What is a VFD Line Reactor?

Many of the components that make up a variable frequency drive (VFD) are semiconductor components, which are sensitive to power or current surges, voltage spikes, line distortion, and general power anomalies. A line reactor is an optional component that can be added to a drive system to protect the VFD and other devices from power surges and transients.
A line reactor is essentially an inductor—a coil of wire that forms a magnetic field as current flows through it. The magnetic field limits the rate of rise of the current, which reduces harmonics and helps avoid unnecessary tripping of the drive.

A reactor can be referred to as either a line reactor or a load reactor, depending on where it's installed. A line reactor (also called an input reactor) is installed before the VFD and protects the drive, while a load reactor (also called an output reactor) is installed after the VFD and protects the motor.

When a current wave form is not sinusoidal, it's said to contain harmonics. Harmonic distortion (often referred to as THID, or total harmonic current distortion) can be as much as 85 percent for a three-phase rectifier using six diodes or thyristors and a filter. A line reactor lowers the current peak and extends the wave further over time, making it more sinusoidal. This lowers the harmonic level to around 30 to 35 percent and improves system performance and reliability.

Basic equation for an inductor

$V = L (di/dt)$
Where:
V = voltage (volts)
L = inductance value of the reactor (Henries)
di/dt = rate of change of current (amps/s)

This equation shows that an increase in current will cause voltage to be induced. But this induced voltage has the opposite polarity of the applied voltage, so it reduces the rate of rise of current.
The inductance value also influences the inductor's reactance, whose equation is:

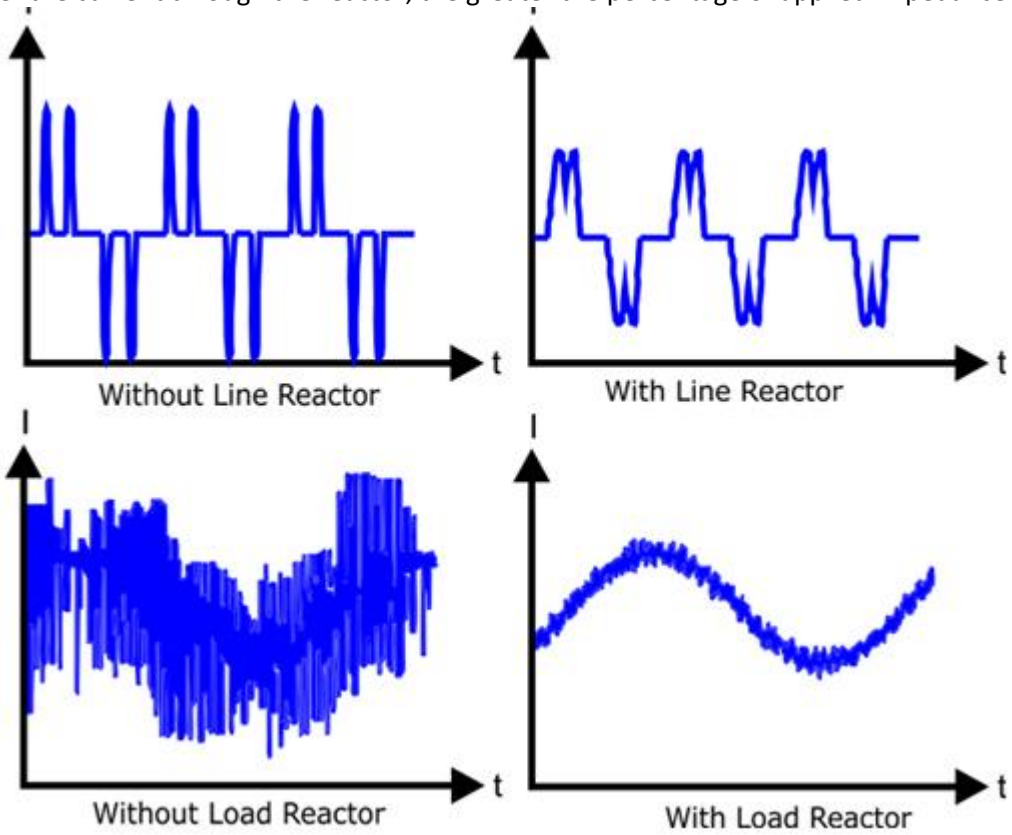
$X_L = 2\pi FL$

Where:
X_L = inductive reactance (ohms)
F = applied frequency of AC source (Hz)
L = inductance value of reactor (Henries)

So the reactor adds impedance to the AC circuit in proportion to both its inductance value and the applied frequency.

