VLT 4000 VT Engineering Data – AC Line Protection

Minimizing Harmonic Distortion

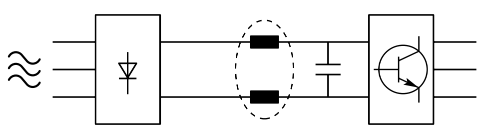
An adjustable frequency drive causes a non-sinusoidal current on the AC line, which increases the input current I_{RMS}. A non-sinusoidal current can be transformed by means of a Fourier analysis and split up into sine wave currents with different frequencies, i.e. different harmonic currents I_N with 60 Hz as the basic frequency:

Harmonic currents (Hz)	I_1	I_5	I_7
	60	300	420

The harmonics do not affect the power consumption directly, but increase the heat losses in the installation (transformer, cables). Consequently, in plants with a rather high percentage of rectifier load, it is important to maintain harmonic currents at a low level to avoid overload of the transformer and high temperature in the cables. Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance in connection with power-factor correction devices.

Harmonic currents compared to the RMS input current:

	Input current
I_{RMS}	1.0
I_1	0.9
I_5	0.4
I_7	0.2
I_{11-49}	< 0.1



The voltage distortion on the line supply depends on the size of the harmonic currents multiplied by the line impedance for the frequency in question. The total voltage distortion THD is calculated on the basis of the individual voltage harmonics using the following formula:

$$THD\% = \sqrt{U^{2}_{5} + U^2_7 = \ldots U^2_N} \quad (U_N\% \text{ of } U)$$

Danfoss harmonic currents are lower than other drive designs, and therefore, provide the lowest voltage distortion and offer less chance of disturbing other equipment.

The built-in DC link filter in the VLT 4000 VT reduces the harmonic distortion currents that it injects back into the AC line. A properly sized inductor, such as that in a VLT 4000 VT can reduce line harmonic currents to 40% or less of the fundamental current without the use of AC line inductors and their resultant line voltage reduction.

The added heat generated by harmonic currents requires larger conductors and transformers for the same amount of delivered energy, therefore, increasing the cost of the installation. Other sources of harmonic current distortion include fluorescent lights, computers, UPS systems, copiers, printers, induction heaters, and battery chargers. Many of these nonlinear loads are not only the source of harmonic distortion, but are also adversely affected by harmonic distortion as well.

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Handling AC Line Fluctuations

Every manufacturing facility experiences fluctuations in the AC line. With a Danfoss drive, these fluctuations do not pose any hazard to the drive and will not cause speed or torque variations in the application. Danfoss drives compensate for AC line fluctuations so that the motor shaft's actual torque is constant.

To protect itself from AC line fluctuations, a monitor of the AC line phases interrupts the drive if there is a loss of phase or if there is a significant difference between phases.

Transient Voltage Spikes

Most industrial AC lines are disturbed by line transients which can be short overvoltages of up to 1000 V. They arise when high loads are cut in and out elsewhere on the AC line. A lightning strike directly to the supply wire is another common cause of transient high voltage. The transient may damage installations at distances up to four miles from where the lightning strikes. Short circuits in the supply lines can also cause transients. High currents due to short circuits can result in very high voltage in the surrounding cables because of inductive coupling. The VLT 4000 VT os built to a stringent German specification for surge suppression (VDE 160). Fast acting MOVs, Zener diodes and oversized DC link filter provide protection against high potential spikes. The VLT 4000 VT can withstand a spike of 2.3 times the rated voltage for 1.3 msec.

Voltage Sags and Surges

The VLT 4000 VT is designed for a wide range of operating conditions. The 460 volt drive will operate from 342 to 504 VAC. The 230 volt drives will operate on 180 to 264 VAC. Although the drives output current and torque are affected by low voltage, the drive will not trip. Full rated motor voltage and torque can be delivered down to 10% undervoltage in the AC input line.

AC Line Drop Out

During an AC line drop out, the VLT 4000 VT continues to operate until the intermediate circuit voltage drops below the minimum stop level, which is typically 15% below the VLT 4000 VT's lowest rated supply voltage.

The time before the inverter stops depends on the AC line voltage before the drop out, and on the motor load.

Power Factor

The VLT 4000 VT drives hold near unity power factor at all loads and speeds, and eliminate the need for power factor correction, resulting in both financial and space savings.

The power factor is the relation between I_1 and I_{RMS}. The power factor indicates the extent to which the drive imposes a load on the AC line supply.

The lower the power factor, the higher the I_{RMS} for the same kW performance.

In addition, a high power factor indicates that the different harmonic currents are low.

$$I_{RMS} = \sqrt{I_1^2 + I_5^2 + I_7^2 + \dots + I_n^2}$$