When studying how to use our inverters

Notes

Leakage current

This inverter uses high-speed switching devices for PWM control. When a relatively long period of time is required, current may leak from the control cables 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 length 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 to the ground via the noise filter
Route (2) Leakage due to the capacitance between the ground and the inverter
Route (3) Leakage to the ground via the cable connecting the inverter and the motor
Route (4) Leakage to the capacitance of the control cables connecting the motor and inverter in another power distribution line

1) Minimize the capacitance between the ground and the inverter by: 
- Installing shielded control cables between the inverter and control panel frame.
- Installing noise filters in each inverter.
- Using shielded cables which have grounded metallic sheaths and cover electronic systems with grounded metallic cases.

2) MIN Invest in high-speed switching devices for PWM control.

3) Minimize the capacitance of the ground cables which pass through the above routes by following the necessary measures.

[Measures against effects of leakage current]

Leakage current is pumping current and may cause malfunction of the ground-fault relay. To prevent current leakage, it is recommended to take the following measures:

1) Increasing the PWM carrier frequency of the inverter
2) Decreasing the PWM carrier frequency of the inverter
3) When connecting multiple inverters to a single ELCB, use an ELCB with a carrier frequency narrower than the carrier frequency of the inverter

Radio interference

[Noise produced by inverters]

- Electromagnetic noise produced by PWM control, it produces noise and sometimes affects nearby instrumented devices, electronic and electrical systems, etc.
- The noise is produced with the noise resistance of individual devices, temperature conditions, the distance between it and the inverter, etc.

[Examples of protective measures]

- Place the power lines from other systems with such as 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 conduit, and cover electronic systems with grounded metallic cases.
- Install a noise filter at the power line from other systems with such as current lines and signal lines, and always ground one of each pair of wires.

- Install the input and output cables of the inverter apart from each other.

- Route (4) ... Leakage due to the capacitance between the ground and the noise filter

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 to the same power distribution system as the three-phase AC power source

When wiring the inverter

Wiring procedure

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 on the molded-case circuit breaker on and off frequently to turn on/off the inverter.

Installing a magnetic contactor (MC) (primary side)

1. To prevent automatic restart after the power interruption or overload relay has tripped, or actuation of the protective circuit, install an electronic magnetic contactor in the power supply.
2. The inverter is provided with a failure detection relay (FL). So, 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 primary side 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 inverter.

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 OFF/ON while running, a large current may flow in the inverter, causing inverter damage and faults.
2. A magnetic contactor may be installed to change the motor current or the power source current when the inverter is stopped. Always use an interlock with the magnetic contactor so that the commercial power supply is not applied to the inverter's output terminals.

External signals

1. Use a relay for low-current signals. 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, FLDC and FLD are electronic circuits. Therefore, input signal must isolate with power circuit.

Installing an overload relay

1. The VR-11 type overload relay 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 characteristic must be installed between the inverter and the motor.
2. When using a motor having a rated current value different from that of the overload relay, adjust the sensitivity of the overload relay accordingly to the setting of the VR-11 type overload relay.
3. As a rule, if a magnetic contactor is used for overload protection, we recommend the use of a motor equipped with a grounded thermal relays.

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 inverter, adversely affecting the inverter itself or causing the inverter to trip. To improve the power factor, install an input AC reactor or a DC reactor (optional) on the primary side of the inverter.

When changing the motor speed

(Application to standard motor)

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 high 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 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 chain, 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 operation is acceptable for the motor.

(Application to special motors)

Gear motor

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

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 motors

Pole-changing motors can be driven by this inverter. Before changing poles, however, be sure to let the motor come to a complete stop.
For inverter users

Selection (model of the inverter)

Selecting the capacity of the inverter

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 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 will be less than their respective value determined by the following equations.

<table>
<thead>
<tr>
<th>Acceleration time (sec)</th>
<th>Deceleration time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA + (N-1) x (A-1)</td>
<td>MA + (N-1) x (A-1)</td>
</tr>
<tr>
<td>A: Maximum number of poles</td>
<td></td>
</tr>
<tr>
<td>N: Number of poles</td>
<td></td>
</tr>
<tr>
<td>V: (Difference in rating speed between before and after motor)</td>
<td></td>
</tr>
<tr>
<td>T: Motor rated torque (N.m)</td>
<td></td>
</tr>
<tr>
<td>J: Motor synchronous inertia x 0.5 (Jm)</td>
<td></td>
</tr>
<tr>
<td>L: Motor rotor inertia (Jl)</td>
<td></td>
</tr>
<tr>
<td>N: Motor rated torque x 0.2 (Ne.m)</td>
<td></td>
</tr>
<tr>
<td>N: Moment of inertia of load (kg.m²)</td>
<td></td>
</tr>
</tbody>
</table>

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 speeds, 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.

