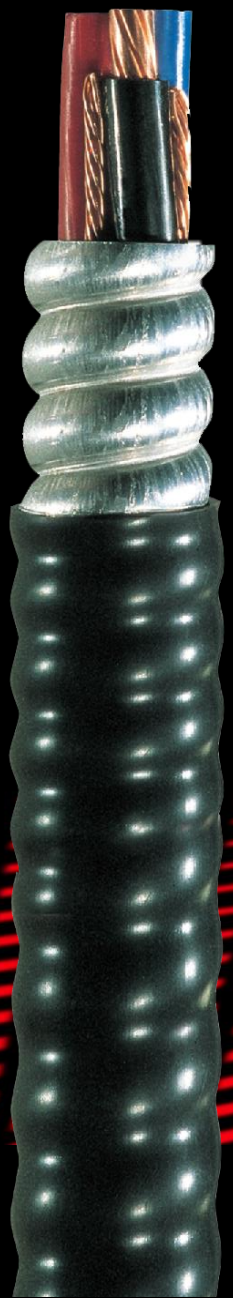

DriveRx® VFD Cables 2.0

By: Isaac Müller, P. Eng.
Applications Engineer

September 15, 2020

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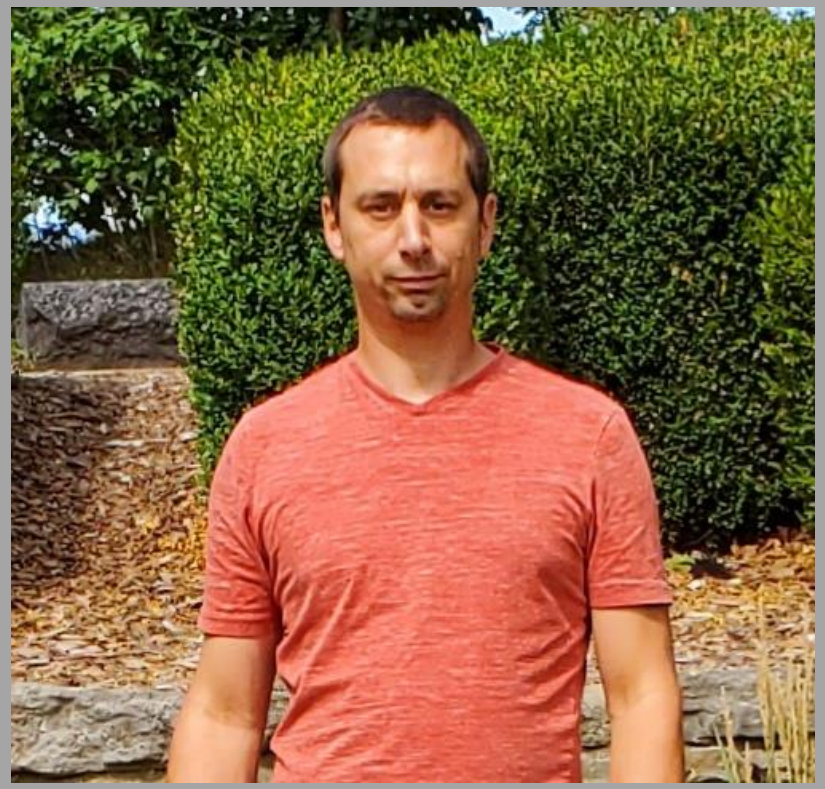
AUDIENCE PARTICIPATION

- **Questions can be asked at any time using the chat function on the webinar screen**
- **Any unanswered questions will be followed up through email**
- **This presentation will be emailed to all registrants**

Introduction

- Active Canadian Electrical Code Member
- Chair of Section 4 (conductors)
- Vice-Chair of Section 12 (wiring methods)
- Voting member of the Committee on Canadian Electrical Code, Part I, representing wire and cable manufacturing



Isaac Müller, P.Eng.
Applications Engineer, Nexans Canada Inc.

