Set-up of frequency converter parameters

Operating fans with frequency converters has many advantages, but also some risks. Especially a wrong setting of the parameters for the frequency converters can lead to heavy damages such as impeller fatigue failures, resonance vibrations on various parts and ripped or overheating couplings caused by a too rapidly executed start-up or by too frequent switching. The control systems must have a slow response time, with a minimal acceleration and a low number of switching cycles. With regard to the adjustment of the control system it is important to examine the total drive train including the impeller, and not only, as is most normal practice by the makers of frequency converters, only to match the motor to the frequency converter, sometimes with a disconnected fan.

The following generic procedure can be useful when employing frequency converters with fans (each frequency converter may require additional parameters to be considered):

Step 1 Set the basic parameters of the frequency converter
Step 2 Adjust detail parameters
Step 3 Check the result and if necessary adjust settings.

Basic settings

1.1 Enter the **designation of the motor** and other data required by the frequency converter set-up program, as shown on the motor name plate.

1.2 **Motor identification run** Note: Do not start an ID-run (standard or reduced), but only an ID-magnetization test, where the motor is magnetized for 20 to 60 seconds, without rotation of the motor. For example with ABB converters the "standard" ID-run delivers good pre-settings, but must be carried out with the motor disconnected from the fan. The "reduced" ID-run can be completed with a connected motor, but there is a high risk of damage at the start without prior defined parameters.

1.3 Set the **maximum frequency /** maximum permissible fan speed.
ABB: for a left turning motor the maximum fan speed is to be set to 0 min^{-1} and the minimum fan speed is to be set to minus the maximum required speed.

1.4 Check or set **corner frequency** (if not automatically set). The corner frequency is the frequency at which the maximum output voltage is reached. After this point the voltage ceases to rise and the motor is controlled by field attenuation. In this range the available power remains constant while the fan speed rises.

Examples:

Motor frequency	Fan speed	Voltage	Corner frequency
50 Hz	1,500 min^{-1} (50 Hz)	400 V	**50 Hz**
50 Hz	1,650 min^{-1} (55 Hz)	400 V	**50 Hz**
60 Hz	1,650 min^{-1} (55 Hz)	480 V	**60 Hz**

1.5 **Set the current limit**
Set the current limit to the rated current of the motor operated with a frequency converter (if the name plate gives no indication then use the value given for direct connection).
Note: The level of the maximum current setting determines the dynamic response of the complete drive system.
Attention: With ABB set the maximum current at 150% for quadratic load torque curve. Only for a constant load torque curve the maximum current should be set at 100 % rated motor current.

Parameter settings

2.1 Start up time t_A
With motors of the rotor class 16 the start up time is approx.

$$t = \frac{10 \bullet M \bullet D^2 \bullet n^2}{10^6 \bullet P_N} [sec]$$

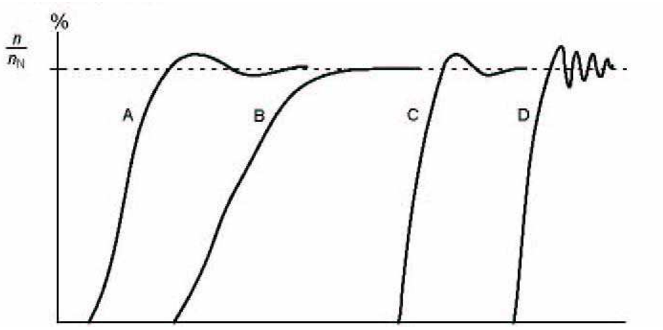
where n is the fan speed in min^{-1} , P_N is the rated motor power in kW, M is the mass of the impeller in kg and D is the impeller diameter in m.

2.2 Set the **breaking time** t_{br} (if applicable) so that the converter does not shut down because of over-voltage, i.e. breaking power being too high. Depending on the moment of inertia of the impeller (total drive train), fan speed and the density of the gas medium, the run down time can be several times longer than the start up time (fan suppliers can provide more exact data).

If due to the process longer times are possible or even required the parameters should be set accordingly.

2.3 Setting of the type of control: voltage/frequency control or torque control. Field oriented / torque control (with DTC by ABB) often gives the best dynamic control. Also, some extra functions, (such re-starting with turning motor) are not possible with voltage/frequency control.

2.4 Setting or checking the PID controller
The basic settings of the PID control are either default values from the factory settings or set during the ID-run (without the control of the impeller!).
Depending on the parameter setting, different control modes can occur.



A: Under compensated (I component - too short and gain too low)
B: Normal setting (better setting for fans than C)
C: Normal setting
D: Over compensated (I component too short and gain too high)

Note: As can be seen from the graph, by changing the PID settings, the total system performance can be optimised or made to experience extreme vibration levels.

