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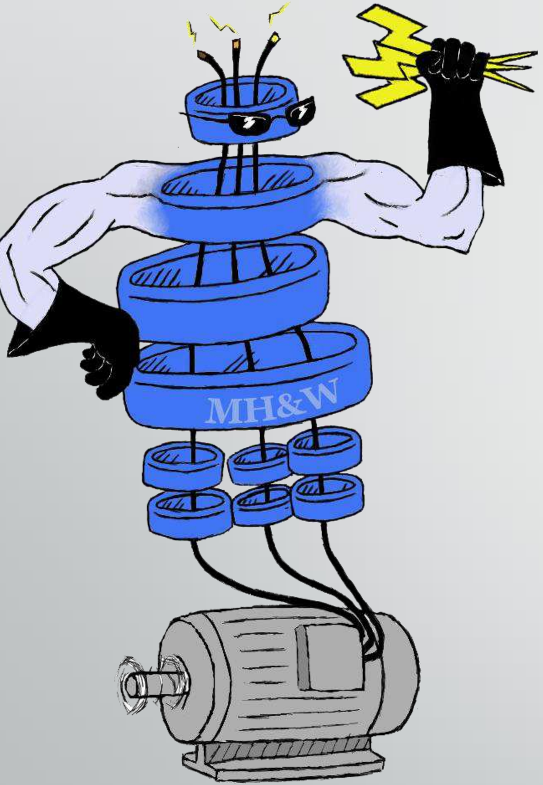

"MH&W, Keeps Your Motor Running!"

MH&W Presents

MNT Nanotech®

MH&W Nanocrystalline Technology

MH&W International Corp.
A Powerful Solution Company

A POWERFUL SOLUTION™

MH&W Nanotech®

Setting the Right Priorities to Address our Energy Challenges

Electric motors are the single biggest consumer of electricity, and account for approximately 45% of total global electricity consumption. They account for about two thirds of industrial power consumption. Lighting is a distant second, consuming about 19%. This means that almost every second power plant is producing electricity for the sole purpose of running motors.

To reduce overall consumption of power, necessary changes are critical for increasing motor needs.

The Variable Frequency Drive (VFD) was created approximately 30+ years ago to provide substantial energy savings and precise control in commercial, industrial, and now residential applications. Newer technologies are advancing every day toward this increase in demand.

All markets have benefitted from VFD's.

Major advantages of VFD's:

- Fast switching.
- Speed variation.
- Heavy load inertia starting.
- High starting torque requirements.
- Low starting current requirements.
- High efficiency at low speed.
- High power factor.
- Substantially lower power than traditional electric motors.

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Variable Frequency Motor Drive System Overview

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The world's most critical systems run on sophisticated digital systems and data centers that leverage a vast networking infrastructure. This critical infrastructure is increasingly vulnerable to disruption, and destruction, from high levels of ElectroMagnetic Interference (EMI). The cause could be a natural phenomenon or malicious intent, but more than likely, from other electronics in the system. Though it may be impossible to predict both intentional and unintentional EMI, it is not impossible to protect against it.

A relatively new class of filter, Nanotech® chokes, are designed to suppress destructive EMI caused by the high-speed switching essential in variable frequency drive systems.

EMC (EMC = electromagnetic compatibility) is essential for reliable, long term functionality of any system.

From this presentation, you will get a firm understanding of VFD motor systems and associated EMI noise:

- **Learn how critical electronics are commonly protected with a choke.**
- **Get an overview of Nanotech® .**
- **Learn about Nanotech® filter function and performance.**

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Variable Frequency Motor Drive Systems

The motor industry is continuing to maximize performance, while at the same time conscientiously improving electric motor energy savings. One of the most advanced energy savings comes by using VFD's on electric motors. Since they are so widely used now, it is therefore imperative to be aware of the side effects caused VFD's.

MH&W presents the complete solution to motor bearing damage and stray ground current problems caused by modern day VFD motor systems. This is the way it should be done…electrically, and at the source.

Nanotech® nanocrystalline material is used to eliminate electro erosion and stray ground currents, especially in motor bearings, gear boxes, sensors, metal detectors, pump monitors, and other system electronics.

To be clear, MH&W is not discouraging the use of these highly effective VFD motor system control methods. Rather, this presentation is intended to inform the industry about potential conditions that can lead to early bearing failure and disrupt associated electronic systems.

Proper EMI Education – Education is key to learning how a choke works in all electrical systems. Misconceptions and false claims in the field will be cleared up.

- **MH&W** provides an elementary overview of how a VFD system works.
- **MH&W** provides expert knowledge on the phenomenon of EMI in the VFD system.
- **MH&W** provides results of how bearings get damaged, and how stray ground currents affect sensors, pump monitors, metal detectors, and general radio interference.
- **MH&W** provides common approaches to minimizing risks for bearing damage, including presenting a method to eliminate the electrical current flow by absorption at the source.

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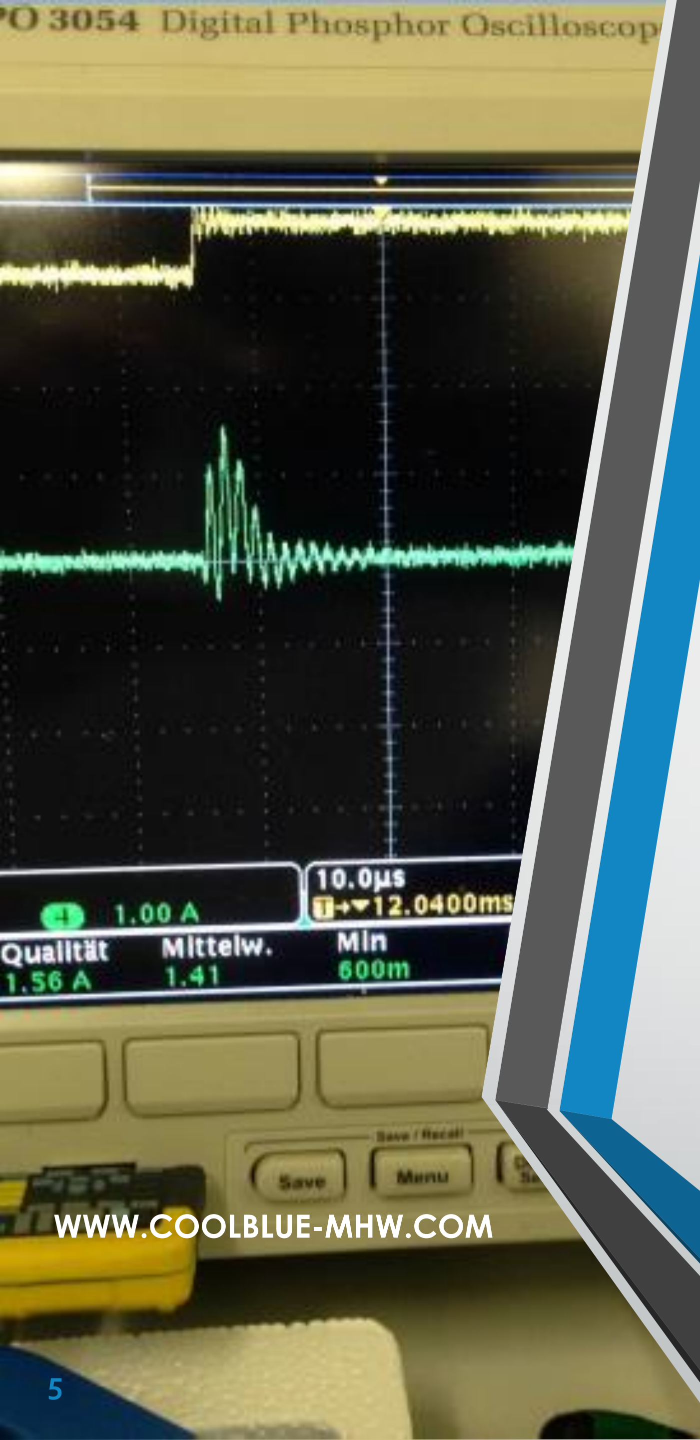

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Problems with IGBT/SiC/GaN and newer switching Systems in VFD's

VFD systems are not sinusoidal but are a continuous generation of pulses (Pulse Width Modulation or PWM). The pulses have a constant voltage and a dv/dt rise and fall time of the pulse. The original VFD systems were based on Bipolar Junction Transistors (BJT). Most VFD's now have IGBT's (Insulated Gate Bipolar Transistor from Mitsubishi, On Semi, Infineon, ST Micro, etc.) in their systems which give a faster switching dv/dt with lower switching losses and a more efficient drive than BJT's. The trend now is going to even faster switching with Gallium Nitride (GaN) and Silicon Carbide (SiC). According to most recent studies, it appears SiC will win out (now being used in most electric automobiles). The drawback of SiC switches will be even higher EMI caused by the high dv/dt and over-voltage shoots.