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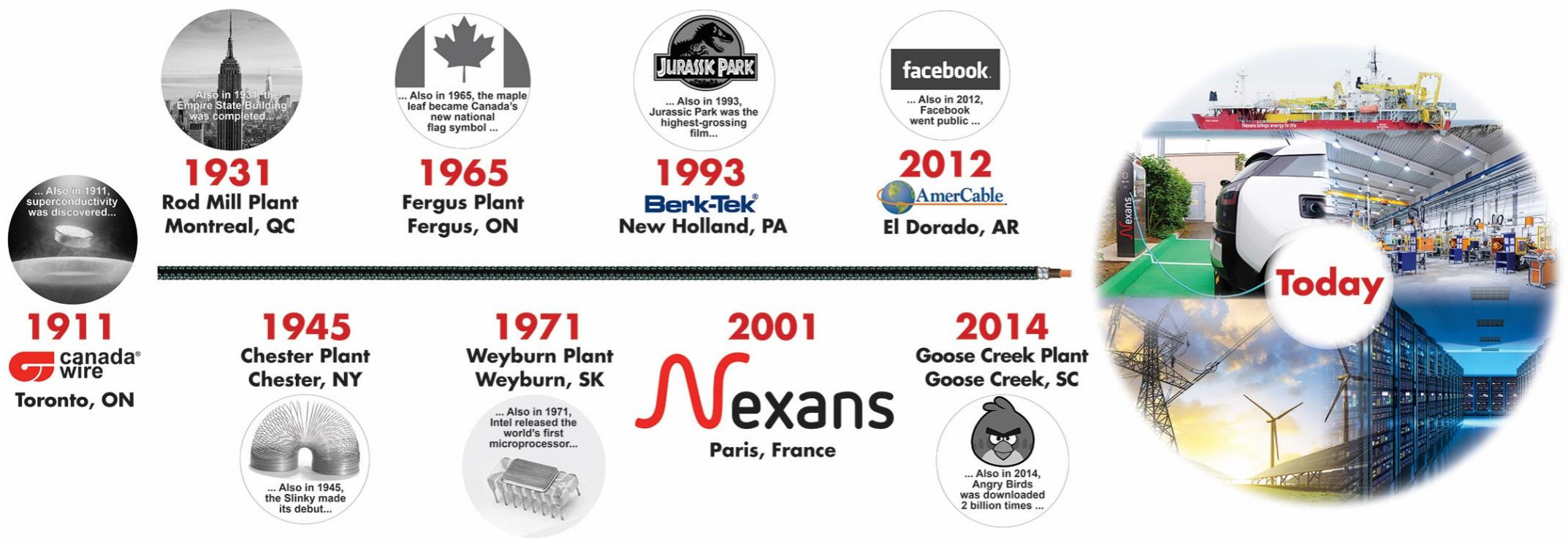
Nexans is a global leader with a long legacy in North America



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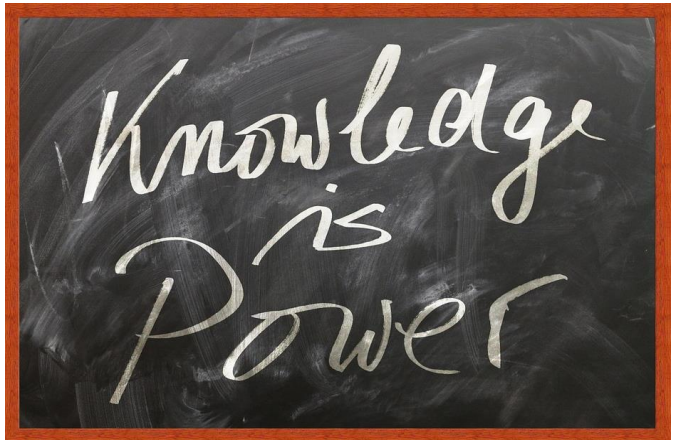
INDUSTRY EDUCATION

- Nexans' leadership - educating the industry on wire and cable
- Most recent **CORFLEX® webinar** – click here to watch it
- **2019 Nexans in Canada Webinar** for an overview of our products & services – click here to watch it
- Previous **2018 Canadian Electrical Code Changes Webinar** – click here to watch it
- Prior **VFD webinar** – click here to watch it



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SERVICES WE OFFER

- Full technical support for products manufactured
- Electrical and physical cable properties calculations (i.e. impedances, dimensions)
- Conductor ampacity and temperature calculations
- Post installation product support
- Custom engineered solutions to optimize a project from conception to energization
- Overhead line calculations, including conductor ampacity, temperature, impedance, as well as sag and tension

