GROUND-FAULT MONITORING IN ADJUSTABLE-SPEED DRIVE APPLICATIONS

Issues with variable frequency drives

The built-in ground-fault-trip level of many drives is not adjustable, and is set to function at a ground-fault current that is a proportion, such as 50%, of rated drive current. As a result, variable-frequency drives used on resistance-grounded power-distribution systems may not trip when a ground fault is present. Because the trip level of the drive is higher than the maximum ground-fault current, the drive will continue to operate with a fault present. An SE-701 Ground-Fault Monitor, an SE-703/SE-704 Earth-Leakage Monitor, or an EL731 AC/DC Sensitive Earth-Leakage Relay can be used to add ground-fault protection to these systems.

Many VFD's have EMI-reduction capacitors connected phase-to-ground at their input. The capacitors are often rated for line-to-neutral voltage, with the assumption that the power system will be solidly grounded. However, during a ground-fault on a resistance-grounded system, the voltage on the two non-faulted phases rises to line-to-line voltage to ground, possibly destroying the EMI capacitors. Unless the capacitors are line-voltage rated, it is prudent to remove these capacitors before failure occurs. For more information, review the VFD documentation or contact the drive manufacturer.

Most VSD's have a constant volts per Hertz output ratio to avoid motor-winding saturation at 10 W frequencies (often a very-low-speed torque-boost system is also implemented). The result is load-side ground faults that have both variable-frequency and variable-current characteristics.

Filtering, filter selection, and recommended set point

For applications in which a VFD is often operated at a low output frequency, use an EL731 AC/DC Sensitive Earth-Leakage Relay. The EL731 has a 0 to 6,000 Hz ground-fault-current frequency response that can be filtered in various steps. See Fig. 3 for EL731 filter characteristics.

When an SE-700 Series Ground-Fault/Earth-Leakage Monitor is used in a variable-frequency application for ground-fault detection across a wide frequency range, select the Variable-Frequency (peak-detection) filter. This filter has a wider pass band and less attenuation of frequencies below 60 Hz than the Fixed-Frequency (DFT) filter.

When used to detect a low-frequency fault, a lower trip setting can be required due to the SE-700 Series frequency response. Use the normalized response value from the chart in Fig. 1 to calculate the appropriate trip-level setting, considering the lowest expected operating frequency. To calculate the setting, multiply the desired trip level by the normalized response value at the lowest-expected operational frequency.

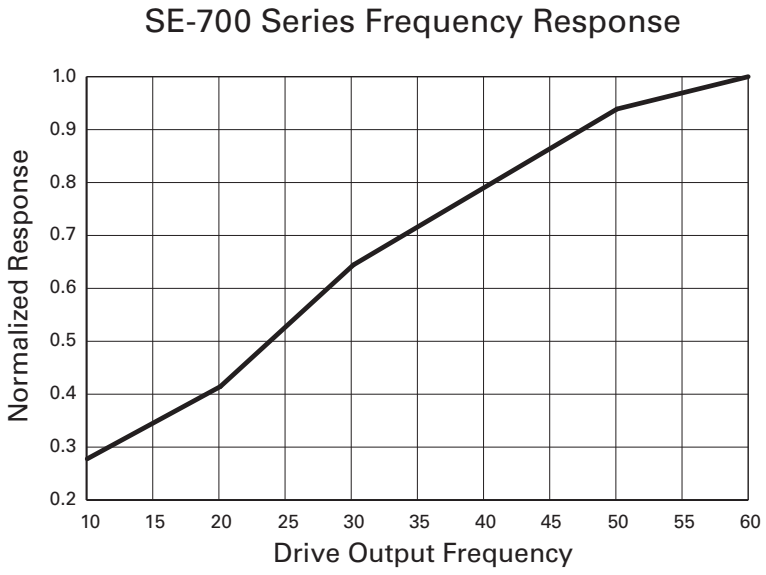

Figure 1: SE-700 Series Frequency Response, Variable-Frequency Filter

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Recommended setting = (desired trip level) x (normalized response at lowest frequency)

For instance, if a 625-mA RMS trip level is desired and the VFD will often be operating at 40 Hz, the recommended setting is 625 mA x 0.8 = 500 mA.

Ground-fault current transformer location

Install the zero-sequence current transformer(s) on the line side of the drive. Without an isolation transformer, a VFD does not isolate downstream fault current; a ground-fault located on a VFD-supplied load will be detected equally by ground-fault monitors upstream and downstream of the drive. In the resistance-grounded system shown in Fig. 2 with a ground fault in the load, the measured ground-fault current is the same at each ground-fault relay.

