1) Use a relay rated for low currents. Mount a surge suppressor on the excitation coil of the relay.
- (2) When wiring the control circuit, use shielded wires or twisted pair cables.
- (3) Because all of the control terminals except FLA, FLB, FLC, RY and RC are connected to electronic circuits, insulate these terminals to prevent them from coming into contact with the main circuit.

Installing an overload relay

- (1) This inverter has an electronic-thermal overload protective function. However, in the following cases, the thermal relay operation level must be adjusted or an overload relay matching the motor's characteristics must be installed between the inverter and the motor.

- (a) When using a motor having a rated current value different from that of the equivalent.
 - (b) When driving several motors simultaneously.
- (2) When using the inverter to control the operation of a constant-torque motor (VF motor), change the protective characteristic of the electronic thermal relay according to the setting of the VF motor.
 - (3) In order to adequately protect a motor used for low-speed operation, we recommend the use of a motor equipped with an embedded thermal relay.

Wiring

- (1) Do not connect input power to the output (motor side) terminals (U/T1, V/T2, W/T3). That will destroy the inverter and may result in fire. Please pay attentions of wiring before power supply turns-on.
- (2) The DC terminals (PA+, PC-, PB and PB) are for specified options. Do not connect other devices to these terminals.
- (3) Within 15 minutes after turning off input power, do not touch wires of devices (MCCB) connected to the input side of the inverter.

Grounding

The inverters and motors must be connected to ground securely. In case of grounding for inverters, please use the grounding terminal of the inverter.

Operating precautions

- (1) The inverter operates in abnormal circumstances the security function, and stops outputting. However, the inverters can not stop the motors quickly. Please install the

mechanical brake or maintenance function in the mechanical equipment and the device for which the emergency stop is necessary.

- (2) When you drive the machine and the device that hangs the load repeatedly with the inverter, the semiconductor within inverter might cause thermal fatigue, and it come to have a short life if a big current flows repeatedly when driving and stopping. In this case, it is possible to extend life span by controlling the starting current and the load current low or setting the PWM carrier frequency low. If you can not decrease the starting current, please select larger capacity of inverters for current margins.

4. When changing the motor speed

Application to standard motors

Vibration

When a motor is operated with an inverter, it experiences more vibrations than when it is operated by the commercial power supply. The vibration can be reduced to a negligible level by securing the motor and machine to the base firmly.

If the base is weak, however, the vibration may increase at a light load due to resonance with the mechanical system

Acoustic noise

The magnetic noise of motors with inverter drives is changed by PWM carrier frequency. In case of high PWM carrier frequency settings, its acoustic noise is almost same as commercial power supply drives. Moreover, when the motors are operated over rated rotation, the windy noise of the motors is increased.

Reduction gear, belt, chain

Note that the lubrication capability of a reducer or a converter used as the interface of the motor and the load machine may be affected at low speeds.

When operating at a frequencies exceeding 60 Hz or higher, power transmission mechanisms such as reduction gear, belts and chains, may cause problems such as production of noise, a reduction in strength, or shortening of service life.

Frequency

Before setting the maximum frequency to 60 Hz or higher, confirm that this operating range is acceptable for the motor.

Starting method

When you drive the motor with changeable connection between star-connection and delta-connection for decreasing starting current, please connect delta-connection only. If you change motor connection while inverter drives, the protective function of inverter occurs.

Application to special motors

Gear motor

When using an inverter to drive a gear motor, inquire of the motor manufacturer about its continuous operation range due to the followings:

- The low-speed operation of a gear motor may cause insufficient lubrication
- The loss of a gear may be increasing than commercial power supply drives.
- In case of the high frequency operation, the acoustic noise and motor temperature may be higher.

Toshiba Gold Motor (High-efficiency power-saving motor)

Inverter-driven operation of Toshiba Gold Motors is the best solution for saving energy. This is because these motors have improved efficiency, power factor, and noise/vibration reduction characteristics when compared to standard motors.

Pole-changing motor

Pole-changing motors can be driven by this inverter. Before changing poles, however, be sure to let the motor come to a complete stop. If you change motor connection while inverter drives, the protective function of inverter occurs.

Underwater motors

Note that underwater motors have higher rated current than general motors. The current ratings of underwater motors are relatively high. So, when selecting an inverter, you must pay special attention to its current rating so that the current rating of the motor is below that of the inverter.

When the lengths of the motor cable are long, please use thicker cable than a table of 'Wiring devices' because the maximum torque is decreased by the voltage dropping.. Moreover, please pay attention to select leakage circuit breakers.

Single-phase motor

Because single-phase motors are equipped with a centrifugal switch and capacitors for starting, they cannot be driven by an inverter. When single phase motors are driven by inverters, a centrifugal switch and capacitors may be broken. If only a single-phase, power system is available a 3-phase motor can be driven by using a single-phase input inverter to convert it into a 3-phase 200V output. (A special inverter and a 3-phase 200V motor are required.)

Braking motor

When using a braking motor, if the braking circuit is directly connected to the inverter's output terminals, the brake cannot be released because of the lowered starting voltage. Therefore, when using a braking motor, connect the braking circuit to the inverter's power supply side, as shown on the below. Usually, braking motors produce larger noise in low speed ranges.