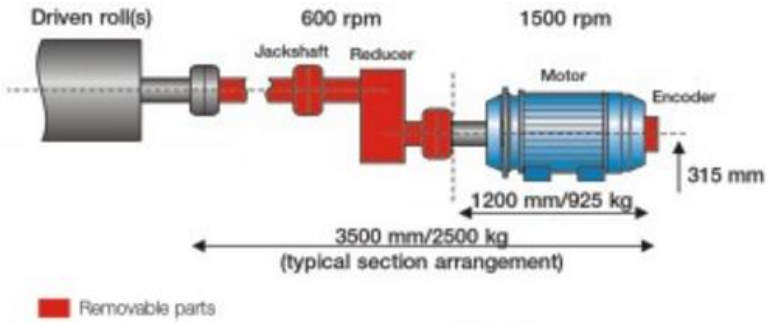
AGENDA

- What is a VFD?
- IEEE Study
- Performance Concerns
- Bearing Currents
- Common Mode Currents
- DriveRx® VFD Cable Solution
- Summary
- Q&A

What is a VFD?

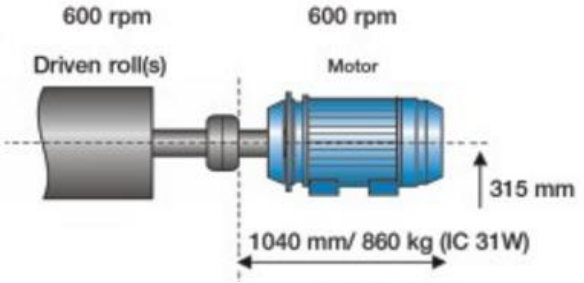
Old Way:

- Single-speed drive
- Mechanical speed control
- Electrical or mechanical direction control



New Way:

- Variable Frequency Drive
- Electrical speed control, plus torque and direction



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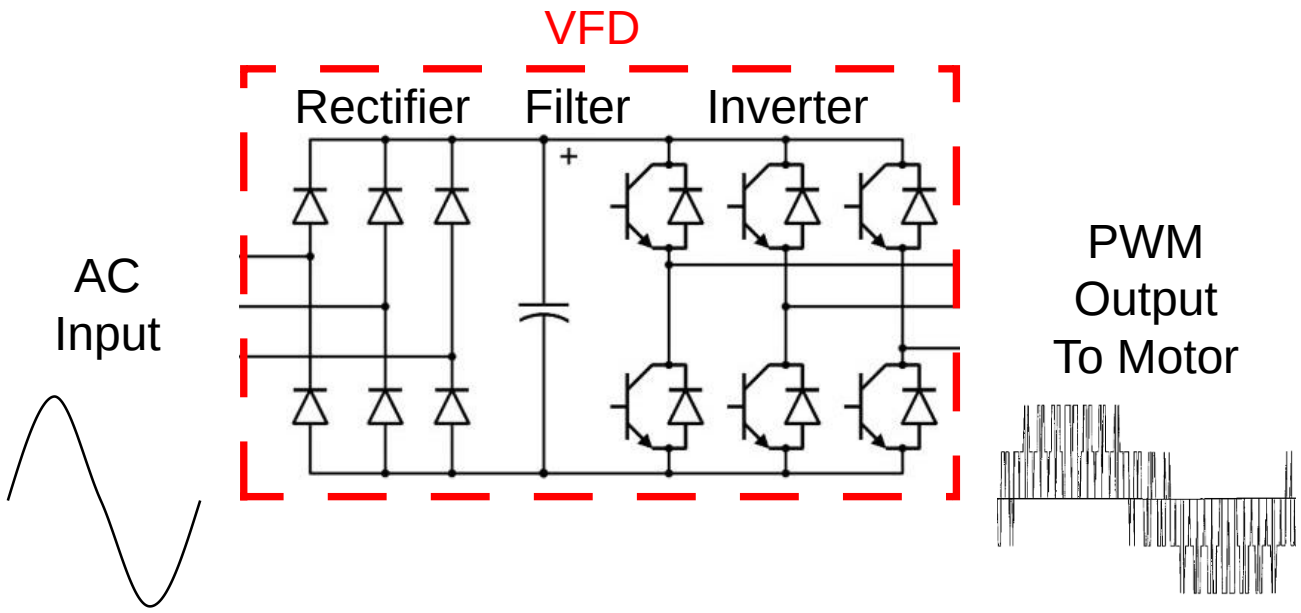
A typical VFD is made of 3 key components:

1. Rectifier – Transforms Alternating Current (AC) current into Direct Current (DC);
2. Filter – Creates a constant DC power source; and
3. Inverter – Transforms DC into a Pulse Width Modulated (PWM) waveform.