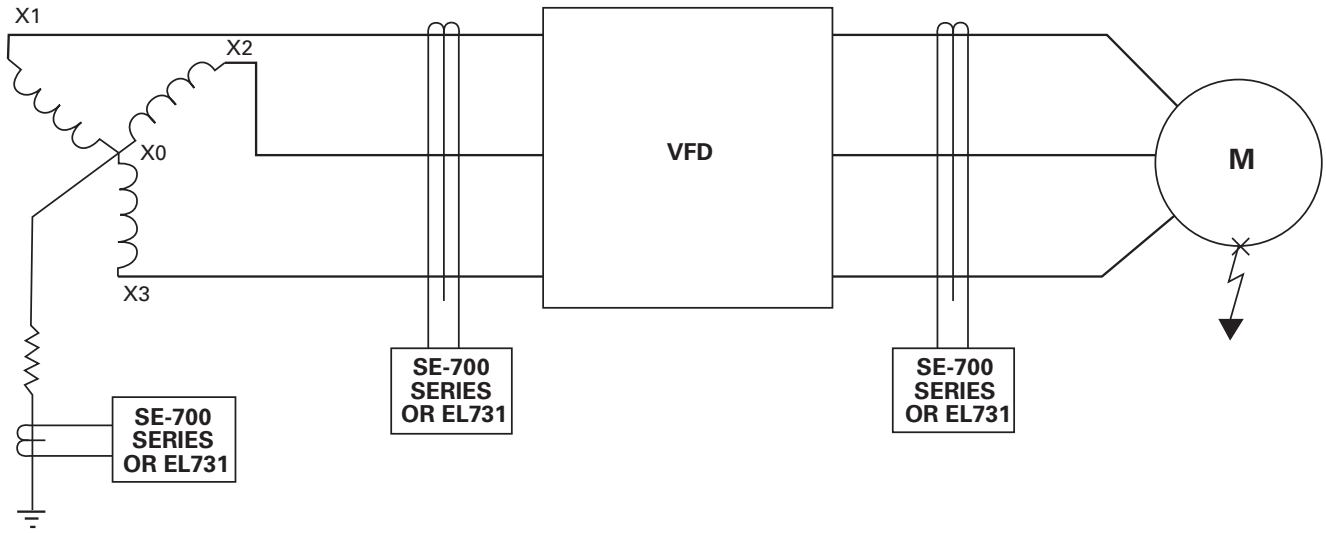

Figure 2: VFD Resistance-Grounded System

Installing the ground-fault CT upstream of the drive is beneficial because it can detect a fault in the cable to the drive, in the drive, and downstream of the drive.

DC bus ground-fault

When the CT(s) for an EL731 series is installed on the line side of a VFD, a dc-bus ground fault or low-frequency fault will be measured with no attention by CT1. For this reason, use an EL731 for applications which will often operate at low speeds and for dc-bus fault detection.

When the CT for an SE-700 Series is installed on the line side of a VFD it is possible for it to detect a ground fault on the DC bus of the drive, and to detect a low-frequency fault elsewhere. With the peak-detection filter, the 180 Hz ripple current (150 Hz on a 50-Hz supply) that is always present can be detected. This ripple current is typically of a much smaller magnitude than the total fault-current and requires a low trip-level setting, which should be verified by testing. The expected value of the 180 Hz component is 10 to 15% of the prospective fault current on a resistance-grounded system, requiring a trip-level setting that is a maximum 10% of NGR let-through current.

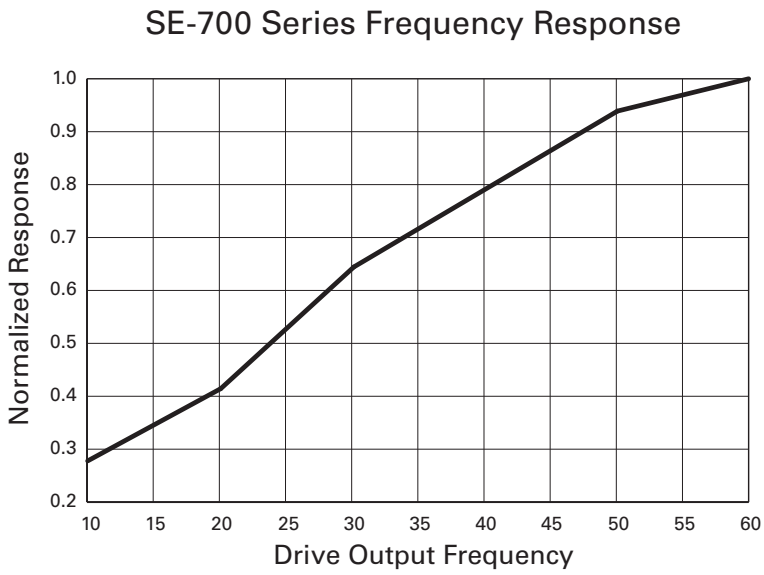

Figure 3: EL731 Filter Characteristics