■ Comparison between DC Link Reactors and AC Line Reactors

Both DC link reactors and AC line reactors can significantly reduce AC power line voltage distortion, if sized correctly.

The major advantage of AC line reactors is that they can easily be added to a drive that needs harmonic filtering. When harmonic distortion is not an issue, which is the case for many industrial applications, they can easily be omitted from the drive package and thereby reduce its cost.

It is important that the AC or DC reactors used are sized correctly to achieve the necessary harmonic performance. As shown in figure 17, the rating of the DC reactor should be approximately 50% larger than the AC line reactors per phase for them to have the same performance. If the total AC reactance is known, then the DC reactance should be approximately 50% of the AC reactance to achieve similar performance. The total AC reactance equals the size of the AC line reactor multiplied by the number of phases.

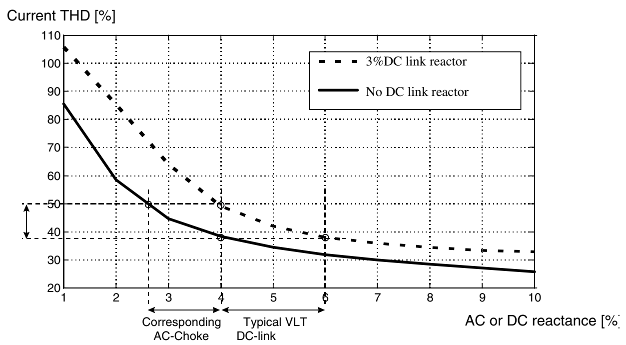

Figure 17: AC and DC reactors' impact on Total Harmonic Current Distortion

The Harmonic constant (H_C) is a performance index which can be used as an indicator of THVD independent of the system data. Figure 18 shows the relationship between H_C and TVHD.

$$THVD = H_C \cdot \frac{I_{FL}}{I_{SC}} = H_C \cdot \frac{P_{VFD}}{S_{SC}}$$

Figure 18: Calculation of THVD based on H_C

Figure 19 shows H_C as a function of the AC line impedance with no DC link reactors and with a 3% DC link reactor. Obviously performance is improved as the 3% DC reactor is added, but the AC line impedance does not have to be a reactor. This might as well be the cabling and the transformer.

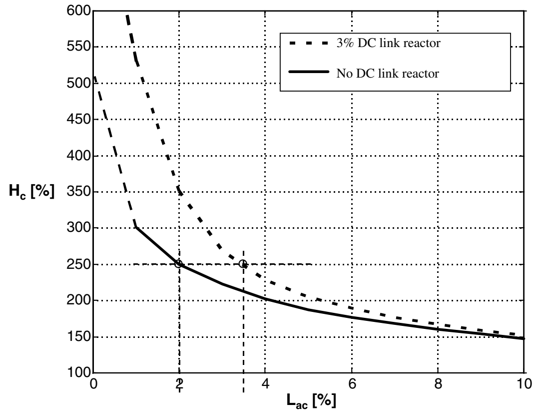

Figure 19: AC and DC reactor's impact on the Harmonic Constant

The current passing through the AC line reactors generates electrical losses which were not anticipated in the original design of the drive. These losses reduce the efficiency of the drive and result in heat generation. AC line reactors mounted below the drive add to the heat generated internally in the drive which results in a decrease in the permitted maximum ambient temperature. In addition, the voltage drop across the AC line reactors reduces the voltage available to the drive. If low line voltage problems are a concern, the addition of AC line reactors will make matters worse since a 5% AC line reactor causes a voltage drop of 2.5% in the intermediate circuit of the drive, decreasing the permitted voltage fluctuation on the mains. Since the available DC voltage drops with the AC voltage and the output power is limited by the current rating of the drive, the power which can be supplied to the motor by the drive will also decrease. DC link reactors only reduce the ripple in the intermediate circuit of the drive, they have no negative impact on the DC voltage level. This means that they do not reduce the AC voltage which can be applied to the motor either. DC reactors generate additional heat in the drive, but because the drive is designed with DC reactors, the drive is able to handle the heat generated by these reactors. Figure 20 illustrates a comparison between the AC and DC reactors' impact on the DC voltage. The top left curve is for a 1% AC reactor and the bottom left curve is for a 10% AC reactor. The curves on the right show the impact of the equivalent DC reactors.

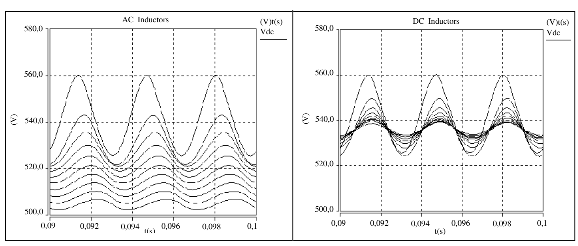

Figure 20: Impact of AC and DC reactors on DC voltage level.

AC line reactors have the advantage that they act as a buffer between power line disturbances and the drive's input rectifier section. A drive designed without AC reactors must use metal oxide varistors (MOVs) and R/C snubber circuitry to protect the drive's input from noise on the AC power line in order to obtain a similar buffer effect. Since most AC reactors are supplied as an external option and not as part of the drive design, these drives will also have to use MOV's and R/C snubber circuitry as standard to secure the protection of the drive.

Conclusion

Distortion of the AC power line by variable frequency drives is a real concern for many applications. It is important that drives provide filtering to reduce the impact that the drive might have on the rest of the electrical system. Two common methods of doing this is by means of DC link reactors and AC line reactors. Danfoss VLT drives, which have been designed with the requirements of a wide range of applications in mind, will include DC link reactors as standard.

System Data

All data in this note are based on the following system data.

Transformer Apparent Power	1.5 MVA
Primary voltage	11 kV
Secondary voltage	400 V
Impedance	6.1%
Short circuit power, secondary	25 MVA
Short circuit power, primary	350 MVA
Short circuit ratio	250
Drive input power	100 kW
H_C of Drive without filter	745%
H_C of Drive with filter	319%

The voltage is assumed to be 100% balanced. It is also assumed that before adding drives to the system, no harmonic distortion was present.

Nomenclature

AC	=	Alternating Current [A]
DC	=	Direct Current [A]
e_X	=	Transformer Impedance [%]
H_C	=	Harmonic Constant [%]
I_{FL}	=	Full Load Current on Transformer [A]
I_{SC}	=	Short Circuit Current of Transformer [A]
P_E	=	Iron Loss Factor of Transformer [__]
P_{VFD}	=	Active Power of Drive Load [kW]
PWHD	=	Partial Weighted Harmonic Distortion
S_{NOM}	=	Transformer Nominal Apparent Power [kVA]
S_{SC}	=	Short Circuit Apparent Power of Transformer [MVA]
S_{VFD}	=	Drive Apparent Power [kVA]
THCD	=	Total Harmonic Current Distortion [%]
THD	=	Total Harmonic Distortion [%]
THVD	=	Total Harmonic Voltage Distortion [%]