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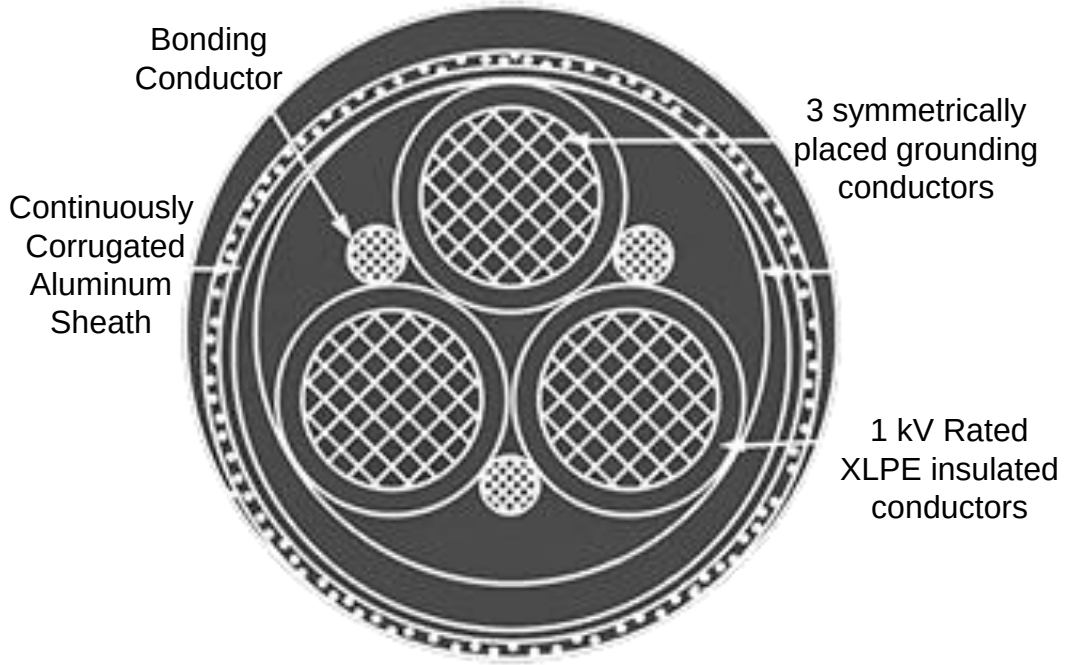
IEEE Study

- **Five performance concerns** were addressed in an IEEE paper titled **"Evaluation of Motor Power Cables for PWM AC Drives“** published in 1996.
- The **DriveRX® VFD cable** design was **#1** out of 8 cable constructions studied for use between a VFD and the motor.



DriveRX® VFD cable construction

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Performance Concern #1

Minimize net injected ground current into drive system ground bus

- *Improve drive system performance*
- *Increase reliability of drive electronics*

DriveRx® VFD cable solution:

- **PVC jacket**
  - *Ensures grounding at cable ends only*
  - *Eliminates ground loops*
  - *Result → no injected ground current*

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Performance Concern #2

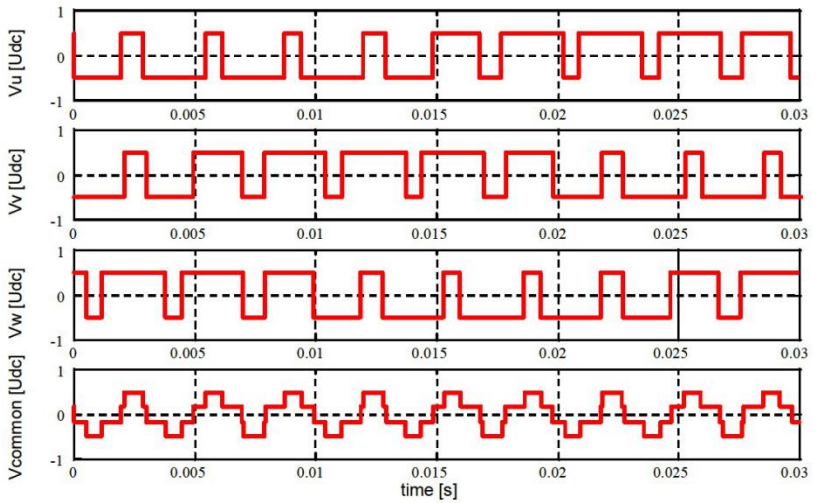
Minimize common mode currents

- *Reduce possibility of bearing current*

What is Common Mode Current?

