Pioneering for you

Raw Water Intake
Consulting guide

FC Operation for Submersible Pumps (Well Pumps)

Frequency converter operation

The listed Wilo submersible pumps (also known as well pumps or borehole pumps) can be operated with pulse-width modulated frequency converters:

- Wilo-Sub TWI 4 up to TWI 10
- Wilo-Actun ZETOS-K
- Wilo-Actun ZETOS-F
- Wilo-EMU D ..., DCH ..., K ..., KM ..., NK ..., SCH ...

Pulse-width modulated frequency converter

The incoming mains voltage is converted into direct current (DC) and stored in a capacitor. An inverter operates at the output of the frequency converter. This inverter has fast-reacting semiconductors. These semiconductors are triggered one after the other to connect the capacitor to the motor windings. This connection occurs at a pulse frequency of approximately 4–16 kHz.

In most frequency converters, the pulse frequency can be adjusted. The duty cycle and the pauses of the square wave can also be modified. These settings permit the output voltage at the motor to be adjusted (see diagram).

Setpoint: The desired output voltage that aligns with the sinusoidal profile of the mains supply.

Pulse: Pulse-width modulated output voltage of the frequency converter.

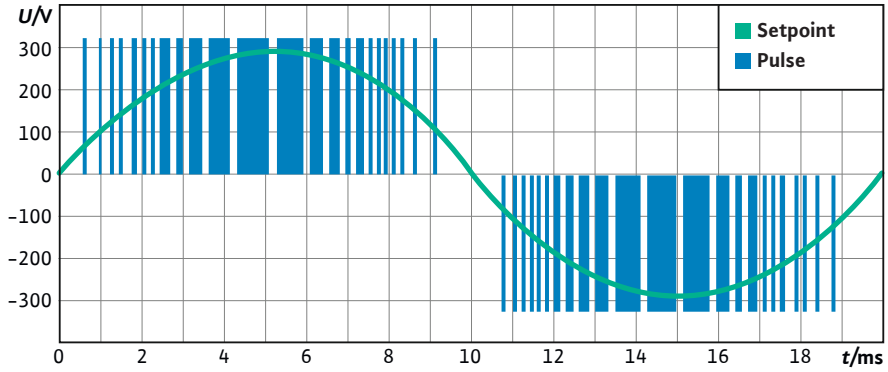

Fig. 1: Output voltage of the frequency converter

Furthermore, output filters can also be connected downstream. These filters soften the outgoing square wave voltage and reduce voltage peaks.

Electromagnetic interference (EMI)

Frequency converters generate electromagnetic interference (EMI) that can cause other electronic devices to malfunction. This interference can affect both the input side (the mains power supply) and the output side (the pump power supply). For example, electromagnetic radiation can disrupt the monitoring of the thermal motor winding. Follow the measures listed for the planning stage to keep potential issues to a minimum:

- Use divided connection cables for the power and the control cables.
- Make sure that there is a sufficient distance between the power and control cables.
- Order the control cables as shielded cables. Also, use shielded cables for level measurement and monitoring devices.
- Install EMC filters on the output side of the frequency converter.
- Do not cross cables.

Motor winding

The motor windings of submersible pump motors are usually made of plastic-insulated wires (PE or PE2):

- PE windings are particularly susceptible to voltage peaks. Do not operate motors with PE windings using frequency converters.
- PE2 windings are more resilient to voltage peaks. Only operate motors with PE2 windings using frequency converters if output filters are installed.

Motor monitoring

Frequency converters have various built-in monitoring devices. It is also recommended that submersible pumps have a thermal motor winding monitoring. For submersible pumps, PT100 resistance temperature sensors are available to order. Follow the listed points:

- The submersible pump has no PT100 sensor as standard. This option must be ordered at the time of purchasing the pump.
- PT100 sensors are available for motors from size 6".
- It is not possible to retrofit a PT100 sensor.

Frequency converter selection

Wilo motors in standard design can operate with a frequency converter at voltages of up to 415 V/50 Hz or 480 V/60 Hz. For rated voltages above 415 V/50 Hz or 480 V/60 Hz, contact customer services.

The minimum requirements for selecting and using a frequency converter are as follows:

- The frequency converter and the pump must be compatible. Compatibility is particularly important for permanent magnet motors. Always examine compatibility with the manufacturer before installation.
- Size the frequency converter according to the motor's rated current. Do not select the converter based solely on the motor's power rating. An incorrect converter can lead to operational problems.
- Motor control through vector control (also known as field-oriented control).
  Vector control allows accurate speed and torque control by adjusting the voltage, frequency, and phase angle between the stator current and rotor position.
  For easier applications, control can be applied using U/f control. This type of control keeps a constant ratio between voltage and frequency. Thus, U/f control is not as powerful as vector control.
- Automatic Motor Adaptation (AMA) function
  This function automatically adjusts the drive's settings to optimise performance with the connected motor, without the necessary manual tuning or load decoupling. It simplifies installation and commissioning by identifying the motor's parameters and adapting the drive accordingly.
- Due to the increased heating caused by harmonics, the motor's rated power must be approximately 10 % higher than the hydraulics' power requirement. For frequency converters with low-harmonic output, the power reserve can be decreased to 7 %.
- Examine compliance with all specified limits for voltage peaks, speed, power consumption, and other relevant parameters.
- There must be connections available for PT100 sensors to monitor the thermal motor winding.