IGBT switches create problems associated with the system performance. The IGBT introduces parasitic currents in the form of two potential destructive characteristics:

1. Transient Voltage/ Harmonic Distortion/Reflective Waves
2. Higher magnitudes of electrical ground noise current

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Electrical Discharge Machining (EDM)

Cause:

VFD Induced, High Frequency, Common Mode Current

VFD's produce **high frequency** electrical noise, in the area of several hundred kilohertz, to several megahertz. The noise is superimposed on the power drive lines of the motors in the form of common mode noise. The common mode noise creates a voltage (dv/dt) across the rotor/stator of the motor resulting in a discharge current through the lubrication and motor bearings to the motor bearing raceway.

Common mode currents will cause bearing damage in the motor, and electromagnetic interference will affect control signals, encoder feedback, communication links for programmable logic controllers, Remote I/O, metal detectors, pump monitors, and other types of sensors including ultrasonic sensors, bar code/vision systems, weight sensors, and temperature sensors.

This current discharge produces an EDM effect (Electrical Discharge Machining) that causes destructive pitting and damage to the bearing raceway, and premature lubrication breakdown. The result is premature failure of the motor.

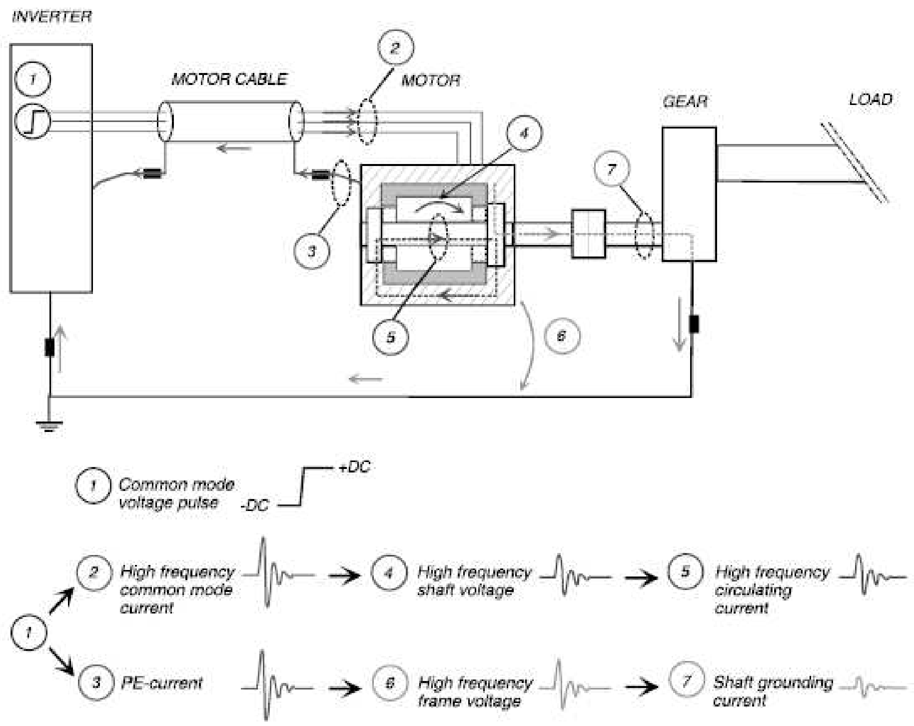
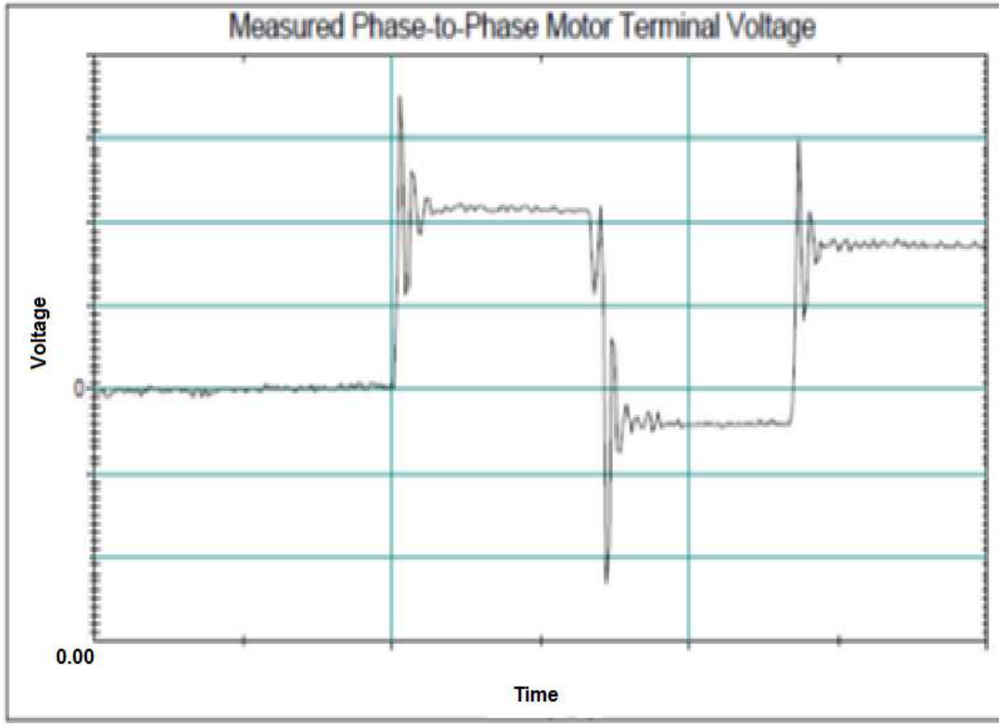


Figure 5: A schematic presentation showing the circulating current and shaft grounding current, the latter resulting from high motor frame voltage with superior machine earthing.

Problems with IGBT, SiC, GaN Switching Systems

Each pulse in a PWM system is not a clean square pulse. Each Rise and Fall of the pulse has an overshoot or transient over-voltage. This over-voltage phenomenon is also known as "Reflected Wave", "Transmission Line Effect" or "Standing Wave".

The per unit overvoltage magnitude is dependent upon drive-cable-motor circuit dynamics defined by drive output voltage magnitude and rise time, cable surge impedance characteristics, motor surge impedance to the pulse voltage, cable length and spacing of the train of pulses by the PWM modulator.



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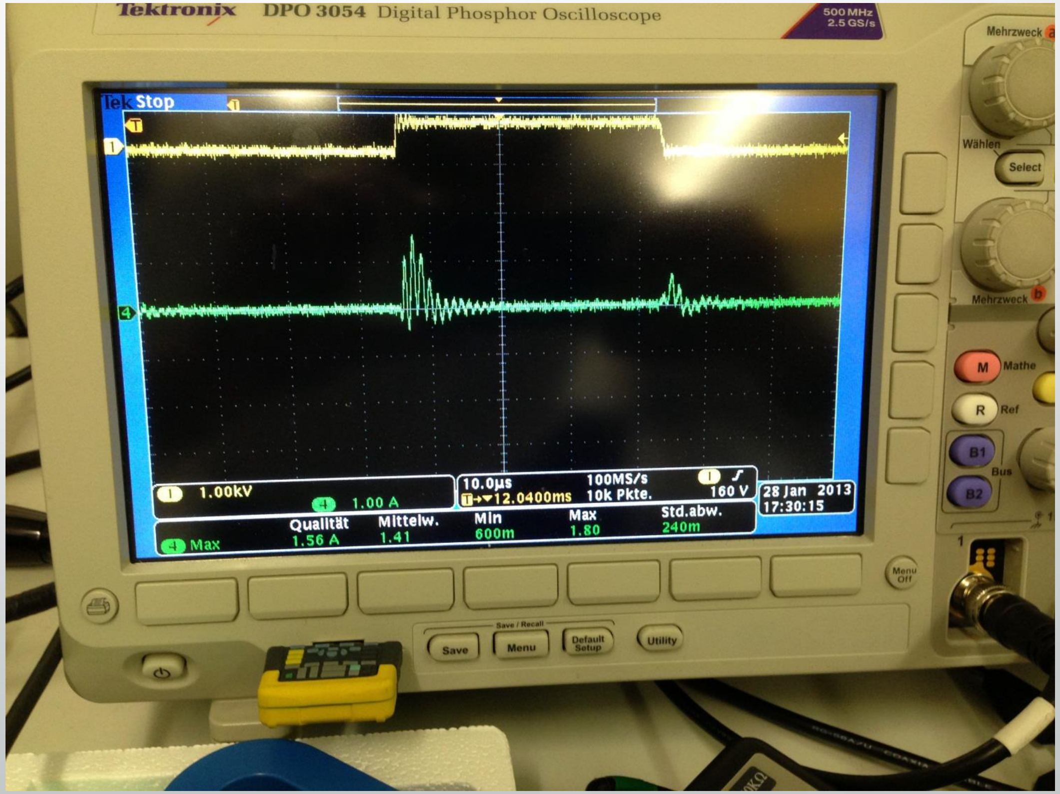
Example of High Frequency Noise

Here is a typical example of the high frequency noise generated by the IGBT devices in a motor system.