What is Impedance?

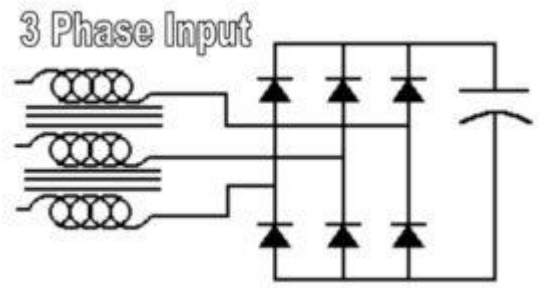
“Resistance in ohms but also commonly referenced in terms of percent when combined with the system voltage and line current flowing through the reactor.
That percentage then becomes the common term used to define the level of impedance for each rating of line reactor. That impedance functions to slow the rate of current changes in the line. The greater the current through the reactor, the greater the percentage of applied impedance will be.



If a reactor is said to have an impedance rating of 3% or 5%, that means the reactor will apply that specified percent of impedance when the current flowing through the reactor is at the rated current of the device.
Installing a line reactor on the input side of the VFD ensures protection to the drive but line reactors also have the capacity to be installed on the output side of the drive blocking potential incoming background line voltage harmonics.
“In almost all drive applications, the addition of an input AC line reactor is a low cost solution for drive protection and harmonic mitigation.

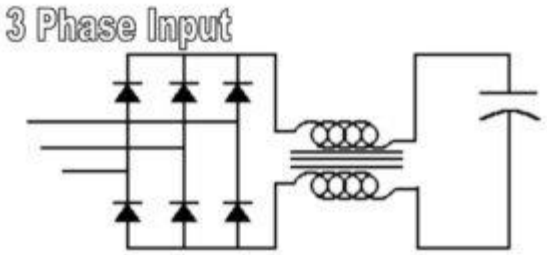
Line reactor vs load reactor

Line reactors stabilize, or smooth, the current waveform, which reduces over voltage (or under voltage) line tripping and potential damage to the drive. They also protect the drive under motor short-circuit conditions by slowing the rate of rise of the current. This gives time for protection circuits in the drive to react safely, preventing damage to components such as transistors. Line reactors also reduce the burden on upstream electrical components.



A reactor on the input side of a VFD is referred to as a line reactor.

Load reactors are used primarily when the distance between the VFD and the motor is very long, generally 100 feet or more (although the distance depends on the motor). VFDs tend to produce noise spikes, which are amplified by long cable lengths and the additional capacitance of the cables. Load reactors can protect the motor from damage by preventing these spikes. They also dampen the dv/dt (rate of change of voltage) that is applied to the motor windings, which improves performance of the motor and of the system.



A reactor on the output side of a VFD is referred to as a load reactor.

Percent impedance: 3% or 5%
Line (and load) reactors are classified by their percent impedance (denoted as percent IZ or %IZ), which is the voltage drop due to impedance, at the rated current, expressed as a percent of rated voltage. The most common line reactors have either 3 or 5 percent impedance. Reactors with 3 percent impedance are sufficient for most solid-state applications almost everywhere. They absorb normal line spikes and motor current surges and can prevent most nuisance line tripping of circuit protection devices.

When higher line disturbances are present, 5 percent impedance reactors may be needed. If the aim is to diminish noise from the motor or to extend motor life, higher impedance reactors can be used to reduce harmonics even further. This additional performance typically comes at a higher cost than 3 percent impedance versions. But, when multiple motors are controlled by a single drive, a single load reactor can be placed between the VFD and the motors, simplifying the system layout and reducing cost.