Solving VFD Over-Voltage Nuisance Tripping

General Application

- Line side of VFD
- Reduction of OV nuisance tripping
- Reduction of DC bus peak overvoltage
- Protection of motor drive electronics

This application note offers advice about reducing nuisance tripping of VFDs and protecting input rectifiers (diodes) from failure due to transient over voltage.

During normal operation, VFDs may be exposed to transient overvoltage due to capacitor switching, utility equipment switching or lightning. Any transient voltage experienced on the input conductors to an AC voltage source drive, will be transferred as an impulse onto the DC bus.

VFDs will attempt to protect themselves against over-voltage by shutting down, but this often considered a nuisance because it stops a production operation. In some cases the transient over voltage may be severe enough to cause damage to the input rectifiers (diodes).

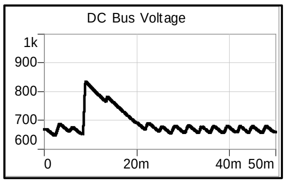
This paper explains simple ways to protect the VFD and to achieve ride through capability for low to medium level voltage transients.

Approvals / Standards

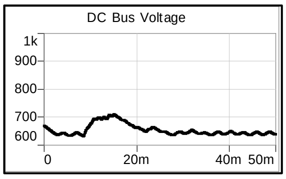
- UL Listed (E173113)
- IEC/EN60076-6 VDE0532-76-6

RoHS 2011/65/EU
c UL US LISTED

DC Bus Voltage Waveform



Without Reactor



With Reactor

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Over-voltage (OV) nuisance tripping is one of the most common power quality issues experienced in variable frequency drive (VFD) applications. This issue relates to the activation of over-voltage protection circuitry which is built into voltage source drives. If the DC bus voltage rises above a pre-set threshold, then the drive will automatically shut off as a means of protecting the electronic components within the drive. The threshold will vary by manufacturer, but may be in the range of about 12% to 15% overvoltage.

There are two common sources of transient over-voltage: 1) capacitor switching, 2) lightning. Capacitor switching may take place at the utility substation, on the distribution lines or within a customer facility. Capacitor switching generally causes a voltage transient with peak voltage of 1.5 to 2.0 p.u. There is a corresponding increase in the DC bus voltage, which ultimately can active OV protection and cause an OV trip. The peak of this transient can decrease as the impulse travels through system impedance due to voltage drop. Generally, the closer a drive is located to the source of the impulse, the greater the effect of the impulse on the drive.

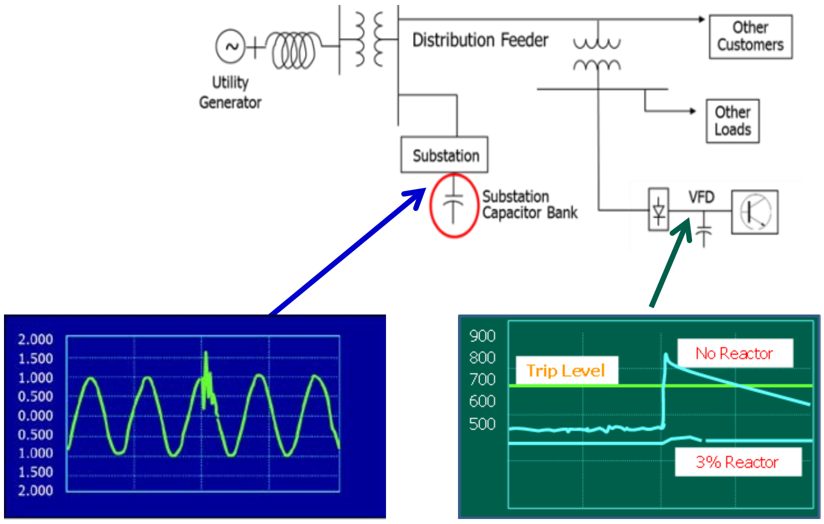

Fig. 1a Power System AC Voltage

Fig. 1b DC Bus Voltage

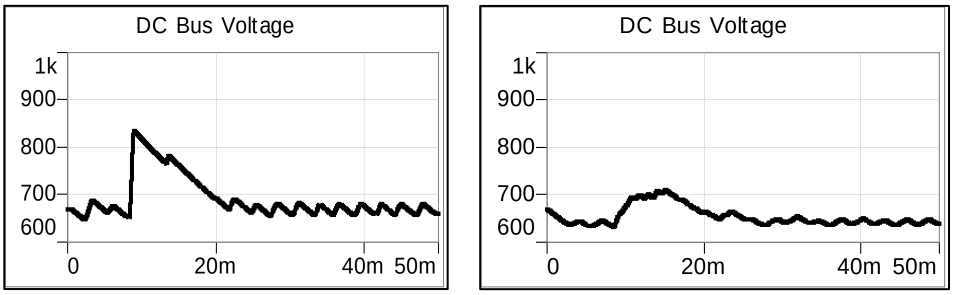

Fig. 1c DC bus (no line reactor)