The yellow line at top of screen indicates the switching of the IGBT in the drive. The green line indicates the high frequency noise generated creating the destructive common mode currents.



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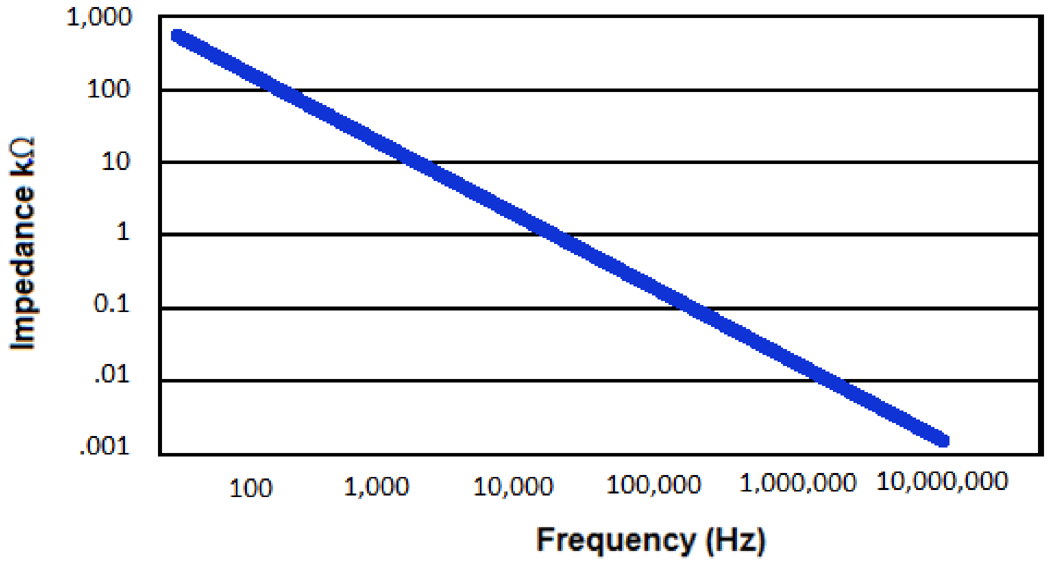
High Frequency Noise and System Impedance

As the frequency of the common mode noise increases, the impedance of the system goes down. This graph shows how low the impedance goes as the frequency increases from Hz to MHz. The decrease in the impedance (system resistance) allows more and more current to flow, causing more current to damage the system and cause substantial stray ground currents.



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High Frequency Noise Versus Typical Line Frequencies (50-60Hz)

A common industry misconception of high frequency in modern day VFD motor applications is to view and associate with 50/60Hz up to 50kHz.

Because of the high-speed switching of IGBT's, the noise (high frequency current) is in the megahertz (MHz) range. Typical systems will see these high frequencies from several hundred kilohertz, up to 5MHz.

Understanding of these high frequencies is beyond most electrical system operators experience. A better understanding will follow in this presentation.

Measuring, and viewing, these high frequencies cannot be seen and accurately measured with a standard amp meter for two reasons:

1) A typical clamp meter will only measure RMS (or average), therefore the measurement will not display peak currents, which is the destructive force in most VFD systems.
2) A typical meter will not accurately display the high frequencies. Most meters will only see up to 50kHz. Again, high frequencies are in the hundreds of kilohertz up to several megahertz, beyond what a typical meter will be able to measure and display.

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Evaluating the Problem

1. Electrical discharge detection.
2. Shaft voltage measurement.
3. Accurately measuring high frequency current.

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Evaluating the Problem

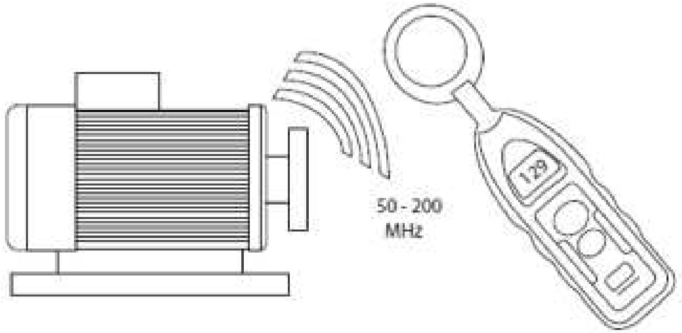
Electrical Discharge Detection

The electrical discharge in a motor bearing is a charge-discharge similar to a spark. A large current is flowing from a high potential to ground. This spark, or arc, generates a high frequency noise that can be detected. A test instrument with antennae attempts to sense every time the spark is generated and discharged.

Holding the instrument close to the motor shaft (within 11”) where the motor bearings are located, the equipment attempts to measures every high frequency current discharge thru the bearings.

This is a relatively safe method of identifying potential problems in that there is no contact with the motor.

Although this is a relatively safe method of testing for discharges, it does not accurately measure the actual discharges. Other outside influences, such as communications and power conductors, can impact the devices measurements.



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Evaluating the Problem

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Measuring Shaft Voltage

There are methods of testing the voltage discharge from shaft to ground by use of brush or wire attached to an oscilloscope probe and touching to the rotating shaft.

Method of testing with brush probe is dangerous, and sometimes not accessible, especially in explosion proof, hazardous duty, vertical mount, or medium voltage motors. Many corporations forbid this type of field testing due to safety concerns. Due to these concerns and risks, this type testing is not advised in the field.

Shaft voltage and current spikes caused by the pulse-width modulated output of motor drives can be exceedingly brief, often in the microsecond measurement range. An oscilloscope with a high bandwidth (up to 200 MHz) and fast sampling rate (from 1-2.5GS/s) is needed in order to capture these spikes.

To prepare the motor for measuring shaft voltage, the user must:

1. Motor shaft must be properly cleaned and prepped in order to make sufficient contact. This is done by smoothing or lightly sanding the surface area of the shaft.
2. Keyway must be filled with a filler in order to make constant, 360° contact with shaft.
3. The probe or wire must be placed in a way that the brush makes continual contact with rotating shaft.
4. Must obtain access to shaft, prepare shaft, install probe on motor shaft, powering system up, powering system down, and disconnecting probe.
5. Explosion proof, hazardous duty, vertical mount, or medium voltage motor applications, and explosion potential applications are not accessible for this method.

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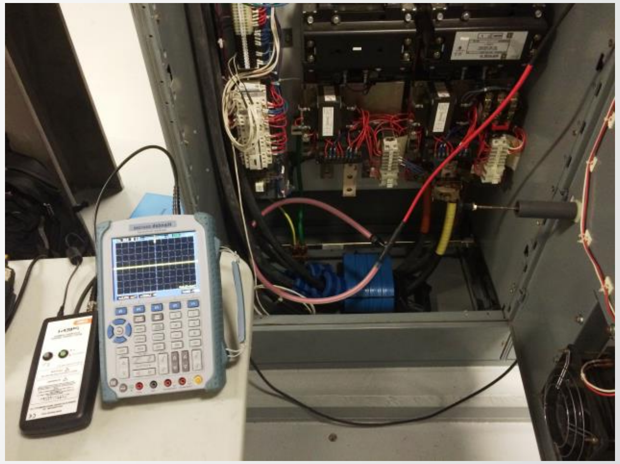
Evaluating the Problem



How To Properly Measure Common Mode Currents (CMC)

The most accurate, simple, and safest way to measure CMC is with a flexible, clip-around, Rogowski coil and oscilloscope. This method is used to measure high frequency destructive common mode currents in motor drives power cables…at the source in the VFD cabinet.

The high frequency Rogowski coil simply connects around the 3 power phases of cable going from the drive to the motor. If multiple cables per phase, coil would go around all cables. The output of the Rogowski coil connects to any oscilloscope (suggested 100MHz+, 1-2.5 GS/s samples per second and above) and displays the common mode current.

Simply power down, place the Rogowski coil around all three phases of power. Power up system. Measure current.

What is a Rogowski Coil?

Named after the German physicist Walter Rogowski, the Rogowski Coil is an electrical device used for measuring alternating current (AC) such as high-speed transient; pulsed currents or power frequency sinusoidal currents. Very common device used in all electronics. The Rogowski coil works similarly to a current sensor.

In its simplest form, a Rogowski coil is an evenly wound coil of N turns per meter on a non-magnetic former of constant cross sectional area A. The winding wire is returned to the starting point along the central axis of the former and the two ends are typically connected to a cable. The free end of the coil is normally inserted into a socket adjacent to the cable connection in a way that allows it to be unplugged thus enabling the coil to be looped around the conductor carrying the current to be measured.

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Methods of Reducing CMC

There are three methods commonly employed to remove the effects of damaging bearing currents on VFD motor systems.