Output filters

Output filters are usually recommended to decrease high-frequency components in the output signal. These filters prevent damage to motor insulation, decrease motor noise, and make sure that EMC regulations are met.

Because motors with PE2 windings are sensitive to voltage peaks, install output filters (sine or dU/dt) downstream. These filters keep the maximum values at the windings in their specified limits:

*Refer to the 'Motor data' table for the maximum values for each motor.

- The maximum rate of voltage rise* at the connection between the connection cable and the motor's winding.
- The maximum voltage peak* at the connection between the connection cable and the motor's winding.

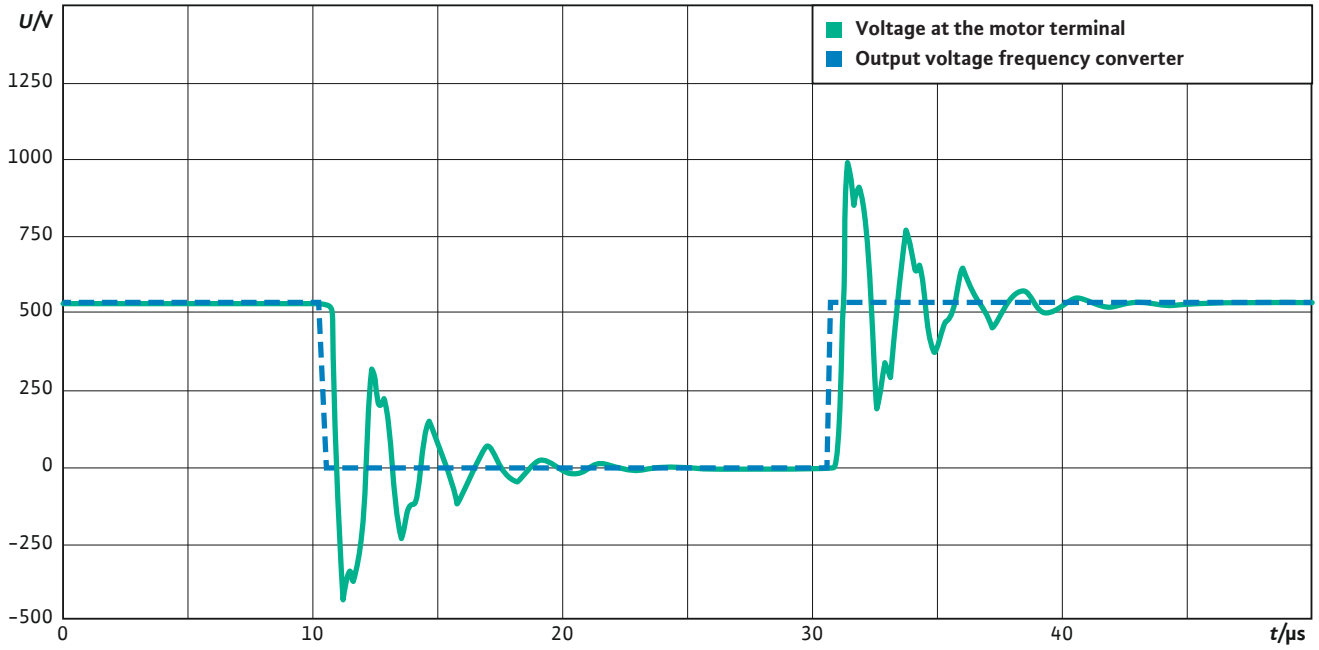

Fig. 2: Output voltage from the frequency converter vs. the voltage at the motor terminal

The 'rate of voltage rise' and 'voltage peak' values are phase-to-phase. Due to the earth potential of the water around the windings, these values must also be complied with between the phase and the protective earth conductor. Due to only one insulated conductor, the voltage peak limits phase-to-earth are 50 % of the phase-to-phase limits. Obey the listed points:

- Not all filters are compatible with all frequency converters. Make sure that the filter and frequency converter are compatible with each other.
- Output filters cause an increased voltage drop. Thus, this voltage drop must be kept in mind when designing the system.
- As the semiconductors in frequency converters are constantly becoming faster, phase-to-earth peaks are also increasing to critical heights. Thus, all-pole filters are installed.

