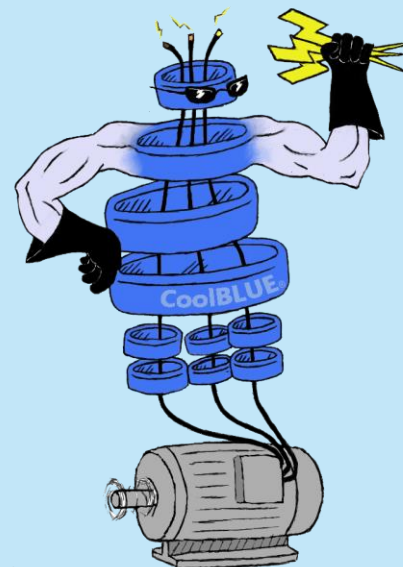


"CoolBLUE, Keeps Your Motor Running!"

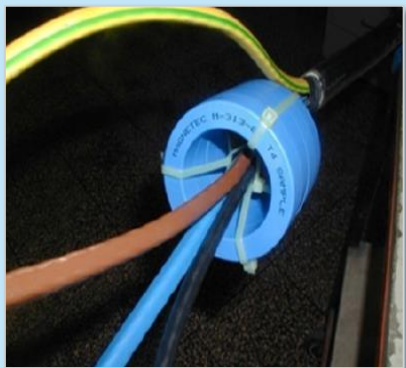
COOLTUBE®



Radiated Emissions Absorber



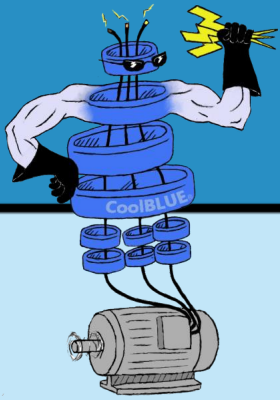
"CoolBLUE, Keeps Your Motor Running!"



Radiated Emissions Solution from MH&W International Corp.



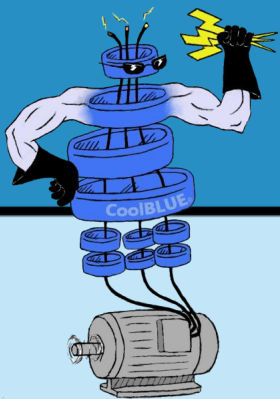
Radiated Emissions In VFD Motor Systems



"CoolBLUE, Keeps Your Motor Running!"



1. Defining the problem
2. Solutions



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What is EMI?

What Are Emissions?



EMI – Electromagnetic Interference

All electrical devices create emissions/radiations that will interfere with the external environment. These emissions have the potential to interfere with the electrical grid and other local electrical devices.

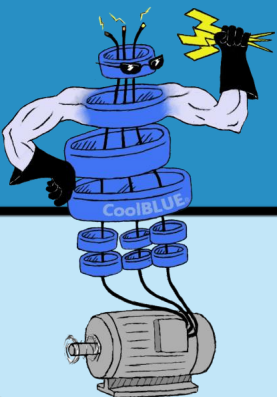
There are two main types of electrical emissions: Conducted emissions and radiated emissions.

Conducted Emissions

Conducted emissions are an electromagnetic energy created by a device and transmitted in the form of an electrical current through its power cord. This can potentially cause problems since power cords are connected to the entire power distribution network.

Radiated Emissions

Radiated emissions are electromagnetic energy created by a device and released as electromagnetic fields that propagate through the air away from the device. Electric devices that create radiated emissions have the potential to interfere with other nearby electrical products.