- Modern AC drives produce 3 independent switching waveforms
- These waveforms do not add up to zero
- Result → common mode voltage and current

Motor Phase Voltages



Source: 2007 IEEE-IAS/PCA Cement Industry Conference "Motor Bearings, not just a piece of metal", Rolf Hoppler (ABB), Reinhold A. Errath (ABB), 2007

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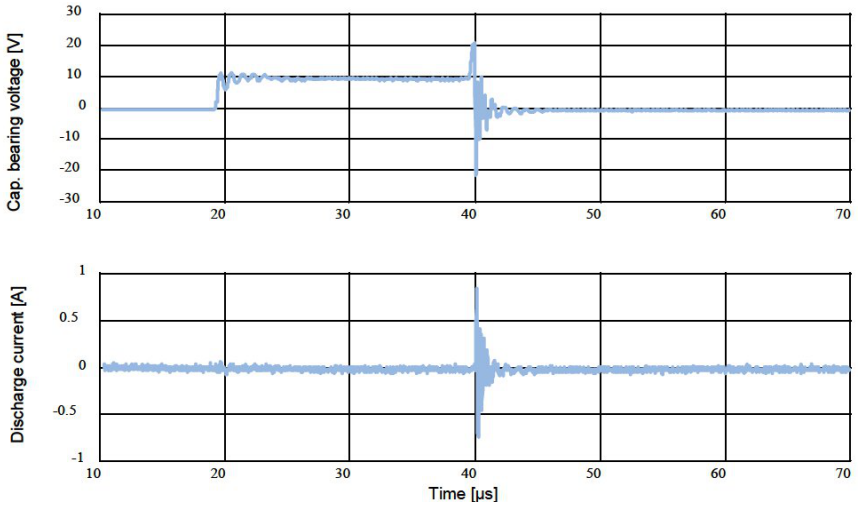
Performance Concern #2

What is Common Mode Current?

- Common mode voltage and current produce repetitive voltage spikes
- These voltage spikes reach 3.1x the nominal voltage rating of the VFD output
  - *Example: 600 V rated VFD has a voltage spike output of 3.1 x 600 = 1860 V*

Capacitive Bearing Voltage & Discharge Current



Source: 2007 IEEE-IAS/PCA Cement Industry Conference “Motor Bearings, not just a piece of metal”, Rolf Hoppler (ABB), Reinhold A. Errath (ABB), 2007

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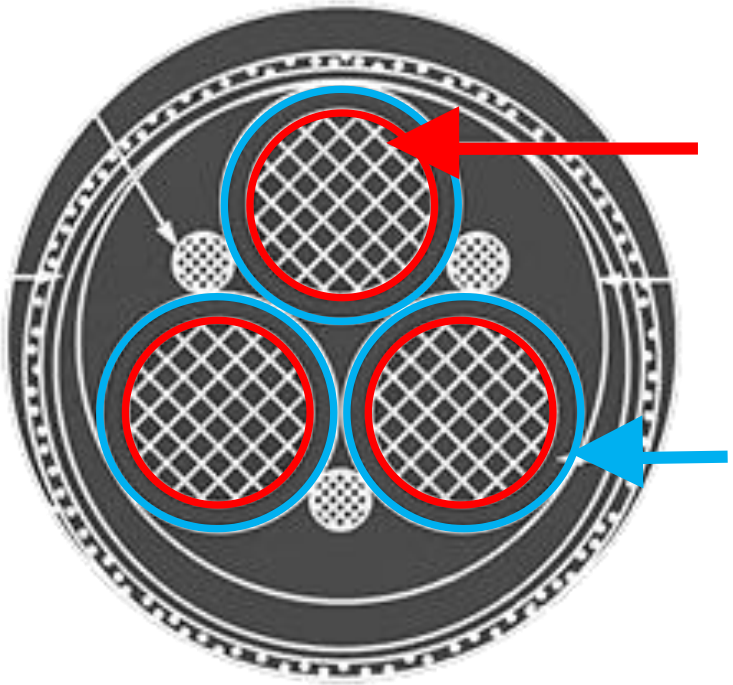
Performance Concern #2



DriveRx® VFD cable solution:

Three symmetrically placed grounding conductors

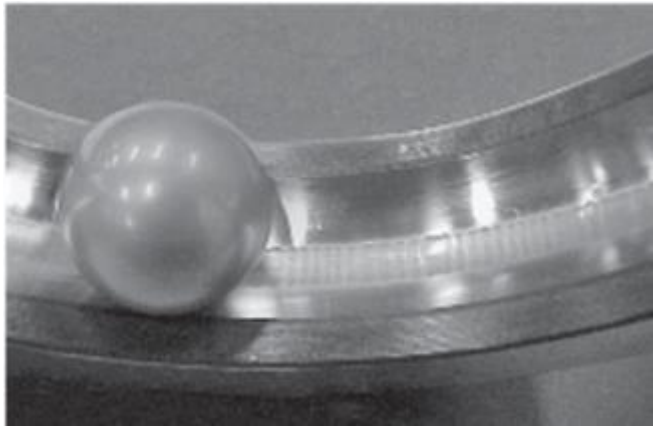
- *Provide best cancellation of common mode currents*
- *Provide the lowest net injected ground current into the drive system*

1 kV rated XLPE insulated conductors

- *High dielectric strength to withstand repetitive high voltage spikes of 2 to 3 times the nominal system voltage rating*

What are Bearing Currents?

- Rapid switching in modern AC drive systems may generate high frequency current pulses through bearings
- When the energy of these pulses is sufficiently high, metal transfers from the ball bearings and the races to the lubricant
  - *This is known as Electrical Discharge Machining (EDM)*
- Each tiny pit is a discontinuity that will collect more current pulses and expand into a crater
- Craters quickly accumulate causing the bearing to fail after a short time in service



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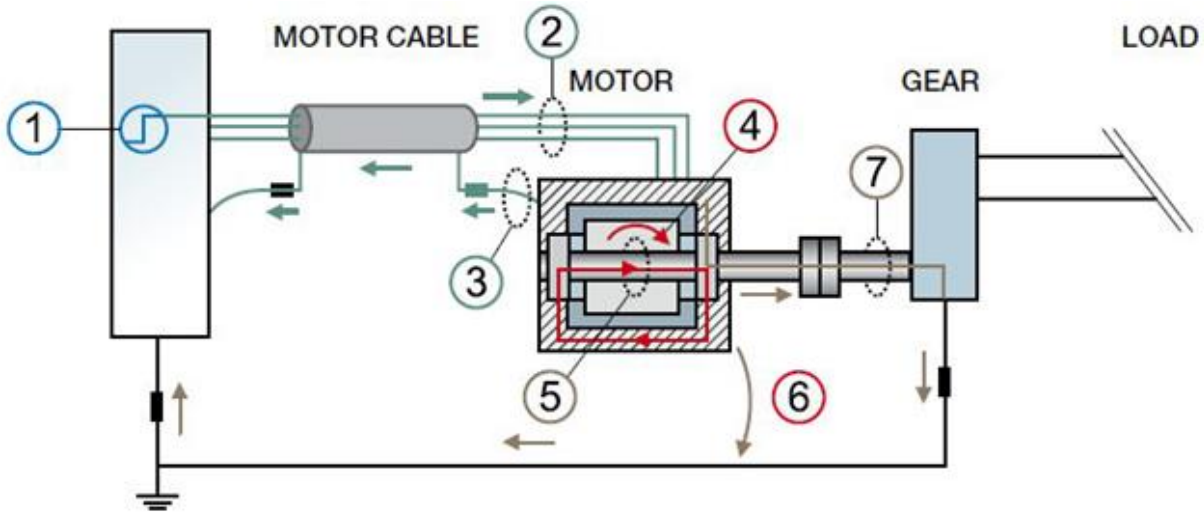
How are Bearing Currents Generated?

- High frequency voltage can be induced over a bearing in three different ways:
  1. High frequency circulating current
  2. Shaft grounding current
  3. Capacitive discharge current



Source: TDM001 EN Rev B 2007 "Bearing currents in AC drive systems", ABB, 2007

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Performance Concern #2

DriveRx® VFD Cable Solution:

- **<u>Three symmetrically placed grounding conductors plus a continuously corrugated and welded aluminum sheath</u>**
  - *Provide a balanced, wide frequency range, low resistance path to ground*
  - *Eliminate bearing currents*
  - *Eliminate the electrical shock hazard*

