

Installation Considerations for
**Variable SPEED Drives (VSD) or
Variable FREQUENCY Drives (VFD)**

**Feedback control of motor SPEED
by changing the FREQUENCY of
power supply**

For Energy Savings and Improved
Process Control

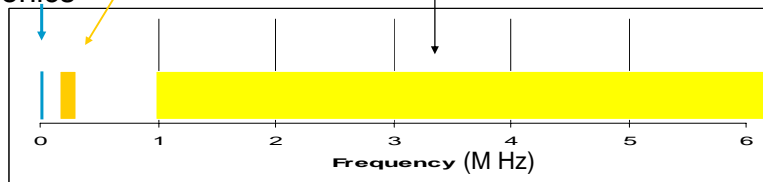
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Conducted vs Radiated

60 Hz and
harmonics

38-125 kHz

RF



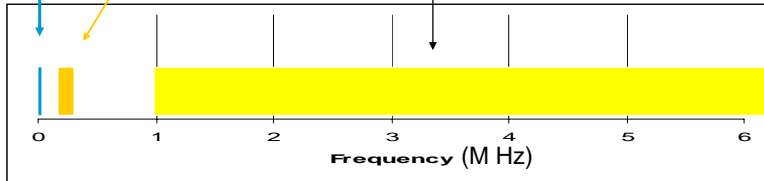
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Frequency (f) = speed of light (c) / wavelength (λ)
 c is approximately 9.8×10^8 ft/s

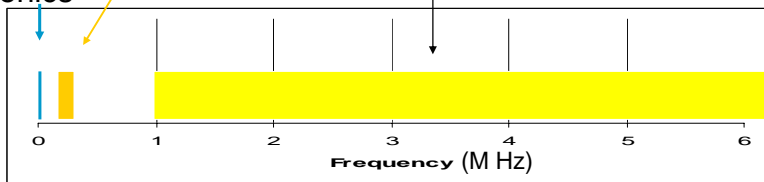
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f (Hz)	60	100,000	5,000,000
$\lambda/2$ (ft)	8,200,000	5,000	100

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VFD/VSD uses

1. Ventilation
 - Ventilate to control set-point temperatures
2. Milk Transfer Pumps
 - Vary speed to pump as slow as possible without flooding the receiver jar
 - Accessory to a precooler/heat exchanger
3. Vacuum Pumps
 - Vary speed to control system vacuum level
 - Vacuum regulation equal or better than regulator system
 - Decrease noise
4. Others – Rotary Palors, etc.

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VFD/VSD installation

- Takes Special Installation Techniques
 - Some noise will be present with filtering
 - VFD create electrical noise which can affect sensitive electronics, such as animal ID.
 - Noise at animal contact locations?
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- Different manufacturers of VSD will have varying amounts of filtering and noise, U.S. has minimal requirements
 - Availability of suitable installation materials may be an issue

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VFD or VSD installations

1. Cable or wire
2. Motor
3. Filters

Wiring can be done to minimize conducted noise or radiated noise and to increase life of wiring.
Filters can be installed to minimize noise.

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Cable or Wire (1 of 3)

- Interlocked armored cable or equivalent for control wires with shielding are recommended
- In an animal environment this may mean plastic coated rigid steel conduit
 1. Electrostatic Shielding is not sufficient, dealing with shielding for magnetically induced voltages and currents
 2. Aluminum conduit not recommended (shielding should be attracted to a magnet)

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Cable or Wire (2 of 3)

- Ideally less than 10 feet of wire between controller and motor
- If more than 40 feet between motor and controller, additional wiring precautions may be needed
- The conduit should be spaced as far as possible from other wiring to reduce the coupling of the electrical noise. Do not run control and power cables together, minimum of one foot of separation.

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Cable or Wire (3 of 3)

- 1000 or 2000V wire recommended – for 480/277 use 2000V
- The motor frame should have only one path for an electrical connection back to the AC power distribution panel, and that should be the green lead used for grounding
- Connection (grounding) of the shielding
 1. The motor and the controller will normally be grounded; therefore grounding at both ends should not change circuit
 2. Some cases such as a milk transfer pump may only be connected at the drive end

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Motor Requirements

- Need VFD rated motor
 - Higher voltage insulation
 - Heat tolerance
- Insulation class – B, inverter duty motor
- May need space heaters in motors to prevent moisture breakdown of insulation when not in use

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Types of Filtering

- Line filter
- Harmonic filter
- RF filter

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Line Filters

- **Originally developed as a VFD can trip off line (the problem)**
 - Line reactor or line filter are possible solutions to this problem
 - Current rated device to protect VFD's. (3% Impedance)
 - Reduces DC over-voltage condition caused by energizing capacitor banks.
 - Limits inrush current to the drive, therefore, reduces harmonics.
 - One-third the cost and weight of an isolation transformer.
 - Will suppress some RF

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(example) TCI - Trans-Coil Inc <http://www.transcoil.com/>

- **Applications**
 - TCI KLR series three phase AC line reactors intended for use as input filters for adjustable speed DC drives and as input or output filters for AC-PWM variable frequency drives.
 - Drive performance significantly improved
 - Input rectifier is protected from failure or damage, and drive harmonic demands are tamed with the addition of a K-rated line reactor
 - KLR line reactors act as interface buffers between solid state power circuits and the line or the motor. (Not unlike the surge protector for your desk-top PC).
 - All drives, in any application, will benefit when applied with KLR series line reactors.

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(example) TCI - Trans-Coil Inc <http://www.transcoil.com/>

■ **Before KLR Line Reactors**

- Drives susceptible to problems caused at their interface to the line or motor.
- Some of these issues include AC voltage waveform line notching or cross-talk, DC bus overvoltage trips, inverter overcurrent and overvoltage, and poor total power factor.
- Since all drives demand nonlinear current and voltage, drives demand currents rich in harmonics.

■ **After KLR Line Reactors**

- KLR line reactors provide additional circuit inductance which slows rapid changes in current that are the heart of the problems listed above.

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- Voltage line notching, or commutation notching, caused by SCR phase-controlled rectifiers.
- KLR line reactors provide voltage-dividing impedance which reduces the depth and rounds the edges of the notches, thereby eliminating drive cross-talk, interference, and equipment damage.
- Transient voltages on the AC power lines can cause inrush currents to an AC-PWM drive, resulting in over-voltage condition of the DC bus.
- These transient voltage conditions are often caused by utility capacitor switching and will cause VFDs to shut down without warning.

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Harmonic Filters

- Harmonic filter
 - May or may not be needed

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RF (Radio Frequency) Filters

- Recommended and/or supplied by some milking machine manufacturers to reduce interference with animal ID systems
- Electrically isolate the VFDs from all metal structures such as the roof
- For further reduction of electrical noise, an isolation transformer can be installed to substantially eliminate the electrical noise from reaching the power panel.

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