The following gives some guidelines to possible initial parameter settings for various suppliers (as per mid 2005)

For detailed settings please always refer to the frequency converter maker's latest manual/ instructions!

Maker	P - gain	I component in s	D - component
ABB	ca. 25	ca. 10	OFF
Danfoss	0,01 – 0,05	2 – 5	OFF
Siemens	3 – 5	2 – 5	OFF
Loher	MotImax ca. 250 GenImax ca. 150	MotImax ca. 7000 GenImax ca. 7500	MotImax ca. 16000
Vacon			OFF
other makers			OFF
	Note: If P amplification is too high, the process can become unstable.	**Note:** If the I-time is too low, the process can become unstable because of overshooting.	**Note:** A D gain that is set too high can lead to rotational vibrations.

Test of satisfactory set up

3.1 Start-/stop performance

Make visible the motor current using on oscilloscope and a current transformer (clamp-on probe). Observe the current form for frequency variations of +/- 1 Hz of the operating points 50%, 75% and 90% of the design point. If instabilities occur the control settings must be changed as suggested in the table above.

The theoretical presetting of the run up-/down times should be tested under full load and the settings changed to conform to the actual times.

The peak value of the current must not be instable (floating or modulated). To make such problems visible long sample periods should be used. (The sinusoidal character of the current will not be visible, because of the compressed time-axis).

3.2 Restart with turning Motor

When it is required that the frequency converter after a supply motor incident, after the return of normal voltage, must be able to be reactivated while the motor is still turning, this function must permit the frequency converter / fan to be accelerated within 10 seconds to at least 90 % of the set speed before the supply power incident occurred. This supply power incident could be a non-permissible voltage drop or a complete power cut for ≤ 1 second.

The aim is to avoid that the process master control within the failure detection time registers a lack of air volume or pressure, which could lead to process shut down. The correct functioning of this ability to restart the frequency converter after a power supply incident, without tripping the process control must, if required in the installation, be tested under normal load.

If it is permitted to exclude the resonance frequencies from an operating point of view (customer release) they can be blocked in most frequency converters, so that they are passed through quickly without harming the fan. If that is not an option for some/all resonance frequency, each resonance point needs to be investigated closely. By a combination of changing converter parameters (gain, corner values) or mechanical changes (rebalancing of the impeller, reinforcing node points on the fan etc.) it is possible to reduce the problematic vibration levels.

Note:
When restarting with turning motor most frequency converter makers (exception Danfoss) do not use the normal start-up ramp, but accelerate up to the set maximum current, or on a specific restart ramp.

For Loher Dynavert T frequency converters activate the function of dynamic power supply buffering in order to obtain a short re-start time. This uses the voltage generated by the running down motor to maintain the control for a certain time in case of a short power cut.

3.3 Vibration measurements

After all parameters have been set, the effective vibration levels v_{rms} is to be measured over the full speed range and documented.

Set the fan to the agreed main operating point under load so that the power consumption approximately is equal to the design point.

Set the converter to a long ramp (300 – 360s) and vary the converter over the complete speed range from maximum to minimum speed (within the agreed range). Document the vibration level at all bearings (vertically, horizontally and axially) as a function of the rotational speed (frequency) of the fan.

Determine the resonance frequencies from the resulting curve as a function of the speed (frequency). Set the fan under load to operate at the resonance speeds until the maximum vibration level has been determined. In case the permissible vibration levels according to ISO 14694 / ISO 10816-3 are exceed, the vibration performance must be changed by e.g. changing the parameter setting of the frequency converter.

If increased vibration levels are found in some speed ranges these are to be investigated in detail and measures are to be taken in the parameter settings to avoid these vibrations. Parameters such as the boost, the set points of the voltage / frequency curve etc. must be adjusted, but also de-tuning of the mechanical system, rebalancing or, depending on how the vibrations manifest themselves through vibrations, stiffening of components, may have to be carried out in order to maintain the vibrations in a permissible range. If the process permits the vibration frequencies should be blocked at the frequency converter.

3.4 Input und output values

Set the frequency converter to conform to the signal exchange in the system wiring diagramme e.g. the preset value of 4-20 mA is equal to 20 mA for our design speed of 1560 min^{-1} i.e. 52,3 Hz / 4 mA would then be the minimum speed of 156 min^{-1} (5,23 Hz) at the control ratio of 1:10.

3.5 Document parameters

The complete settings of the frequency converter must be documented. **This form is part of the documentation to the customer, who should be made aware that guarantee claims arising from vibration damage would not be covered by warranty if the parameters have subsequently been changed or the system is otherwise altered.**