Overview To Input Line Reactors With AC Inverters

MCW Hints & Tips 0009

Quite often, input line reactors can be installed on AC drives without an understanding of why it has been necessary to fit one and the pros and cons of fitting one. This document provides some guidelines on where and when a reactor is needed and how to size one.

Fitting a line reactor to an AC inverter drive can:

- Help with harmonic distortion of the input line current
- Improve the balance between input line currents
- Reduce nuisance over-voltage trips caused by notches or transient voltage spikes on the input lines
- Protect the drives input stage from inrush currents caused by sudden line surges or sags
- Extend the life of the drives DC bus capacitors by reducing internal heating caused by ripple current

What is a reactor?

Essentially a reactor is an inductor. Physically it is a coil of wire that allows a magnetic field to form around the coil when current flows through it. When energized, it is an electric magnet with the strength of the field being proportional to the current flowing and the number of turns. A simple loop of wire is an air core inductor. More loops give a higher inductance rating. Quite often some ferrous material such as iron is added as a core to the winding. This has the effect of concentrating the lines of magnetic flux there by making a more effective inductor.

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Going back to basic AC Circuit theory, an inductor has the characteristic of storing energy in the magnetic field and is reluctant to a change in current.

The main property of a reactor is it inductance and is measured in henrys, millihenrys or microhenrys. In a DC circuit (such as that of the DC bus in an AC drive), an inductor simply limits the rate of change of current in the circuit since current in an inductor wants to continue to flow at the given rate for any instant of time. That is to say, an instantaneous increase or decrease in applied voltage will result in a slow increase or decrease in current. Conversely, if the rate of current in the inductor changes, a corresponding voltage will be induced.

Like most things there are side-effects to using a reactor. Though these issues should not prevent the use of a reactor, the user should be aware of and ready to accommodate these effects. Since a reactor is made of wire (usually copper) wound in a coil, it will have the associated losses due to wire resistance. Also, if it is an iron core inductor (as in the case of most reactors used in power electronics) it will have some "eddy current" loss in the changing magnetic field and the iron molecules being magnetically realigned. In general a reactor will add cost and weight, require space, generate heat and reduce efficiency.

Sometime the addition of a line reactor can change the characteristics of the line you are connected to. Other components such as power factor correction capacitors and stray cable capacitance can interact with a line reactor causing a resonance to be set up. Ac drives exhibit a relatively good power factor and do not require the use of correction capacitors. In fact, power factor correction capacitors often do more harm than good where AC drives are present.

With these side effects, why use a reactor? The fact is there are good reasons to install a reactor under certain conditions. Let's start with the input side of a drive.

Use an AC Line Reactor at the Input to reduce Harmonics:

As you may already know, most standard "six pulse" drives are non-linear loads. They tend to draw current only at the plus and minus peaks of the line. Since the current wave-form is not sinusoidal the current is said to contain " harmonics". For a standard 3 phase input converter (used to convert AC to DC) using six SCR's or six diodes and a filter capacitor bank the three phase input current may contain as much as 85% or more total harmonic distortion. If a line reactor is installed the peaks of the line current are reduced and somewhat broadened out. This makes the current somewhat more sinusoidal, lowering the harmonic level to around 35% when a properly sized reactor is used. This effect is also beneficial to the DC Filter capacitors. Since the" ripple current" is reduced. The capacitors can be smaller, run cooler and last longer.

Small drives may need an input line reactor

In general, drives of less then 7.5kW (10HP) do not have a DC link choke. In most cases this is not an issue since any harmonic distortion would be small when compared to the total for a facility. If many small drives are required for a process, an input line reactor is a good method in reducing harmonics.

One time where a serious consideration to fitting a line reactor should be given is when a small drive or a number of small drives are fitted on to a large capacity supply (a transformer with low source impedance and high short circuit capability). The line reactor will limit the peak currents that will flow in the drives input and capacitor bank

Using an AC Line Reactor as a line voltage buffer:

In some cases, other switch gear on the line such as contactors and disconnects can cause line transients, particularly when inductive loads such as motors are switched off. In such cases, a voltage spike may occur at the input to the drive that could result in a surge of current at the input. If the voltage is high enough, a failure of the semiconductors in the DC converter may also result. Sometimes a reactor is used to "buffer from the line". While a DC link choke, if present will protect against a current surge, it cannot protect the converter from a voltage spike since a link choke is located after the converter. The semiconductors are exposed to whatever line voltage condition exists. For this reason a reactor at the input to the drive may be of some help.

DC drives on the same supply as the AC drives

Another case where line reactors should be considered is when large DC drives with no or inadequate line reactors are used on the same supply as the AC drives. When the thyristors in a DC drive switch or commutate, a notch on the supply occurs.

Commutation occurs when a thyristor in one phase is turned on to turn off a thyristor in another phase. For this very small duration of time, a short circuit is created between the two phases. With a short circuit, the current increases and the voltage decreases. The decrease in voltage is defined as a line notch.

These notches cause disturbances on the supply that can affect the AC drive.

Sizing an input line reactor

Usually the impedance value of the reactor should be between 2 and 5%. Typically a value of 2 or 3% should be adequate for most installations. Higher values can result in the loss of motor torque at high speed because of excessive voltage drop across the reactor and thus reduced motor voltage.

The following equation can be used to calculate the value of a single phase reactor for use with a 240V single phase drive:

$$L = \frac{A \times V \times 1}{100\ 2\pi f I}$$

Equation 1

where:

L = inductance (H)
A = % inductance
V = line to line voltage
I = drive rated input current
f = is the frequency of the supply

The following equation can be used to calculate the value of a 3 phase inductor:

$$L = \frac{A \times V \times 1}{100\ \sqrt{3}\ 2\pi f I}$$

Equation 2

where:

L = inductance (H)
A = % inductance
V = line to line voltage
I = drive rated input current
f = is the frequency of the supply