Starting torques

- When a motor is driven by an inverter, the operation is restricted by the inverter’s overload current rating, so the starting characteristics are 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.

Harmonic current and influence to power supply

- Harmonics are defined as sinusoidal waves that is 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 circuits and reactors).

Measures for suppressing higher harmonics

- [An example of V/f control at a basic frequency of 60 Hz]

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting a reactor</td>
<td>The leakage of electrical interrupter from an inverter can be restrained by connecting an AC reactor (ACL) to the input side of the inverter or a DC reactor (DCR) to the DC side of the inverter.</td>
</tr>
<tr>
<td>Connecting a higher harmonic suppressing reactor (HCR)</td>
<td>A PWM converter that shapes the waveform of an output current into a substantially sinusoidal waveform. The leakage of higher harmonics is restrained by connecting a harmonic suppressing reactor (HCR).</td>
</tr>
<tr>
<td>Connecting higher order phase advancing reactor</td>
<td>A harmonic current can be reduced by the use of a phase advancing reactor that consists of 5-phase advanced capacitors and a DC reactor.</td>
</tr>
<tr>
<td>Connecting a magnetic suppressor</td>
<td>A harmonic current can be restricted by the use of a phase advanced capacitors and a DC reactor.</td>
</tr>
<tr>
<td>Output of operation of harmonics</td>
<td>The maximum allowable harmonic current can be suppressed by the use of reactors (ACL) and reaction filters.</td>
</tr>
</tbody>
</table>

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 source. In such a case, the starting characteristics may not be as robust as those of a machine on a standard power source such as a Thyristor and a larger capacity motor is recommended in such cases.
Power

Input AC reactor (ACL)

Devices

Table 1: Specifications of Input AC Reactors

<table>
<thead>
<tr>
<th>Model</th>
<th>Rating</th>
<th>Inverter type</th>
<th>Dimensions (mm)</th>
<th>Terminals</th>
<th>Approx. weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFL5520</td>
<td>Input 4MV-2050PL</td>
<td>VFS11-2050PL</td>
<td>45 35 75 115 80 65</td>
<td>A, B, C, D</td>
<td>0.6</td>
</tr>
<tr>
<td>PFL5520</td>
<td>Input 2MV-2000PL</td>
<td>VFS811-2000PL</td>
<td>45 35 75 115 80 65</td>
<td>A, B, C, D</td>
<td>0.2</td>
</tr>
</tbody>
</table>

DC reactor (DCL)

Table 2: Specifications of DC Reactors

<table>
<thead>
<tr>
<th>Model</th>
<th>Rating</th>
<th>Inverter type</th>
<th>Dimensions (mm)</th>
<th>Terminals</th>
<th>Approx. weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCL2001</td>
<td>Input 2MV-2050PL</td>
<td>VFS811-2050PL</td>
<td>45 35 75 115 80 65</td>
<td>A, B, C, D</td>
<td>0.6</td>
</tr>
</tbody>
</table>

External dimensions and connections

Zero-phase reactance core-type radio noise filter

Table 3: Specifications of Zero-phase Reactors

<table>
<thead>
<tr>
<th>Model</th>
<th>Rating</th>
<th>Inverter type</th>
<th>Dimensions (mm)</th>
<th>Terminals</th>
<th>Approx. weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB1-1201</td>
<td>120W-200G</td>
<td>VFS11-2000PL</td>
<td>45 155 20 4.2 172</td>
<td>A, B, C, D, E, F</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Banding resistor

Table 4: Specifications of Braking Resistors

<table>
<thead>
<tr>
<th>Model</th>
<th>Rating</th>
<th>Inverter type</th>
<th>Dimensions (mm)</th>
<th>Terminals</th>
<th>Approx. weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB1-1201</td>
<td>120W-200G</td>
<td>VFS11-2000PL</td>
<td>45 155 20 4.2 172</td>
<td>A, B, C, D, E, F</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Note: Use the same type of banding resistor of VFS11-2000PL to VFS11-600A/PL. The current values are approximate values due to the internal composition of resistance.