1. **Insulated Bearings.**
2. **Shaft Grounding Device (commonly known as a voltage diverter, because this device attempts to divert voltage around the bearing).**
   Note: This method attempts to remove voltage by shorting to ground. Stray ground currents continue to flow through the system back to the VFD.
3. **Common mode chokes/inductive absorption device.**

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Insulated Bearings

Insulated bearings are a mechanical solution where the motor bearings, or race, are made of insulated material or insulated coating.

The problems associated with this solution are:

1) Cost. Installation, added bearing costs for coating, replacements, and does not absorb or remove the actual current flowing. Attempts to block current flow.
2) Motor bearings do have to be replaced, increasing the expense over time.
3) Common mode currents can overcome the insulated bearing and damage bearing race and cause stray ground currents.
4) This solution only attempts to protect the motor bearings.
5) Increased heat in system because motor cannot provide a path for the current to flow.
6) Several motor manufacturers recommend the use of isolated bearings, which should break the current flow through the bearing. There are, however, many documented cases of bearing damages even on isolated bearings, so it is not a fool-proof solution. As with many other problems, it is always better to attack the root cause.

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Shaft Grounding (Voltage Diverter)

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A mechanical brush device that "rides" on the rotating motor shaft. The device attempts to divert voltage directly to ground (via motor casing) through the brush. Commonly called a diverter ring, or shaft grounding ring.

Problems associated with this device:

1. Brushes must be properly maintained/replaced–system becomes expensive over time.
2. Brushes lose contact with shaft over time due to high current flow, heat, contaminants, and physical wear.
3. This method does not solve the problem as it does not absorb the voltage or current. Shaft grounding attempts to divert the voltage to ground. And, if system ground is insufficient, path of current will go through other parts of the systems.
4. Must be maintained and replaced periodically causing downtime for maintenance and added costs.
5. This solution is only targeted at protecting motor bearings. A significant problem in the field is with stray capacitive currents flowing through other motor system devices such as sensors, detectors, and other system communications. Shaft grounding just adds to the problem by allowing current to flow into the overall system.
6. Motors 100HP/75kW and above must have isolated/hybrid bearing on opposite end to force current through brush. Added cost of bearing and installation, and maintenance time.
7. Literally hundreds of types for different motors and shafts. i.e., drill and tap for screw mount, shaft size varies per hp/ kilowatts, wash down applications, chemical/harsh environment resistant, hazardous condition types, disassembly of housing, internal mount, just to name a few examples.

Shaft grounding rings are sold to manage the circulating currents in the motor and ensure that the current bypasses the bearing and goes straight to ground, thus preventing damage to the bearing. They are mounted around the shaft and bolted to the stator housing. While this is a widely specified solution, it is again little more than a band-aid! It adds cost to the installation without dealing with the actual root cause. The best solution is to eliminate the source entirely.

The shaft grounding system attempts to short the voltage to ground. While voltage is part of the formula of power, watts are the destructive force (V * I = Watts). For example, 30 volts times 1 amp is 30 Watts of power. 30 volts times .1 amp is only 3 watts. Absorbing the current at the source near the IGBT's, before it gets to the motor is the solution…not diverting it somewhere else after current flows through the motor!

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The only **SOLUTION** for permanently removing damaging currents is to install a common mode choke around the power conductors going from VFD to motor. **Nanotech®** cores absorb the damaging currents at the source of the noise (IGBT's)…well before the damaging currents reach the motor.

Nanotech® cores are a permanent solution for the life of the system…regardless if the motor or drive are replaced.

- High-frequency common-mode choke consisting of high-permeable (Nanocrystaline) magnetic cores.
- The cores suppress high-frequency common mode currents (EMI source).
- The effect is the elimination of discharges in the motor bearings and the reduction of high-frequency electromagnetic interference (EMI), especially important when unshielded cables are used.

Important Note:
It is advised to continue to follow EMC installation rules strictly. A good high frequency return path should be provided between motor and frequency converter, for example, by using shielded cables. Make sure that the motor is properly grounded, grounding has low-impedance for high frequency currents, and provide a good high-frequency ground connection between motor chassis and load.

MH&W engineers are trained in providing knowledgeable assistance in proper EMI grounding.
Ask your local MH&W engineers about the use special **Nanotech®** cores to replace shielded cabling.

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MNT Nanotech® Common Mode Choke

What is a common mode choke?

In electronics, a **choke** is an inductor used to block **high frequency** alternating current (AC) in an electrical circuit, while passing lower-frequency or direct current (DC). The choke's impedance increases with frequency.

The name comes from blocking—“choking”—high frequencies while passing low frequencies. It is a functional name; the name “choke” is used if an inductor is used for blocking or decoupling higher frequencies.

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Common Mode Choke

A common mistake, or deceptive statement, with the using a choke is to look for a reduction in shaft voltage. Clearly a choke, in this case **Nanotech®** reduces current, not voltage (per definition of a choke mentioned previously).

One manufacturer of shaft voltage diverter rings attempts to disqualify a choke with this misinformation.

Again, a choke, in this case **MNT Nanotech®**, absorbs high frequency CURRENT, not voltage. If you reduce the current, there is no damaging power. Ohms Law.

Note: Chokes have been used since the beginning of electronics well over 75 years ago. It has only been within the last 12 years that MH&W has found a product that will work on VFD motor systems.

All OEM's, especially companies such as ABB, Allen Bradley/Rockwell, Danfoss, Weg, etc. use, or suggest the use of chokes in their systems.

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Nanocrystalline versus Ferrite Material Used in a Choke

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Some OEM manufacturers of VFD's attempt to use ferrite material for chokes in their system (typically on the VFD DC Link). MH&W engineering has found that they are not sufficient to suppress common mode currents, and/or go into saturation to quickly. With this knowledge and expertise, MH&W recommends Nanocrystalline.

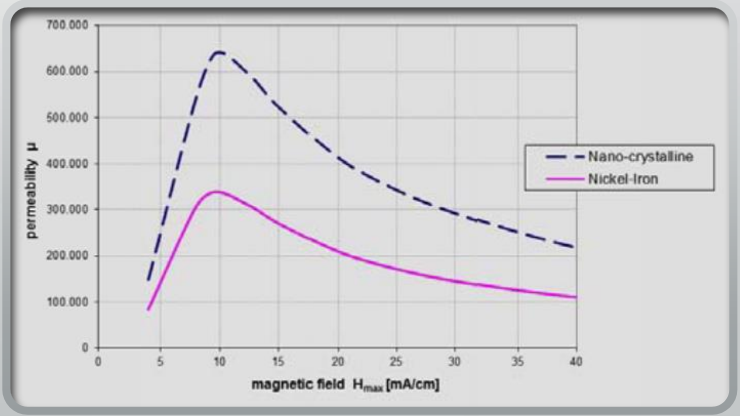
Ferrite versus Nanocrystalline:

- Application Example 1: ELCB/RCCB/RCD

Years ago, ELCB (Earth-leakage circuit breaker) were equipped with Permalloy (NiFe – Nickel Iron) cores. In recent years, those same cores are being replaced by Nanocrystalline version due to double the permeability, smaller size, and lower overall costs.

Application Example 2:

For over 50 years, common mode filter chokes were solely equipped with Ferrite cores. Due to their significantly higher permeability (Ferrite up to 15k, Nanocrystalline from 1k to >200k), Nanocrystalline core materials reduces weight, size, and much lower losses at less than 50%).



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Nanocrystalline Common Mode Choke Material

Note of importance:

Nanotech® cores have two important functions in a VFD motor system:

1) Reduce the damaging common mode currents.
2) Reduce the high frequency (di/dt), thereby reducing current further by increasing the system impedance.

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Call MH&W engineering for information on our new radiated emissions products for use instead of shielded cable.

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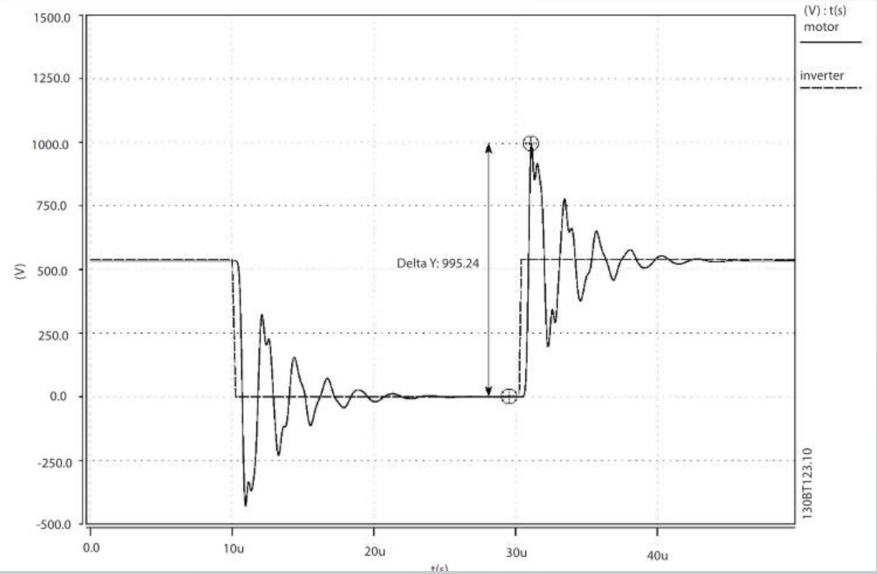
Ringing Oscillations in Motor Cable

The ringing oscillations in the motor cable are one of the most significant sources of EMI (ElectroMagnetic Interference). The frequency of the oscillations depends exclusively on the cable parameters: specific capacitance, specific inductance, and cable length.

