For inverter users

When studying how to use our inverters

Notes

Application of this inverter

VF-FS1 is not applicable for apparatus which needs sudden deceleration and stop. Also it can not be used for machine which requires continuos electrical braking (generaters regeneration power) such as a winding machine.

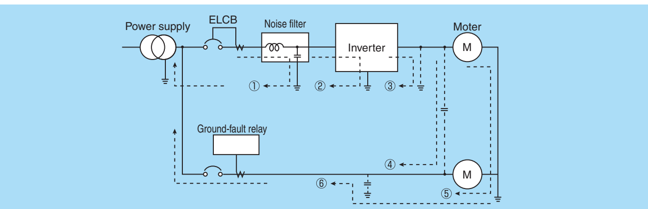
Leakage current

This inverter uses high-speed switching devices 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, 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 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 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 rate current



Leakage current flow routes

【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
(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 (e.g.,Toshiba CCR12 type of relays) 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. (Inapplicable 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)

Note) This inverter allows you to decrease the frequency up to 6.0kHz.
If the carrier frequency reduce, the acoustic noise caused by the motor increase.

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 EMI filter, turn off the grounding capacitor detachment switch to reduce the leakage current. Note that doing so leads to a reduction in the noise attenuating effect.

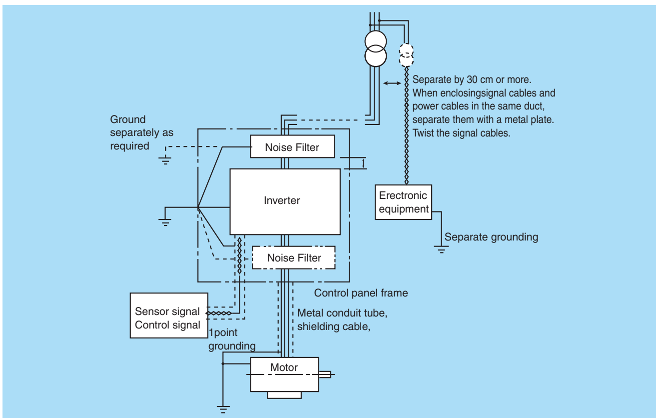
Ground fault

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 filter in each inverter. It is effective for noise prevention to install noise filters 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. The three-phase 400V models have built-in noise filters, which significantly reduce noise.



Power factor improvement capacitors

Do not install a power factor improvement capacitors on the input or output side of the inverter.
Installing a power factor improvement capacitor on the input or 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 (optional) 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 inverter is connected the same power distribution system as a thyristor-committed control equipment.
(2) 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.

When wiring the inverter

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.

Installing a magnetic contactor [MC] [secondary side]

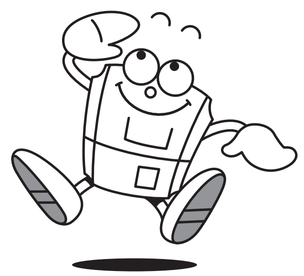
(1) As a rule, if a magnetic contactor is installed between the inverter and the motor, do not turn ON/OFF while running. (If the secondary-side contactor is turned ON/OFF while running, a large current may flow in the inverter, causing inverter damage and failure.)
(2) A magnetic contactor may be installed 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) All control terminals, except FLA, FLB and FLC are electronic circuits. Therefore, input signal must insulate with power circuit.

Installing an overload relay

(1) The VF-FS1 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 a embedded thermal relay.



When changing the motor speed

Application to standard motors

Vibration

When a motor is operated with an industrial 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.

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 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.

Application to special motors

Gear motor

When using an industrial inverter to drive a gear motor, inquire of the motor manufacturer about its continuous operation range, since low-speed operation of a gear motor may cause insufficient lubrication.

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.

Multipolar motors

Note that multipolar motors(8 or more poles), which may be used for fans, etc., have higher rated current than 4-pole motors.
The current ratings of multipolar 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.