Performance Concerns #3

Minimize motor frame standing voltage

- *Reduce possibility of bearing current*
- *Increase safety*

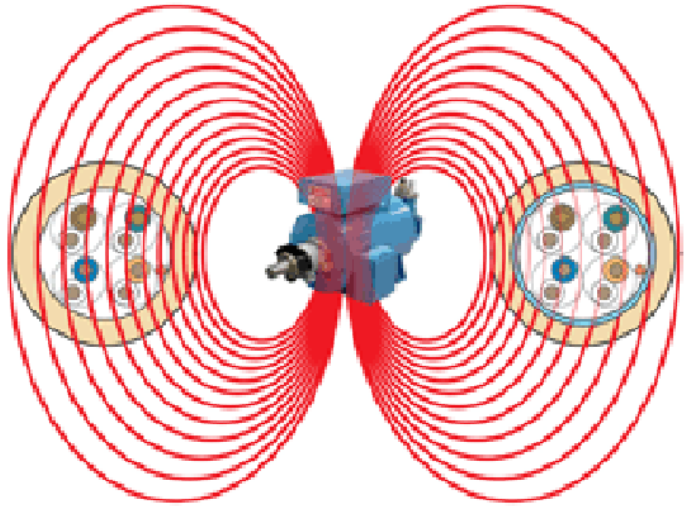
DriveRx® VFD Cable Solution:

- **<u>Three symmetrically placed grounding conductors plus a continuously corrugated and welded aluminum sheath</u>**
  - *Provide a balanced, wide frequency range, low resistance path to ground*
  - *Eliminate bearing currents*
  - *Eliminate the electrical shock hazard*

Performance Concern #4

Best possible cable shielding

- *Reduce crosstalk between adjacent cables*
- *Reduce inductive and capacitive coupling causing induced current or voltage, which could be a safety hazard*



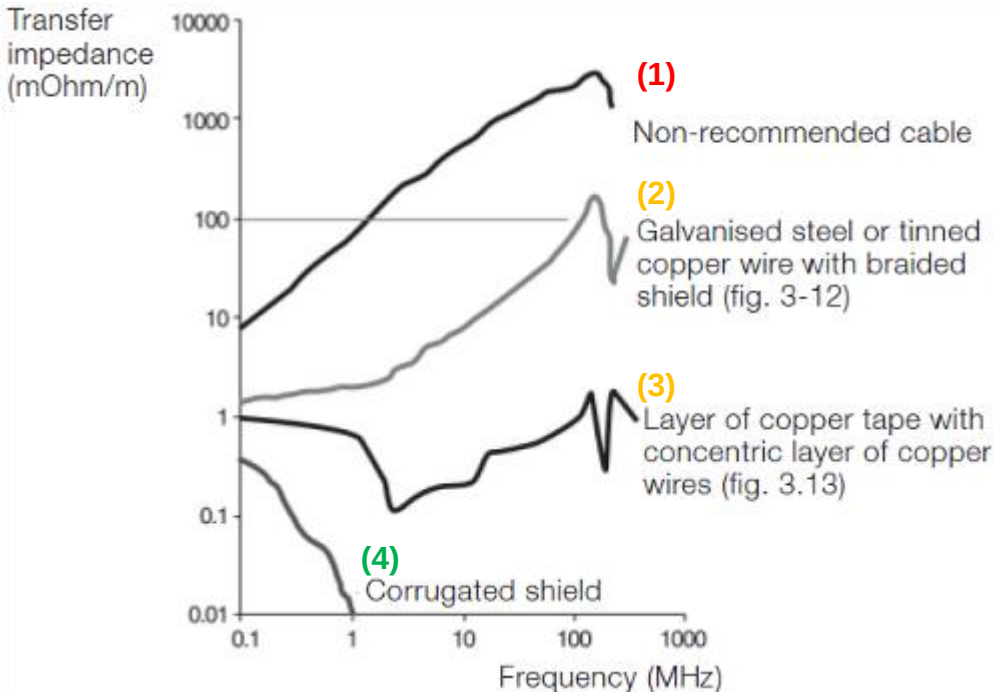
Source: http://www.networktechinc.com/blog/protecting-video-signals-from-emi-when-using-catx-extenders/133/

Shielding Effectiveness

Cable Comparisons

1. Building Wire or Cable in Conduit
   - TECK90
   - RW90 in EMT
2. Tinned Copper Braid
   - Very flexible VFD cable
3. Copper Tape with Wires
   - Flexible VFD cable
4. Corrugated Aluminum Sheath
   - Trainable, self supporting VFD cable

Transfer Impedance



Source: “Technical guide No. 3 EMC compliant installation and configuration for a power drive system”, ABB, 2012