For example, a 650’ cable can exhibit frequencies up to 250kHz, whereas a 15’ cable can exhibit up to 2Mhz.

Example of a measured ringing on cabling



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MNT Nanotech® Common Mode Choke

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Measuring just voltage doesn't show how much current on any circuit. Measuring just current doesn't show how much voltage. Measuring both on the screen at the same time shows voltage and current in the system.

See Figure 1 and Figure 2 below.
Yellow signal on channel 1 indicates shaft voltage measured with a voltage brush "riding" on the motor shaft.
Blue signal on channel 2 shows current measured with a Rogowski coil around three phases of power cables.

Figure 1: Before the installation of nanocrystalline chokes.
Figure 2: After installation of nanocrystalline chokes .

As you can see in Figure 2, the voltage stays roughly the same, but the current is greatly reduced. Equally important, the high frequency ringing is greatly reduced.

With this simple test/analysis, it is clearly visible that current is greatly reduced, regardless of what voltage is measured. By reducing current, Nanotech® cores have effectively removed damaging power!

Figure 1

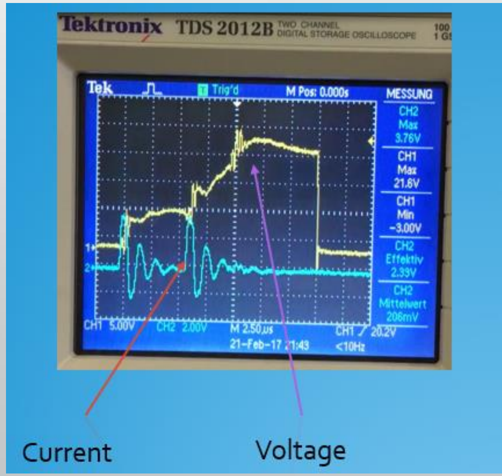
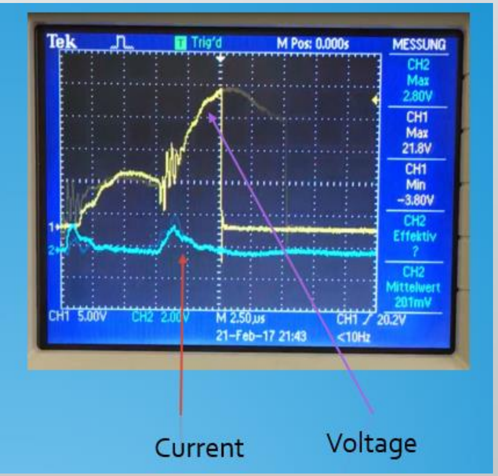


Figure 2



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Inductive Absorption Common Mode Choke

Inductive absorption is an electrical solution where inductive components are placed over the drive cables to absorb the transient voltage and common mode currents. The inductive components need to have high permeability, high saturation, and low power loss. They do not affect the symmetrical power currents but efficiently dampen the asymmetrical EMI noise currents. This creates a common mode choke.

The initial installation cost is about the same, or less, than other temporary fixes such as diverter rings or insulated bearings.

There are no long-term costs as there is no maintenance, or replacement ever needed with this solution.

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MNT Nanotech® CMC Common Mode Choke

Solution!

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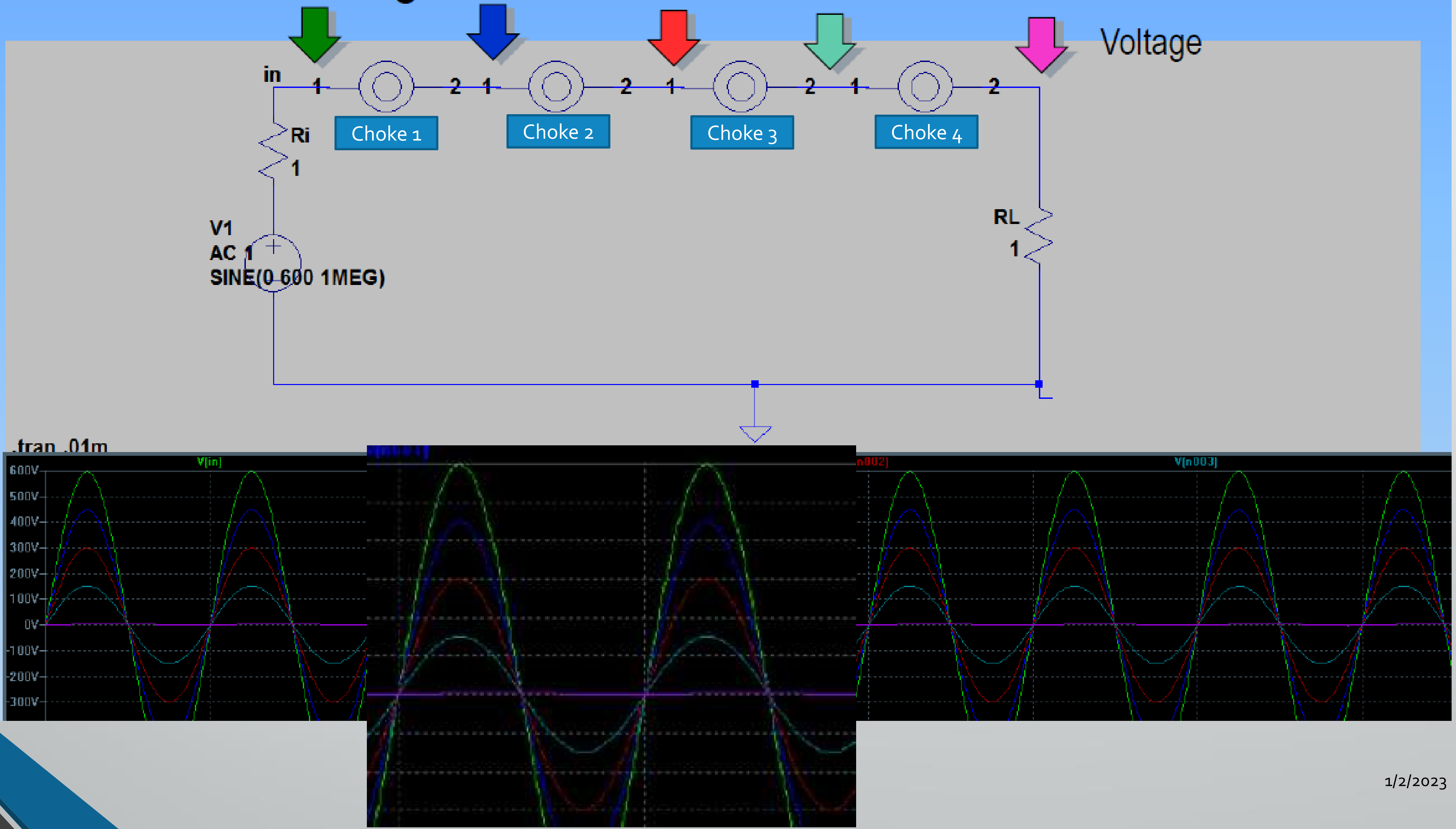
The advantages of a common mode choke solution are:

- Core and installation cost less than shaft grounding or insulated bearings.
- Easy to install around power cables.
- Can be retrofitted to any system in the field.
- Reduces transient voltages, stray capacitive currents, and common mode currents. Small number of cores fit all motor applications (AC, DC, Servo, Medium voltage)
- Other electronic devices in the systems like sensors, monitors, metal detectors are protected as well as motor bearings.
- Lifelong solution – magnetic properties do not degrade over time nor affected by heat.
- This is a permanent solution!

Theoretical Background: Simulation



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Correct Installation of Nanotech® Cores

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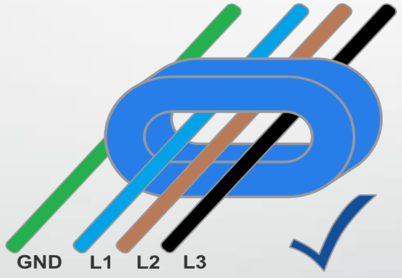
Nanotech® CMC Common Mode Chokes

All power cables must go through **Nanotech® CMC** cores (shown below). No grounding wire or shielding. In case of multiple conductors, all power conductors go through cores (shown below). No ground or shielding.

