

Grundfos MS/MMS submersible motors can be used with variable frequency drives (VFD) provided the following guidelines are followed.

Variable frequency drives inherently produce voltage spikes due to differences between cable length impedance and motor surge impedance. Voltage spikes in excess of 850V may exceed motor insulation protection, causing premature motor failure. Known as, Reflected Wave Phenomenon this voltage spiking is common in applications where there are long distances between the VFD and motor, typical of submersible pump applications.

In **Fig. 32**, the voltage (V_{uv}) graph shows a common VFD output square waveform with voltage spiking rather than a desired sinusoidal waveform. The current waveform (I_u) while more sinusoidal in appearance, still has damaging spikes.

Voltage (V) and Current (I) at Motor without Sine-Wave Filter

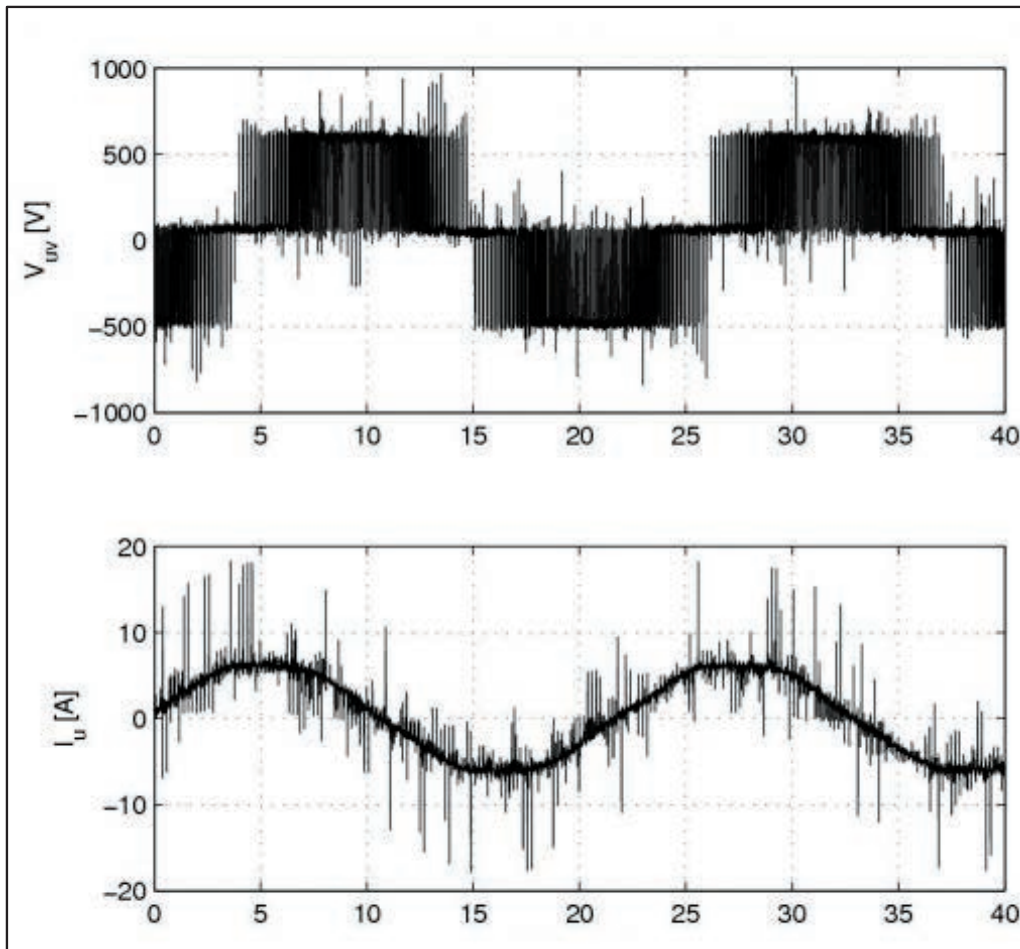


Fig. 32

Sine-wave filters are designed to provide the desired smooth sine-wave VFD output, ideal for the operation of a submersible motor. Output filters are used to reduce the impedance differences between cable and motor. Therefore, reducing voltage spikes on motor windings, insulation components, and for decreasing acoustic noise from the VFD.

When a sine-wave filter is applied properly between the VFD and motor, the waveforms are nearly smooth. See Fig. 33 and 34.