Fig. 1d DC Bus (with ACL Line Reactor)

Fig. 1a shows a transient produced at a utility electrical substation, where a capacitor is switched. The amplitude of the peak voltage at this location is dependent upon the instantaneous voltage available at the moment switching occurs. There can also be oscillation at the natural resonance frequency of the power system. If the capacitor is switched near the peak of the voltage sine wave (Fig. 2a), then the transient can be as large and may double the peak voltage. If the capacitor switching occurs at a point in the voltage sine wave that is near to the zero axis (Fig. 2b), the transient can be lower in amplitude.

Capacitor switching near the peak of the sine wave and near the zero cross are illustrated below in Fig 2.

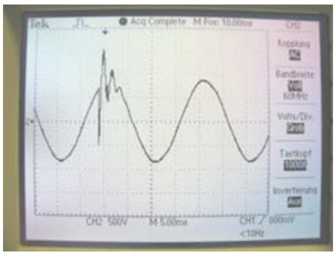

Fig. 2a Capacitor switched near voltage peak

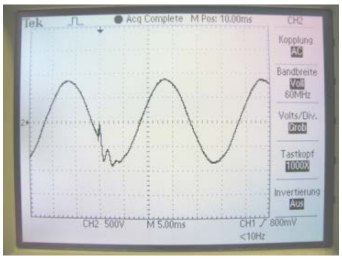

Fig. 2b Capacitor switched near zero cross

Most capacitor switching is not synchronized with the AC line voltage and therefore occurs randomly. Peak transient voltage due to capacitor switching will therefore be anywhere up to about 2.0 p.u. and will often cause VFDs to trip off due to activation of their over-voltage protection feature.

In cases of lightning, the transient voltage may be higher than for capacitor switching. In these cases, it is possible to sustain damage to the diodes in the input rectifier stage of the drive. Facility lightning arrestors and transient voltage surge suppressors (TVSS) are recommended to protect against the effects of lighting impulses.

It is typically easy and economical to protect drives from capacitor switching transients. This is usually accomplished by the addition of a line reactor in series with the input terminals of the drive. As the name implies, the line reactor is connected at the line (input) side of the drive. In order to be effective, the line reactor should be minimum of 3% impedance, but 5% impedance is recommended for best overall performance and protection.

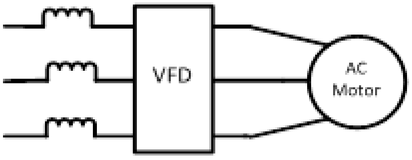

Fig. 3   VFD + Motor with AC Line Reactor

The purpose of the line reactor is to absorb a significant amount of the transient so that the drive does not see this, and will ride through the event without interruption or damage. By absorbing transient energy on the AC input lines, the diodes do not have to handle the impulse and the DC voltage will not rise nearly as high. In cases of severe transients such as those caused by lighting on the utility distribution system, the reactor will absorb some of the transient energy, but not all of it. For protection against lightning, the facility needs to be protected through the use of lightning arrestors and TVSS, which is beyond the scope of this technical note.

Some VFDs may include internal DC reactors (chokes). These are connected in series with the DC bus inside the drive, between the diodes and the DC capacitor. DC reactors in some cases, such as reducing input harmonic current, can be a substitute for AC line reactors. However, in the case of protection against transients, it is recommended that AC line reactors be used. This will provide protection for the diodes in the event of severe impulses. Even if a drive has an internal DC choke, an AC line reactor may also be added.

DC reactors in VFDs are located after the diodes and before the DC bus capacitor, enabling them to protect against low level OV transients. However, due to their location, all transients pass through the diodes before reaching the DC reactor, thus a severe transient will damage the diodes before it can be suppressed by the DC reactors. An AC line reactor is always best to protect the overall VFD against transient overvoltage.

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