Nanotech® DMC Differential Mode Chokes

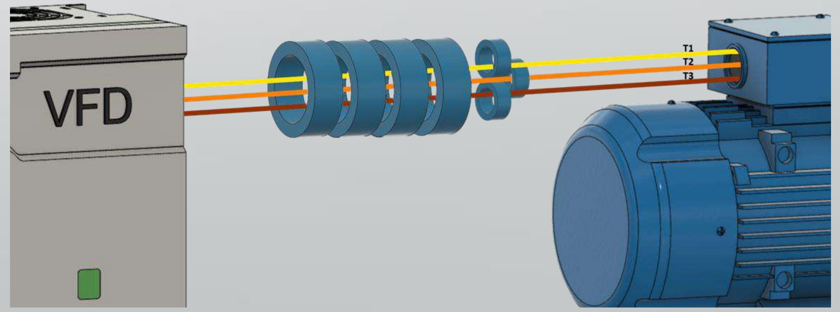
Each phase must have at least one differential mode core. In multipower-cable applications, a **Nanotech® DMC** must be on each individual cable, or around all cables each phase.



Correct Installation

Incorrect Installation.
GND and shielding should NOT go through cores.

Multi-conductor Example



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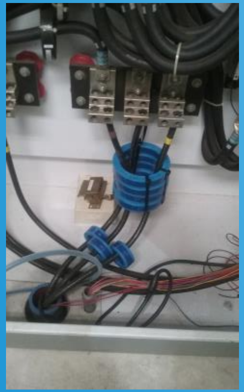
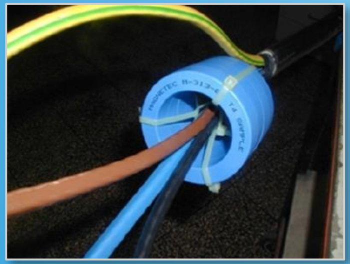
Correct Installation of Nanotech® Cores



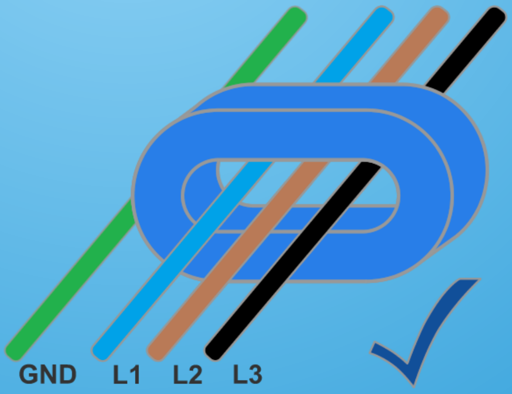


Shield and ground must be removed from power cables before inserting through cores.

For Clarification - Shield and ground bypass the cores providing an alternative path around cores, in effect, disabling the cores functionality.

Use of shielded cable, without removing ground and shield, will disable Nanotech® cores. Shield and ground must be peeled back far enough to allow cores around cables without disruption

Please call your local MH&W engineer with questions.



Correct Installation

Incorrect Installation.
GND and shielding should NOT go through cores.

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MNT Nanotech® CMC Common Mode Choke

MNT Nanotech® DMC Differential mode choke

Installation

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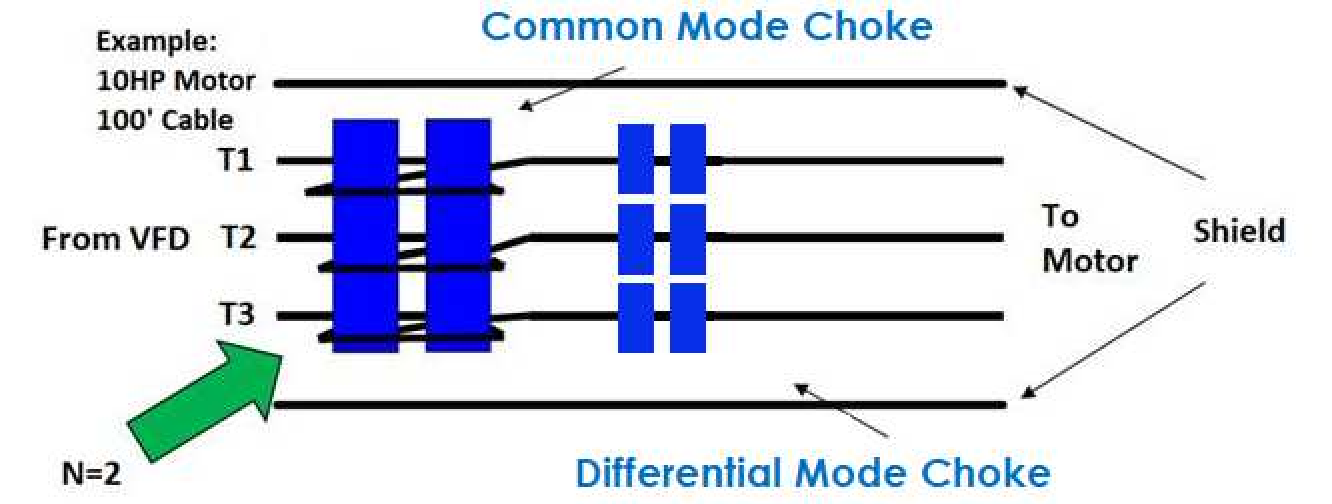
Inductive absorption is an electrical solution whereas inductive components are placed over the drive cables to absorb the transient and common mode currents. In some cases, the inductance of the choke needs to be increased by installing more **Nanotech® CMC** cores, or by adding multiple turns of power cable through cores.

In motors ¼-10 hp, there needs to be an increase in inductivity by following the application guidelines and incorporating two turns of the cable through the recommended cores (application example picture below).



Two turns of cable through the CMC cores for ¼ to 10 Horsepower motors (CMC cores only, not DMC as shown)

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Nanotech® DMC Differential Mode Choke Effects

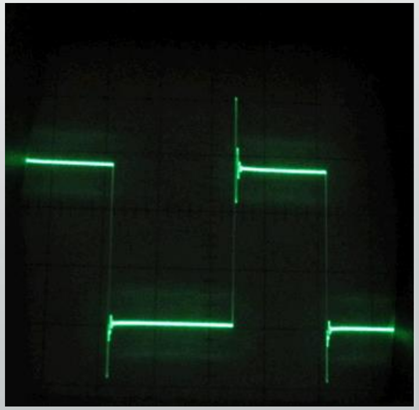
Differential mode inductive absorbers increase the reliability of the system by further reducing noise and peak values.

The use of a differential mode choke increases the reliability of these systems by further reducing the noise and peak values of current. These cores must be placed around each individual wire. Not around all phases like common mode chokes. Differential mode chokes are to be used in conjunction with common mode choke cores.

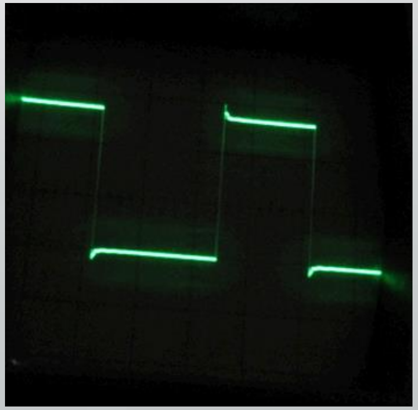
As you will see in the following pictures, the use of differential mode chokes reduces the di/dt of the high frequency charge and subsequent ringing.

Effects of Differential Mode Choke on di/dt

No chokes Installed



CMC and DMC installed



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Common mode cores per application

1. Determine the VFD size by horsepower.
2. Determine the cable length.
   NOTE: Cable length is determined by the run from drive to motor. If parallel (or multiple) cables are in the system, each phase length must be added together. Example: If three cables are run from drive to motor per phase, at 100 feet of run, then cable length is calculated times 3, or 300 feet.
3. Reference “VFD Application Guide” **Nanotech® CMC** cores per power range and cable length”
4. Round and oval cores are electrically identical.
5. Call your local MH&W engineer for medium voltage, DC, and servo type motor applications.

VFD Application Guide Nanotech® CMC cores per power range and cable

Nanotech® CMC Round				CBR123HP101-428A12	CBR166HP429-1631A16	
Nanotech® CMC Oval	CBO43HP1/4-50A4	CBO43HP1/4-50A4	CBO68HP51-100A6	CBO155HP101-428A12	CBO249HP429-1631A16	CBO326HP1632+A23
Power Range (hp)	1/4-10	11-50	51-100	101-428	429-1632	1632+
Cable Length	# Cores	# Cores	# Cores	# Cores	# Cores	# Cores
150ft/50m	2	4	4	4	4	4
300ft/100m	4	4	4	4	4	4
450ft/150m	6	6	6	6	6	6
900ft/300m	8	8	8	8	8	8

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Important Notes about Common Mode Choke Installation

- *It is important to use the correct number and type of cores per application guide.*
- *Motors up to* ***10HP*** require *two turns through cores (pass cables through cores twice).*
- *Data in the application guide is for information and guideline purposes. Please contact your local MH&W Engineer for detailed information.*
- *Round and oval shaped cores are for ease of installation and mechanical functionality. Round and oval cores have same electrical properties.*
- *CMC (Common mode choke) cores installed on the load side of the drive.*

  **CMC cores may be installed on the line side of VFD as well to reduce conductive and radiated emissions back to the grid. Please contact MH&W engineer for more information.*
- *Installing cores in a drive cabinet is preferred, but not required. If possible, CMC cores should be installed as close to the noise source as possible (VFD IGBT's).*
- *Do not place conductive wires through the cores for any reason in applications.*

  **If needed, MH&W offers brackets, and cable ties to hold CMC cores in place.*

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Nanotech® DMC Cores Per Application

1. Determine the VFD size by horsepower.
2. Determine the cable length.
3. Use one core (per application guide), per phase.
4. Reference "VFD Application Guide" Nanotech® DMC cores per power range and cable length".
5. Use in conjunction with appropriate CMC cores, per Nanotech® CMC application guide.
6. Call your local MH&W engineer for medium voltage, DC, and servo type motor applications.

