Submersible Motors

Always. Submersible motor applications are unique in that the dielectric constant for water is about eighty (80) whereas for air it is only one (1). This causes the inverter output circuit capacitance to be much higher than for conductors in air (typical conduit applications) and therefore voltage reflection will be more pronounced. When the motor cables are immersed in water, voltage reflection problems can be experienced at much shorter motor cable distances. Submersible motors should always be protected by sinewave filters regardless of cable length.

Conductors in air (conduit in air)

Depending on motor cable length, when conductors (and conduit/raceway) are in air, the survivability of a motor will depend on cable length and system voltage. Motors operated from lower system voltage and with shorter cable lengths, can often be adequately protected by a reactor of about 4-5% impedance. Higher system voltages and longer cable lengths require sine wave filter protection.

	100 ft	300 ft	500 ft	1,000 ft	15,000 ft
Submersible Pumps	**SWF**	**SWF**	**SWF**	**SWF**	**SWF**
230 V motors	4-5% Impedance	4-5% Impedance	4-5% Impedance	5% Impedance	n/a
400 V motors	4-5% Impedance	4-5% Impedance	5% Impedance	**SWF**	**SWF**
460 V motors	4-5% Impedance	4-5% Impedance	**SWF**	**SWF**	**SWF**
575 V motors	**SWF**	**SWF**	**SWF**	**SWF**	**SWF**
690 V motors	**SWF**	**SWF**	**SWF**	**SWF**	**SWF**

Background

Voltage reflection is caused when fast rising voltage pulses, such as those produced by PWM inverters, travel on an electrical conductor that is terminated by a high impedance load (motor). The magnitude of the reflected pulse is a function of the characteristic (or surge) impedance of both the cable and motor. The greater the mismatch between motor and cable surge impedance the greater the reflected voltage pulse. The safe distance for the motor cable length is a function of both the impedance mismatch (between motor and cable) and the pulse voltage rise time (IGBT characteristic).

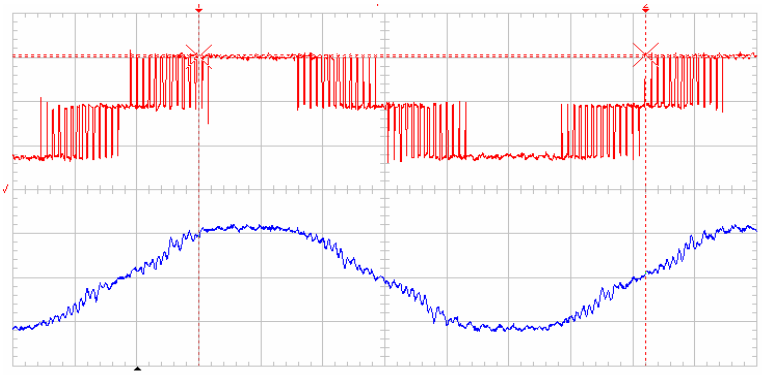
NEMA MG-1, Part 30 & 31

APQ Type SWF filters meet the requirements of both Nema standard MG-1, part 30 (non- inverter duty motors) and part 31 (inverter duty motors). Type SWF filters protect motors against premature insulation breakdown caused by excessive peak over-voltage and dv/dt. Nema MG-1, part 30 rquires 1000V peak or less and the rise time must be 2 micro-seconds or slower. Type SWF filters achieve this for all VFDs and motors rated 690 volts or less.

Comparison of Motor Protection Techniques (480V system voltage)

APQ Type SWF – Sine Wave filter Red – measured at inverter output terminals. Blue – measured at motor terminals.
Motor terminal voltage (1000 feet, conductors in air)
Motor peak voltage measures approximately equal to DC bus voltage.

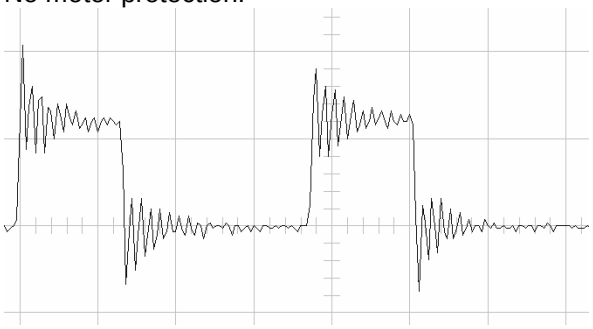
Good motor protection.
Eliminates voltage reflection.



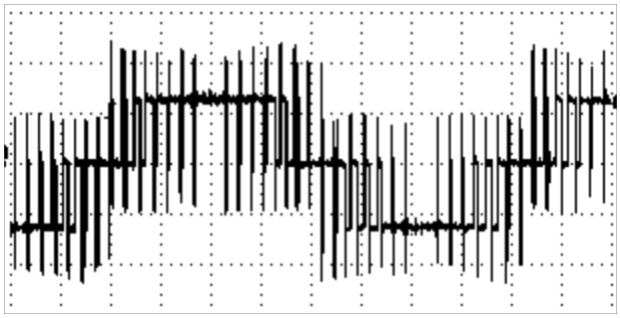
5 msec per division

No Filter
Motor terminal voltage (conductors in air)

No motor protection.



50usec per div

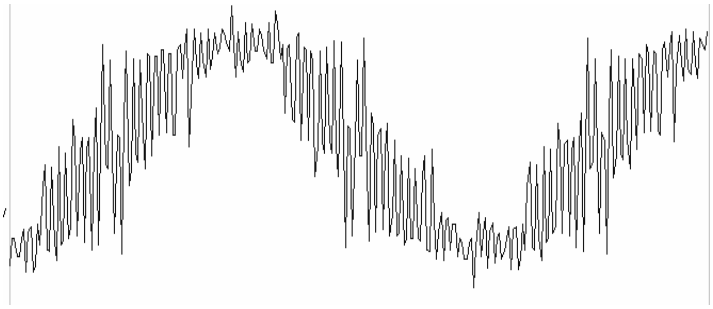


2msec per division

With dv/dt Filter
Motor terminal voltage (conductors in air)

Marginal motor protection.

100usec per division



2msec per division