

Using Ground Fault Circuit Interrupters with Lenze AC Tech Drives

There are many applications that require a ground fault circuit interrupter (GFCI) device. A GFCI can be installed on single or three-phase systems with amperage values of 20, 40, 60, 80 or 100 amps. GFCI devices are used to protect a line where leakage current is prevalent or becomes a safety issue. These devices are used in a location where water is present to protect against electrocution or other safety hazards. Installation of a GFCI device to a pulse-width modulated drive can cause nuisance trips from parasitic capacitance. In most cases, nuisance trips can be resolved with the right drive settings, motor and power cabling.

GFCI Device Types:

How many types of GFCI devices are there?

There are two types of GFCI devices, Class A and Class B. *NFPA 70 – Article 100* defines Ground-Fault Circuit-Interrupter (GFCI) as a device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.

Class-A ground-fault circuit-interrupters trip when the current to ground is 6mA or higher and do not trip when the current to ground is less than 4mA. For further information, refer to UL 943, Standard for Ground-Fault Circuit Interrupters.

NFPA 70, Article 110.3 - Examination, Identification, Installation, and Use of Equipment.

(B) Installation and Use. Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling.

NFPA 70E Article 110.9 – Use of Equipment

(C) GFCI Protection Devices. GFCI protection devices shall be tested per manufacturer's instructions

Class-B ground-fault circuit-interrupters trip when the current to ground is 20 mA or higher and only allowed by NFPA 70 (the NEC) to be used in swimming pool installations installed prior to May 1965.

Some GFCIs have custom design features such as grounded neutral protection, inverse time curve to prevent nuisance tripping, external TEST and RESET buttons and are UL listed. Some brands can be equipped with isolated NEMA rated contactors and others are designed specifically to be used with a variable frequency drive. Figure 1 illustrates the internal layout.

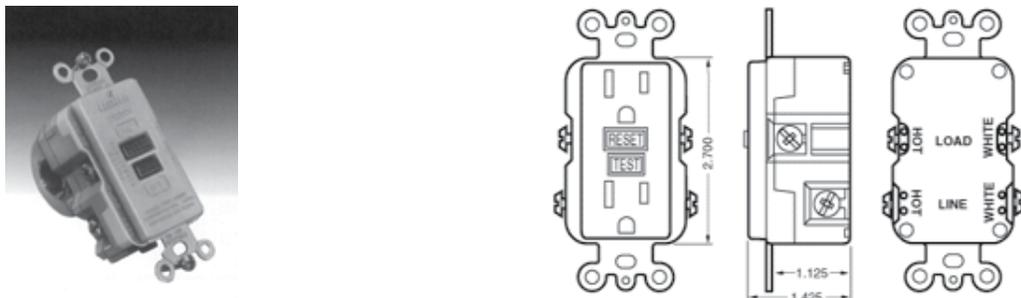


Figure 1: GFCI Layout

Using GFCI Devices with our VFDs

Why does a VFD trip these GFCI devices?

A Pulse-Width Modulated (PWM) drive consists of four major function blocks: an input rectifier bridge circuit, a power stage to generate the DC Bus, a driver circuit for logic control of the phase-firing signals, and an inverter section that converts DC to a three-phase PWM output. These DC pulses of varying width (voltage) and polarity (frequency) operate based on the carrier frequency setting of the drive. The motor coil's inductance resists the rapid voltage changes and averages these high frequency pulses making them appear to the motor as a three-phase sine wave.

Since a capacitor approximates a short circuit at high frequencies, insulated gate bipolar transistors (IGBTs) induce more capacitive-coupled current than slower devices such as a motor. Higher carrier frequencies induce more capacitive energy to the rotor and the stator frame since there are more pulses in a given period. In addition, PWM drives utilizing IGBTs can cause electric discharge machining (EDM) currents. This common-mode current does not circulate but rather travels to ground. The path to ground can be made through the motor bearings, load or auxiliary equipment bearings. These EDM currents manifest themselves as "leakage currents", which are inherent in PWM based drives.

Leakage currents produced when using GFCI Devices:

How do we troubleshoot for using GFCI devices with our VFDs?

If the VFD has no motor connected and nuisance tripping occurs, the problem is more likely related to input power filtering. If it's a voltage-doubler drive (input voltage is 120V and output is 230V) the GFCI is more likely to trip because there is more ripple on the DC bus.

If a footprint filter is used on the drive, that by itself may be causing excess leakage! Depending on the model number of the drive, Lenze AC Tech has low leakage filters that may solve this. One suggestion is trying to use the drive without a filter and see if the GFCI still trips. If so, using a low leakage filter may be the best solution.

Leakage currents can also occur between the motor power cable lines during VFD operation, when connecting multiple drives to the same input source and when using RFI filters on the input side.

If the VFD is connected to a motor, the problem could be due to the combination of the VFD, output power cable and the motor. The drive generates a high frequency PWM three-phase output and noise spikes may be present on the leading edge of these signals. These noise spikes get amplified through long cable lengths due to the additional capacitance of the cable itself. In other words, the drive, motor and cabling all play a role in the GFCI tripping.

It is also important to know how much leakage the drive is causing to the GFCI device. Some GFCIs have adjustable trip settings, so always confirm the setting is at minimum equal to the earth leakage current tolerance for the given drive, which is typically > 3.5mA to protective earth ground (PE).

Troubleshooting tips:

If the GFCI is tripping, check these items:

1. Set the lowest possible carrier frequency on the drive; lower carrier means less switching on/off of the output power transistor packs (IGBTs).
2. Set the minimum frequency between 15 to 20 Hz. This means the motor runs at no less than that speed on start-up.
3. Check the type of GFCI being used. Is it rated for residential (class-A) or commercial (class-B) grade usage?
Newer 120V single phase GFCI devices are rated at 6mA for residential rating and personnel protection. (Refer to *GFCI Device Types* for more details).
4. Set the fastest acceleration time possible. This gives less chance of tripping during speed increases.
5. Use the shortest possible motor power cables. Long leads give more added capacitance and also increases the noise spikes generated on the output PWM waveform.
6. Make sure there is a good ground. The motor power cables should have a shield and be terminated at both the drive end and the motor end.

If these suggestions don't solve the problem, further define these specifics about the application:

- How long are the motor power cable leads?
- What is the capacitance?
- What type of grounding scheme is used for drive and motor?
- What is the leakage current when the motor isn't running?
- What is the leakage current when it is running?
- Is a load connected when the GFCI device trips? If so, what type of load?
- It may also be a good idea to add an output choke.

Using a floating input

One of the myths about reducing leakage current on Lenze AC Tech drives is using a floating input. And it is just that - a *myth!*



WARNING:

Lenze AC Tech does NOT recommend operating with a floating input on any of the sub-micro or newer designed drives.

If there are no disturbances on the line, the drive should theoretically run fine. However, serious common mode noise could cause nuisance tripping or worse.



NOTE:

- The older MC series drives use a string of resistors between the DC Bus and ground, which means common mode noise would not be an issue.
- The newer MC 30HP and higher drives still use the resistor string, so that means using the floating ground on this MC series will most likely be okay.
- In general, a floating point system is NOT recommended for all of the newer drive technology.