VFD Application Guide Nanotech® DMC Cores per power range and cable length

DMC Part Number	N18HP1/4-10	N18HP11-40	N29HP41-102	N57HP103-428	N75HP429-1631	N123HP1632+
Power Range (hp)	1/4-10	11-40	41-102	103-428	429-1631	over 1631
Cable Length	# Cores	# Cores	# Cores	# Cores	# Cores	# Cores
150ft/50m	2	1	1	1	1	1
300ft/100m	3	2	2	2	2	2
450ft/150m	4	3	3	3	3	3
900ft/300m	5	4	4	4	4	4

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Important Notes About Nanotech® DMC Installation

- *It is important to use the correct number and type of cores.*
- **Nanotech® DMC** *(Differential mode choke) cores must go around each individual power phase. Not around all cables like common mode chokes.*
- *Data in the application guide is for information and guideline purposes. Please contact your local MH&W Engineer for detailed information.*
- **Nanotech® DMC** *cores must be installed on the load side of the drive only.*
- *Do not place conductive wires through the cores for any reason in application. This effectively bypasses the inductive properties of the cores.*

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**MH&W offers brackets/cable ties to hold cores in place if needed.*

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Nanotech® Packaging

Nanotech® cores are made up of a Nanocrystalline tape. The tape, after processing, is placed inside a premade plastic case.

The plastic case provides better performance than epoxy coating. Can be used in outdoor applications, wet conditions, and can withstand temperatures up to 140°C (more if needed. Please contact MH&W engineering).

Handling is much more robust and does not break if dropped.

Cost of case is lower than any other type of performance coating.

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Industry Application Example:

Paper Manufacturing

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Example: Industrial paper plant manufacturer with typical 150hp IGBT/motor system.

Problem - Customer experiencing random shutdowns (also known as “Ghost”) of system, and premature bearing failures on 150HP motor system. Bearing fluting was evident, and need of repair, every 8 weeks.

Successful Solution - 4 each **CoolBlue®** CMC cores were placed around cabling. Current reduction of over 75% was seen, which resulted in no bearing fluting/frosting/etc. failures. Equally important was no more random or “ghost” system shutdowns because of high frequency stray grounding currents.

Four Nanocrystalline cores were placed over the three leads at the output of the inverter. Significant reduction in the noise level of ground current are shown. Both power ground and signal ground share the same common ground. When noise levels on the ground current are high enough, the noise is injected into signal circuits inductively coupled to the common ground.

The ground loop current caused by the noise also generated a radio frequency noise that affected surrounding equipment, primarily on the signal lines. **CoolBlue®** cores absorbed this high frequency noise current, and no random shutdowns were experienced within the plant system.

Industrial paper and plastic manufacturers all over the world benefit from **Nanotech®**!

Industry Application Example:

Utilities

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October 2016, GCUA in lower New Jersey complained about the high bearing failure rate on one of four pumps in a pump house. The 125HP vertical pump was failing approximately every 60-90 days. GCUA had tried everything to prevent failures such as shaft grounding ring, insulating the carrier, and shielded cables. Nothing solved the issue. Performed proper testing with oscilloscope and Rogowski coil, then installed correct amount and type of **CoolBlue®** cores. Achieved a 72% reduction in high frequency currents…from 11A, down to 3.12A. Failure of motor bearing has ceased from time of installation. The GCUA continued installing more **CoolBlue®** cores in other pump houses.

GCUA has now put into a specification requiring all new pumps have **Nanotech®** installed.

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Industry Application Example:

Automotive Manufacturing

Problem – Automotive manufacturer experiencing random shut down of systems, multiple system errors (especially sensors), and other manufacturing failures with Ethernet controlled 600HP system. High frequency stray grounding currents evident in system ground because of poor building ground. Premature failure of bearings due to large common mode currents.

Solution - 4 each **Nanotech® CMC** cores were placed around cabling for common mode choke to reduce motor bearing wear. 2 each **Nanotech® DMC** differential mode cores were placed around each individual cable line to reduce frequency even more, and to substantially reduce stray grounding currents.

Success- Bearing currents lowered well below level of destructive force, and no more Ethernet based issues.

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Industry Application Example:

Ethanol Plant

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August 2017, Pinal Energy in Maricopa, AZ (ethanol) called MH&W engineers with problems of bearing failures on a 500HP RTO fan. Proper testing with oscilloscope and Rogowski coil found that there was 61.8A of damaging high frequency common mode current.

Proper **CoolBlue®** cores were installed and re-tested. Common mode current was reduced to 13A...a 79% reduction!

MH&W engineers continued testing throughout the plant. Entire Pinal Energy plant is now covered with the **Nanotech®** solution.

Industry Application Example:

Water Treatment

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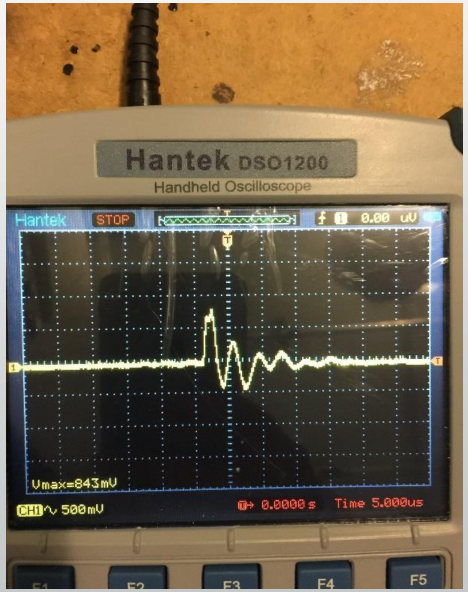
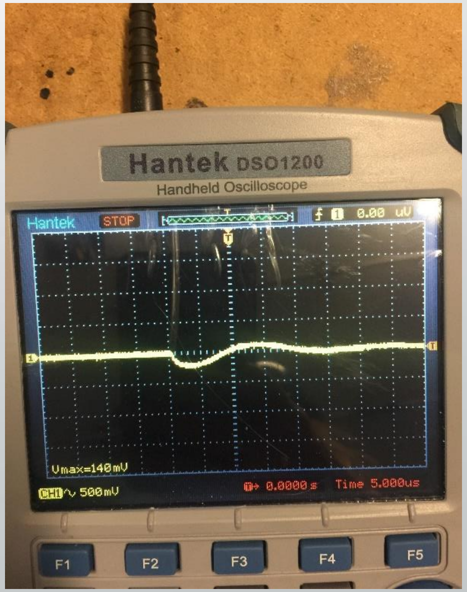
Water treatment plant in Connecticut was suffering from bearing failures due to high frequency common mode current and subsequent fluting. MH&W engineers installed **Nanotech®** on a 200HP pump at the WWTP. Proper testing found found 23.6A of high frequency common mode current. Reduction of 65.5% in common mode current was achieved by bringing the current from 23.6A, down to 8.12 amps.

Customer continues to install **Nanotech®** throughout the plant.





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Industry Application Example:

Office HVAC

Problem – Multiple office building air handling system failures (30HP) within 2 years of installation. Bearing lubrication degradation and fluting evident when removed and inspected.

Successful Solution – Reduced common mode current over 83% by placing 3 each **CoolBlue**® CMC common mode chokes around power cables. 1 each **CoolBlue**® DMC chokes were placed around each individual cable line.

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Industry Application Example:

Hospital HVAC

Problem: ***Mission Critical!***

Major hospital system in New England. Air handling and pump systems experiencing bearing failures in short period of time. Customer had previously installed shaft grounding rings, but still experiencing failures. Unable to install on large vertical mount motors. Operating rooms were critical to keep at constant temperatures.

Successful Solution – Installed 4 each **CoolBlue®** cores around cabling for common mode noise. Bearing currents lowered over 75%.