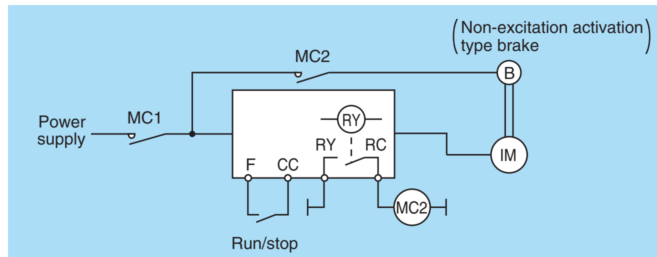
Single-phase motor

Because single-phase motors are equipped with a centrifugal switch and capacitors for starting, they cannot be driven by an inverter. 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 240V output. (A special inverter and a 3-phase motor are required.)

Braking motor

When using a braking motor, if the braking circuit is directly connected to the inverters'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 left. Usually, braking motors produce larger noise in low speed ranges.

Note: In the case of the circuit shown on the left, assign the function of detecting low speed signals to the RY and RC terminals. Make sure the parameter F130 is set to 4 (factory default setting).



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 inertia2 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	$ta=\frac{(J_M+J_L)\times\Delta N}{9.56\times(T_M-T_L)}$ (sec)
Deceleration time	$ta=\frac{(J_M+J_L)\times\Delta N}{9.56\times(T_B+T_L)}$ (sec)
Conditions	J_M: Moment of inertia of motor (kge.m^2) J_L: Moment of inertia of load (kge.m^2) (converted into value on motor shaft) ΔN: Difference in rotating speed between before and after acc. or dce. (min.$^{-1}$) T_L: Load torque (Ne.m) T_M: Motor rated torque x 1.1 (Ne.m) ... V/f control : Motor rated torque x 1.2 (Ne.m) ... Vector operation control T_B: Motor rated torque x 0.05 (Ne.m)

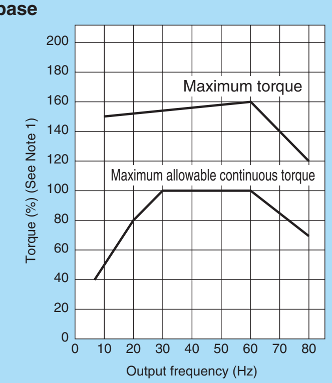
Allowable torque characteristics

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

[An example of V/F control at a base frequency of 60 Hz]

Note 1. 100% of torque refers to the amount of torque that the motor produces when it is running at a 60Hz-synchronized speed. The starting torque is smaller in this case than that required when power is supplied from a commercial power line. So, the characteristics of the machine to be operated need to be taken into consideration.

Note 2. The maximum allowable torque at 50Hz can be calculated approximately by multiplying the maximum allowable torque at a base frequency of 60Hz by 0.8.



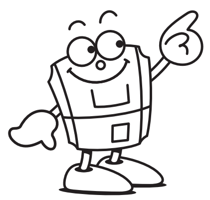
Starting characteristics

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.
If you need bigger starting torque, please consider both upgrading inverter rating and motor rating.

Harmonic current and influence to power supply

Harmonics are defined as sinusoidal waves that is multiple frequency of commercial power (base frequency: 50Hz or 60Hz). Commercial power including harmonics has a distorted waveform.
Some electrical and electronic devices produce distorted waves in their rectifying and smoothing circuits on the input side. Harmonics produced by a device influence other electrical equipment and facilities in some cases (for example, overheating of phase advancing capacitors and reactors).

For this inverter,Toshiba unique technologies suppress harmonics, particularly 5th and 7th harmonic current that affect power sources. And the power factor in all models has been improved. Harmonics are controlled to within the Total Harmonic Distortion (THD) of international standard IEC61000-3-12 without any external reactor. (Rsce ≧120)
Optional AC reactor enables to comply with Partial Weighted Harmonic Distortion (PWHD) of IEC 61000-3-12. (Rsce ≧120)



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