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Performance Concern #4

DriveRx® VFD Cable Solution:

- **<u>Continuously corrugated and welded aluminum sheath</u>**
  - *Provides an excellent shield for high frequency electrical noise*
  - *Prevents interference with data and control signals*
  - *Prevents interference with both wired and wireless systems*

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Performance Concerns #5

Best possible ground path in cable

- *Long term low impedance ground path from the motor back through the cable to the drive*

DriveRx® VFD Cable Solution:

- **<u>Three symmetrically placed grounding conductors plus a continuously corrugated and welded aluminum sheath</u>**
  - *Provide a balanced, wide frequency range, low resistance path to ground*
  - *Eliminate bearing currents*
  - *Eliminate the electrical shock hazard*

DriveRx® VFD Cable

1 kV rated XLPE insulated conductors

- Withstand repetitive high voltage spikes of 2 to 3 times

Continuous aluminum sheath

- Excellent shield for high frequency electrical noise
- Prevents interference with data & control signals
- Tough armour to protect the cable

Three symmetrically placed grounding conductors

- Best cancellation of common mode currents
- Lowest net injected ground current
- Grounding conductors plus sheath provide balanced, wide frequency range, low resistance path to ground eliminating bearing currents and electrical shock hazard

PVC jacket

- Grounds at cable ends only
- Eliminates ground loops; no injected ground current

Summary

- 3 Key VFD Components:

  Rectifier, Filter, Inverter

- 5 Key Performance Concerns:

  1. *Minimize net injected ground current into drive system ground bus*
  2. *Minimize common mode currents*
  3. *Minimize motor frame standing voltage*
  4. *Best possible cable shielding*
  5. *Best possible ground path in cable*

- Common Mode Currents
- Bearing Currents

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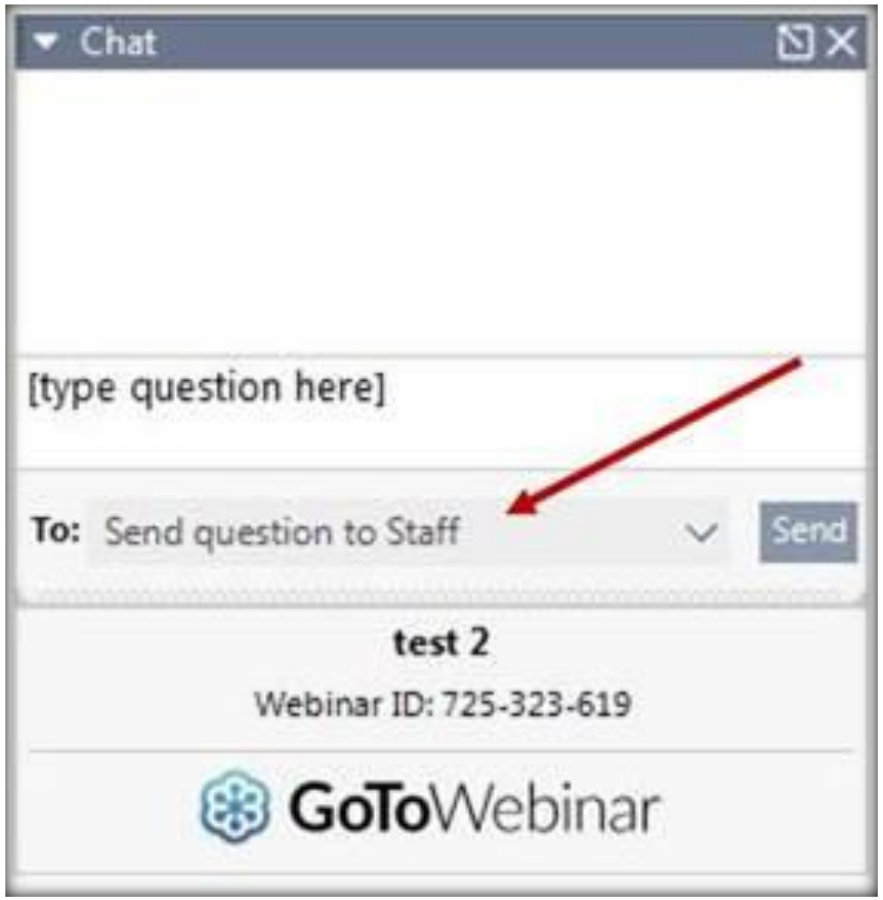
Questions



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