Operating parameters

Refer to the 'Motor data' table for the technical data of each motor, such as maximum and minimum frequencies.

- Increased motor noise due to harmonics in the power supply is normal.
- The lowest part of the speed range (start up to f_{min}) must be passed through in 2 seconds.
- Make sure that the pump operates without jerks and vibrations (without oscillations, resonances, pendulum torques) in the entire control range. Otherwise, the mechanical seal can leak or be damaged.

- The submersible pump has water-lubricated bearings. A minimum speed is necessary to create a lubricating film. The pump is only permitted to operate continuously in the specified control range. Operating outside this range will result in a total loss of the motor bearings.
  Permitted control range: *
- Minimum pulse frequency
  The pulse frequency is set according to the output filter requirements. For initial commissioning, the recommended setting is 4 kHz unless stated otherwise.
- The maximum rate of voltage rise at the connection between the connection cable and the winding in the motor: *
- The maximum voltage peak at the connection between the connection cable and the winding in the motor: *
- Maximum output current at the frequency converter: 1.5 times rated current
- Maximum overload time: 60 seconds

Operation above rated motor frequency

Depending on the motor load, the pump can operate at a frequency higher than its 'rated motor frequency'. The motor must be permitted to handle the higher power requirements of the hydraulics.

Note: The pump's power requirement must not be larger than the motor's rated power minus the specified reserves. For more details, please contact customer service.

Keep the limits listed for operation above the rated motor frequency:

- Pumps with asynchronous motors with a rated motor frequency of 50 Hz can be controlled up to 60 Hz.
- Pumps with asynchronous motors with a rated motor frequency of 60 Hz cannot be controlled at a higher frequency.
- Pumps with permanent magnet motors with a rated motor frequency of 100 Hz can be controlled up to 120 Hz.

Frequency converter for retrofitting used submersible pumps

Wilo submersible pumps have PE or PE2 winding wires that are heat-sensitive. The insulation of these wires degrades over time. Do not retrofit pumps older than five years with a frequency converter.

Motor data

Motor type	Construction	Number of poles	$f_{nominal}$	f_{min}	f_{max}	Ramp time	Maximum rate of voltage rise* (for motors with PE2 windings)	Maximum voltage peak: phase to earth* (for motors with PE2 windings)	Maximum voltage peak: phase to phase* (for motors with PE2 windings)
NU 431	encapsulated, asynchronous	2	50 Hz	30 Hz	60 Hz	1 s	500 V/µs	500 V	1000 V
NU 436	encapsulated, asynchronous	2	50 Hz	30 Hz	60 Hz	1 s	500 V/µs	500 V	1000 V
NU 437	rewindable, permanent magnet	4	100 Hz	60 Hz	120 Hz	1 s	500 V/µs	500 V	1000 V
NU 501	encapsulated, asynchronous	2	50 Hz	30 Hz	60 Hz	1 s	625 V/µs	500 V	1250 V
NU 511	rewindable, permanent magnet	4	100 Hz	60 Hz	120 Hz	1 s	500 V/µs	500 V	1000 V
NU 512	encapsulated, permanent magnet	4	100 Hz	60 Hz	120 Hz	1 s	500 V/µs	500 V	1000 V
NU 611	rewindable, asynchronous	2	50 Hz	25 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 612	rewindable, permanent magnet	4	100 Hz	60 Hz	120 Hz	1 s	500 V/µs	500 V	1000 V
NU 701	encapsulated, asynchronous	2	50 Hz	30 Hz	60 Hz	1 s	500 V/µs	625 V	1250 V
NU 711	rewindable, permanent magnet	4	100 Hz	60 Hz	120 Hz	1 s	500 V/µs	500 V	1000 V
NU 801	rewindable, asynchronous	2	50 Hz	25 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 811	rewindable, asynchronous	2	50 Hz	25 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 812	rewindable, permanent magnet	4	100 Hz	60 Hz	120 Hz	1 s	500 V/µs	500 V	1000 V
NU 911	rewindable, asynchronous	2	50 Hz	25 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 911	rewindable, asynchronous	4	50 Hz	30 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 121	rewindable, asynchronous	4	50 Hz	30 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 122	rewindable, asynchronous	2	50 Hz	25 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 160	rewindable, asynchronous	2	50 Hz	25 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
NU 160	rewindable, asynchronous	4	50 Hz	30 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V
U 210	rewindable, asynchronous	2	50 Hz	25 Hz	60	2 s	500 V/µs	625 V	1250 V
U 210	rewindable, asynchronous	4	50 Hz	30 Hz	60 Hz	2 s	500 V/µs	625 V	1250 V

Key:
*At the connection between the connection cable and the winding in the motor.

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