1 VLT HVAC Drive in Fan Application with Resonance vibrations in the Fan

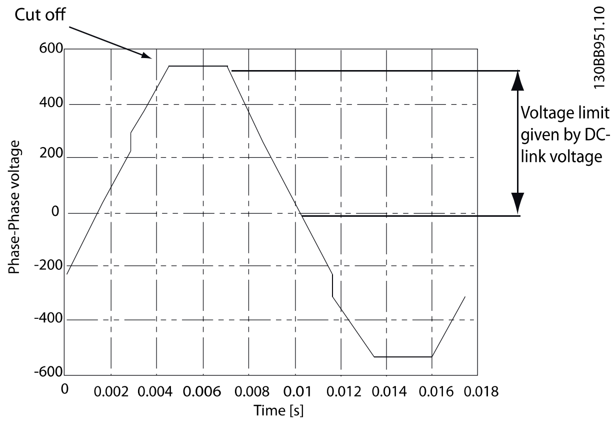
1.1 Application

In applications where Motor with fan mounted directly on the drive end shaft and where the running point is in field weakening area, a small number of customers have experienced vibrations when applying FC102 drives in the power range (7,5 [kW]-18 [kW]). This Application note answers the question of the causes for these Vibrations and give solutions to solve it

1.2 Definitions

- **Over modulation**: Over modulation is a way to increase the motor voltage delivered by the drive between f_{mot} > 45Hz and f_{mot} < 55Hz or f_{mot} < 55 Hz and < 65Hz
- The advantage of over modulation is:
    - Lower currents and higher efficiency at over field weakening area. Speed wise?
    - That the drive can give nominal Grid voltage at nominal at nominal grid frequency
    - If the mains voltage sometimes goes below the correct motor voltage at e.g. 43 Hz over-modulation can again add the needed motor voltage.
- Over modulation means that a voltage is modulated above the possible level given by the DC-link voltage.
    - **The result is non-sinusoidal output voltages, because of the shape of the sinus wave**
- The non-sinusoidal voltages increases the harmonics of the voltages, thereby generating harmonic currents which again generates noise and torque ripple
- The degree of over modulation is depending on the voltage reference from the VVC+ control, which depends on the motor frequency, torque characteristic, load compensation, mains-voltage, etc.

depends on the motor frequency, torque characteristic, load compensation, mains-voltage, etc. Over modulation begins when the required output voltage is higher than 95 % of the input voltage, in VT mode this means from approx. 47 Hz and up.



1.3 Cause to the vibrations

I expect that this is just an example with one motor frequency.

The vibrations occur at frequencies corresponding to the 6th harmonic of the drive output frequency, fout.
The system vibrates when the motor is supplied by a output frequency of approximately 55 Hz (6 multiplied fout = 6*55=330 Hz) (Depends of the resonance frequency of the fan) which is approximately 330 [Hz] on the fan wheel . This 6th harmonics is generated only by the over modulation. If the resonance frequency of the fan is close to this 330Hz, The resonance will cause vibrations. Those vibrations can in the end cause cracks in the Fan and in worst cases a broken fan or /and broken Bearings

1.4 Solutions

1. **The best solution is disabling the over-modulation**
   By disabling over-modulation, vibrations will be reduced to a minimum but this solution might also cause a derating of the applied motor in the range of 5-10% because of the missing voltage applied by the over modulation.
2. **Skipping a small frequency band of the output frequencies may also be a solution**
   In some applications it is not possible to disable the over modulation If the motor is designed to the limit of the fan application the voltage losses in the FC will cause missing torque. In these situations the problem of vibration might be reduced significantly by skipping a small frequency band around the mechanical resonance

frequency approximately 330Hz. This can be done by setting parameters (p4-6*) or by using the Semi auto bypass setup p4-46. However, there is no general design rule for making an optimal skip of frequency bands as this is highly dependent on the width of the resonance peak. In most situations it is possible to hear the resonance