Voltage (V) and Current (I) at Motor with Sine-Wave Filter

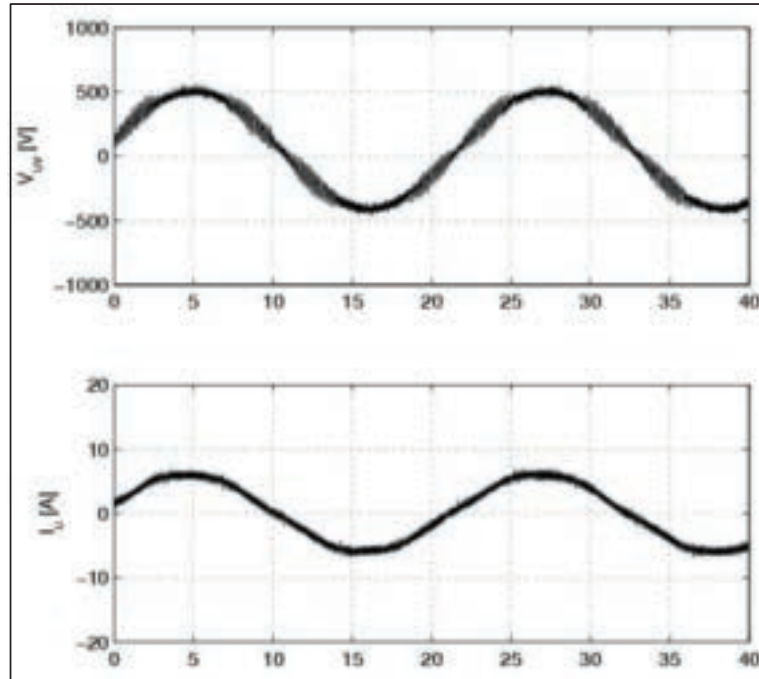


Fig. 33

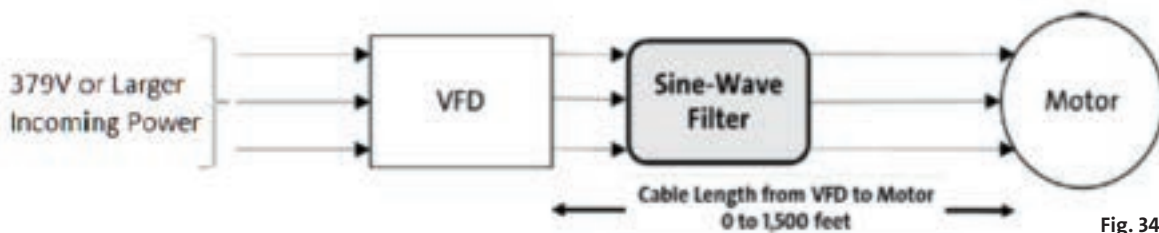


Fig. 34

To ensure warranty considerations, Grundfos recommends installing a sine-wave filter or equivalent type RLC filter when a frequency converter (VFD) is used on a submersible pump application if any of the following conditions are met:

- 1) Motor name plate voltage is over 379V.
- 2) Drive uses pulse width modulation (PWM) and/or IGBT-BJT switches .
- 3) VFD voltage rise-time less than 2 msec (NEMA MG 1-2011).
- 4) Peak voltage at motor terminals exceed 850 volts..
- 5) Power cable length from VFD output to submersible motor terminals is 0 to 1,500 ft.
 - a. For applications with cable length greater than 1,500 ft., contact Grundfos Pumps when using a Grundfos drive.
 - b. If not a Grundfos drive, contact drive manufacturer for acceptable cable lengths.

Variable Frequency Drives

If not using a Grundfos VFD/sine-wave filter combination, the drive manufacturer will need the following information to ensure proper sine-wave filter type and size. All items are required:

- 1) VFD model
- 2) Type of application
- 3) Carrier frequency used
- 4) Motor nameplate voltage
- 5) Motor nameplate service factor Amps
- 6) Motor insulation rating
- 7) Cable type, size, and length from the drive output to the motor terminals

Notice:

- 1) **RL only or dv/dt types of filters are not considered equivalent to sine-wave filters.**
- 2) **The use of line-side filter on power entering the drive does not replace the need for additional output or load-side sine-wave filter.**

To ensure proper motor cooling, the following is recommended:

- 1) **Minimum VFD frequency set to provide no less than required velocity in feet per second past the motor:**
 - a. 4-inch motors 0.25 ft./sec
 - b. 6 to 12-inch motors 0.50 ft./sec
- 2) **Supply voltage within the +6% and -10% from nameplate (example single voltage rated motor of 460V, would be minimum of 414V to maximum 487V). For 60Hz rated multi-voltage motors, the voltage variant of 440/460/480 volt will function within minimum of 396V to maximum 509V.**

Recommended VFD set point values:

- 1) Volt to Hz profile should be set to variable torque, square law, and not set to linear.
- 2) Voltage and current unbalance between phases limits:
 - a. Maximum current unbalance 5% **(max with not over 3% recommended)**
- 3) Motor protection set point values:
 - a. Maximum input current – rated at name plate current
 - b. Overload trip protection set at 115% of systems operating current
 - c. Overload trip protection equal to or faster than NEMA Class 10
 - d. Underload protection is normally set at 80% of normal system load (current)
- 4) Permissible frequency range 30Hz to 60Hz on Grundfos submersible motors.
 - a. Always check with other manufacturers as some have a different minimum frequency on specific motors.
- 5) VFD acceleration and deceleration should be set to no more than 3-seconds:
 - a. 0 - 30Hz 1 seconds maximum
 - b. 30 - 0Hz 1 seconds maximum
- 6) Drive carrier frequency should be set as low as possible – Not above 4 kHz - Not below 1 kHz.
 - a. When using a sinewave filter always check with filter manufacturer for Drive Carrier Frequency setting with a specific drive.