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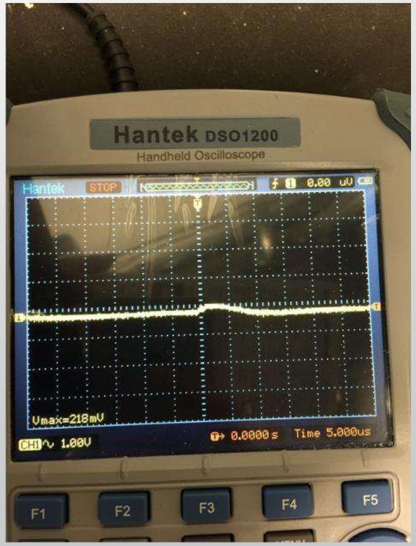
Industry Application Example:

Dairy Farms

St. Albans Cooperative Creamery called with consistent bearing failure issues on a 300HP dryer main exhaust fan. MH&W engineers traveled to the location to test and install **Nanotech®** Without a choke installed, 45A of high frequency common mode current was measured. Engineers installed proper amount and type of **Nanotech®** cores and was able to get an 83% reduction in high frequency current. Reduction from 45A down to 7.5A.



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Industry Application Example:

Food Manufacturing

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Problem – Large manufacturer of candy experiencing random shut down of system, faulty reading on metal detectors, sensors, and random manufacturing failures/shutdowns.

Common mode currents were measured at nearly 12 amps on a 30HP VFD system. Bearing were failing within 6 months, and metal detectors were being slowed down, because of false or completely erroneous readings.

Solution - 4 each **CoolBlue®** CMC cores were placed around cabling for common mode choke to reduce motor bearing wear. 1 each **NaLA®** DMC cores were placed around each individual cable line to reduce frequency even more, and to substantially reduce stray grounding currents.

Success- Bearing currents lowered well below level of destructive force. More importantly no more metal detector-based issues. Company increased revenue significantly due to increased speed of metal detector without false readings.

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Industry Application Example:

Wind Power Generation

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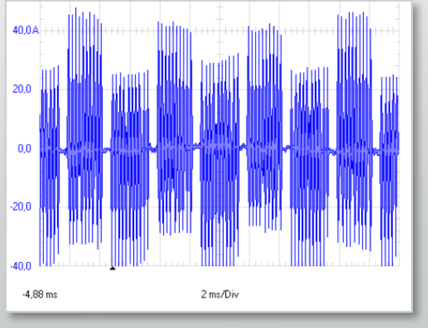
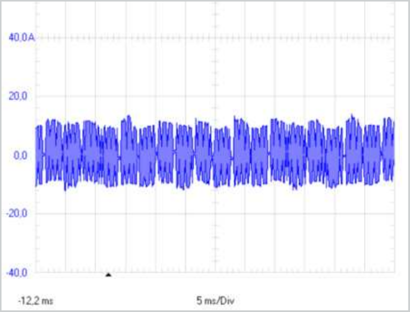
Problem – Up to 6MW wind turbine generators experiencing early bearing failures and ground faults due to high common mode currents. Very high costs associated with bearing replacements, slow down in power generation, and downtime revenue.

Successful Solution – Installed multiple **CoolBlue®** cores around cabling for common mode noise. Bearing currents lowered over 75%. No failure reported in over 15 years, and no ground faults!

Nanotech® cores are currently being used in wind applications up to 6MW. Both AC and DC Link systems!



Without Nanotech®
I_{CM} = up to 40A



With Nanotech®
I_{CM} ~ 10A

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Testimonial's

BRADY

August 28, 2015

Mr. Ulrich Gernhardt
President
MH&W International Corp.
575 Corporate Drive
Mahwah, NJ 08854-2330

Dear Mr. Gernhardt:

I am writing today to tell you about my experience with the CoolBLUE common mode chokes that we have been purchasing from your company.

I was first introduced to this product in February, 2006 when I was asked to participate in a beta test of common mode chokes applied to large water chillers that were equipped with variable frequency drives. The goal was to provide positive protection against induced shaft currents that can damage steel ball bearings.

We removed the original ceramic bearings from both machines and installed standard steel ball bearings. At the same time, we fitted the machines with CoolBLUE chokes and then monitored the operation on a regular basis using vibration analysis equipment. After three years we opened one machine and removed the bearings. There was no visible sign of spark discharge and subsequent metallurgical analysis showed the bearings to be as good as new. The second machine still has the steel bearings that were installed in 2006 and it continues to operate flawlessly. The results of this test, and other tests around the country, have resulted in the elimination of very expensive ceramic bearings and complete conversion to steel bearings.

The chiller tests went so well that CoolBLUE chokes are now added to the bill of material whenever we install a system that uses a VFD. We have retrofitted numerous fans and pumps that had experienced multiple bearing failures as a result of excessive shaft current and spark discharge and in all cases the problem went away.

I would like to take this opportunity to express my gratitude to Bill Wilson and Darleen Boyaci for the terrific support they have provided. They have been a great help to all of us here at Brady.

Sincere Thanks,

Dick Wells

Dick Wells
Technical Service Manager

Your Comfort. Our Promise.

Corporate Office: 1915 North Church Street • Greensboro, NC 27405 • (800) 849-1915
PO Box 13587 • Greensboro, NC 27415 • www.bradyservices.com

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Testimonial's

Boston Children's Hospital
Until every child is well

HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

Engineering Department
300 Longwood Avenue, Mailstop, Boston, MA 02115
617-355-6000 | bostonchildrens.org

Mr. Bill Wilson
National Sales and Engineering MH&W International Corp.
575 Corporate Drive
Mahwah, NJ 08854-2330

Dear Mr. Wilson,

I wanted to share our experience with the Cool BLUE inductive cores that we have been purchasing from the local representative Bob MacKay at AVA HVAC Products LLC in Rockland, Ma.

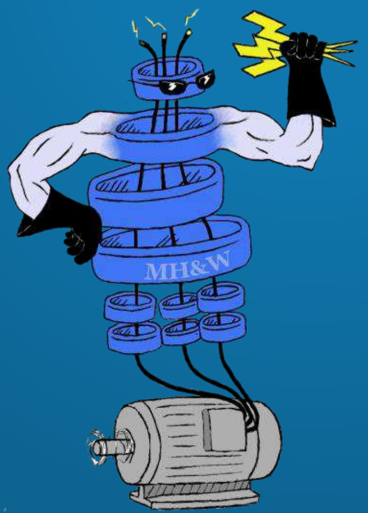
Bob had showed us the product after we had been experiencing fluting in our motor bearings serving the hospitals HVAC air handing equipment. It must first be noted, that these motors had already been equipped with the AEGIS shaft grounding devices both field installed and some already factory installed by the motor manufacturer Baldor. Based on our analysis the SGR's had lost contact due to grease, dirt or rust.

It has been 4 years now and our Cool Blue cores are working great! What I liked best about the Cool Blue alternative is that they are not affected by these elements and never wear out!

We have not experienced one loss due to fluting since switching to the Cool Blue inductive cores. Motor bearing protection is very important since they are installed in some of our most critical pieces of equipment here at the hospital. Cool Blue cores are now our standard for motor bearing protection here at Boston Childrens.

Sincerely
Stephen Fostello
Senior Mechanical Supervisor HVAC systems
Facilities automation and controls
Boston Childrens Hospital
300 Longwood Ave.
Boston Ma, 02115

MH&W MNT Nanotech® Challenge



"MH&W, Keeps Your Motor Running!"

Nanotech®

MH&W Presents

MNT Nanotech® Challenge

MH&W MNT Nanotech® is *the ultimate protection for your VFD-motor system.*
To back this up MH&W proudly introduces the Nanotech® Challenge!

The MNT Nanotech® challenge is the perfect way to put an end to the effects of VFD induced high frequency currents on your system. When Nanotech® common mode chokes are installed, you will immediately see a reduction of those damaging currents, thus preserving system life.

We are so certain that the MH&W Nanocrystalline technology solution is the cure to your system's radiated and conducted emission problems, that in the event it does not remedy your system, we will purchase the cores back.

No questions asked!

Try the best solution on the market with the Nanotech® Challenge. You have nothing to lose; only motor system longevity to gain!

*DISCLAIMER - To qualify for the Challenge, an MH&W Engineer or Certified Regional Partner must test and install proper cores on system, and submit completed "Nanotech® Field Testing" report to MH&W.

Contact MH&W
201-252-8125
www.mhw-intl.com
sales@MHW-Intl.com

MH&W and Nanotech® Engineering and Sales Contacts

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CONTACT MH&W

201-252-8125

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Closing Comments

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- MH&W continues to have tremendous success in thousands of VFD motor installations worldwide.
- MH&W products are a solution…not a temporary, short term “Band-Aid” to an age-old problem.
- MH&W products are now being used, and promoted, by major OEM VFD manufacturers, OEM’s, HVAC/chiller equipment, wind turbines, and end users to keep their equipment functioning properly, and avoid downtime.
- Special **Nanotech®** cores are now being used in place of shielded cabling.
- Call **MH&W Engineering** or your local MH&W **Nanotech®** representative today and have your VFD motor problems resolved permanently!

MH&W International Corp. • 575 Corporate Drive, Mahwah, NJ 07430 • (201) 252-8125