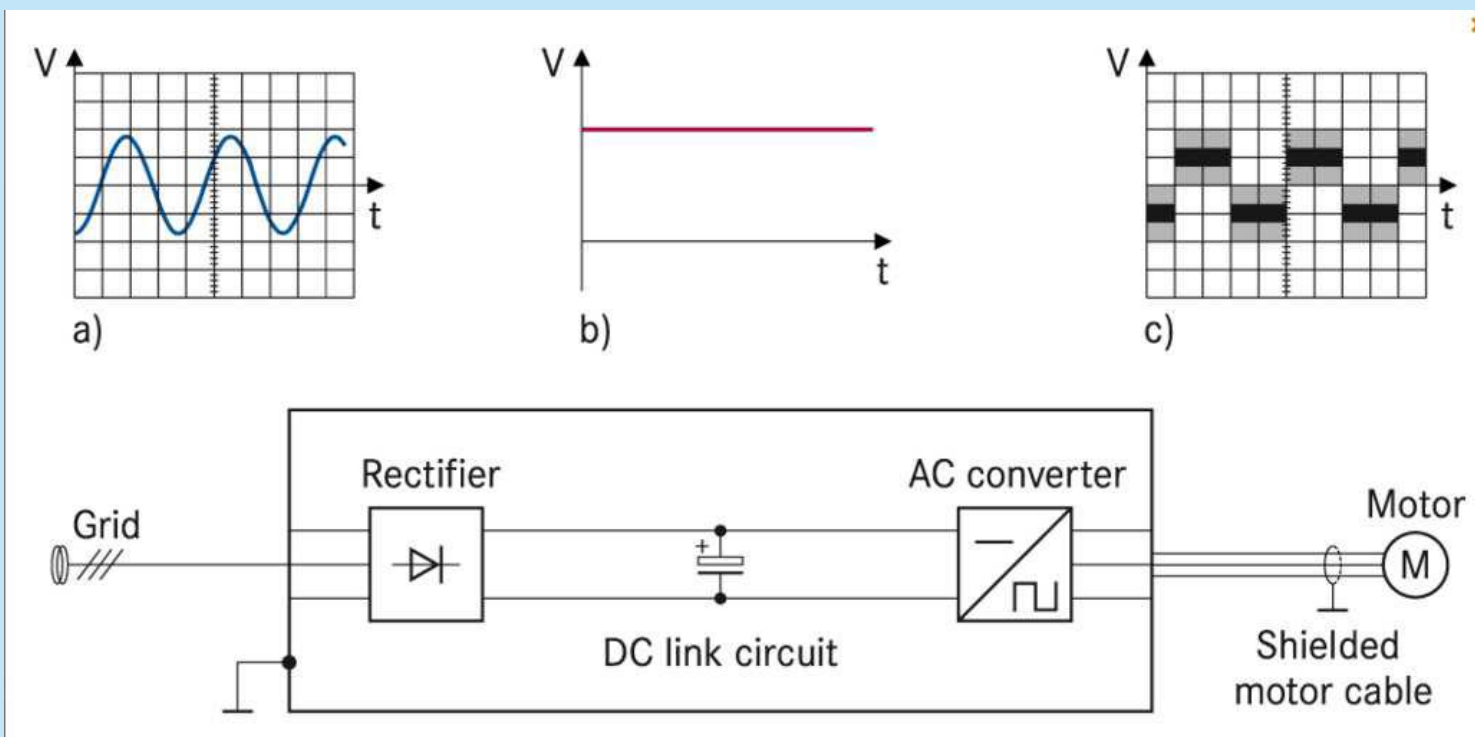


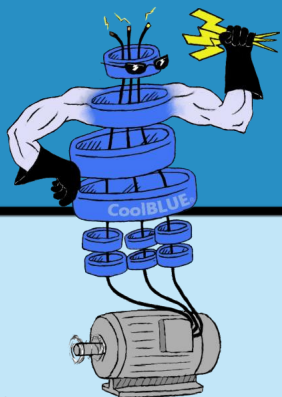
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Variable Frequency Motor Drive Systems



Typical power grid to motor application. Sine wave coming in to VFD, converted to DC, then the PWM pulse sent to motor.



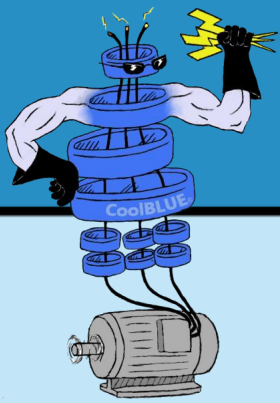


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Radiated Emissions in a VFD System



- The high speed switching of the IGBT's are the cause of radiated emissions.
- The dv/dt (very fast rise over time) is significant.
- Switching frequency is how often a peak repeats itself in a circuit.
- Harmonics of the dv/dt are megahertz to gigahertz.



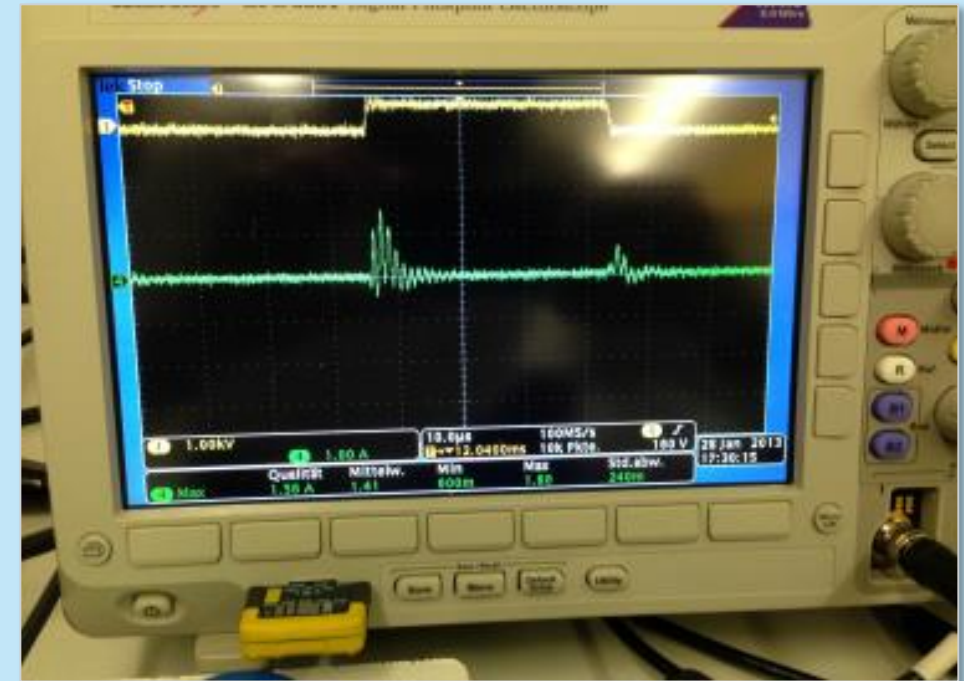
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Radiated Emissions in a VFD Motor System



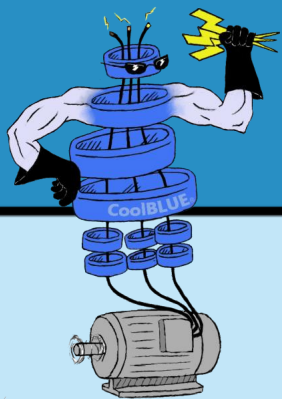
Typical example of the high frequency noise generated by the IGBT devices in a motor system.

The yellow line at top of oscilloscope screen indicates the switching of the IGBT in the drive. The green line indicates the high frequency noise generated.



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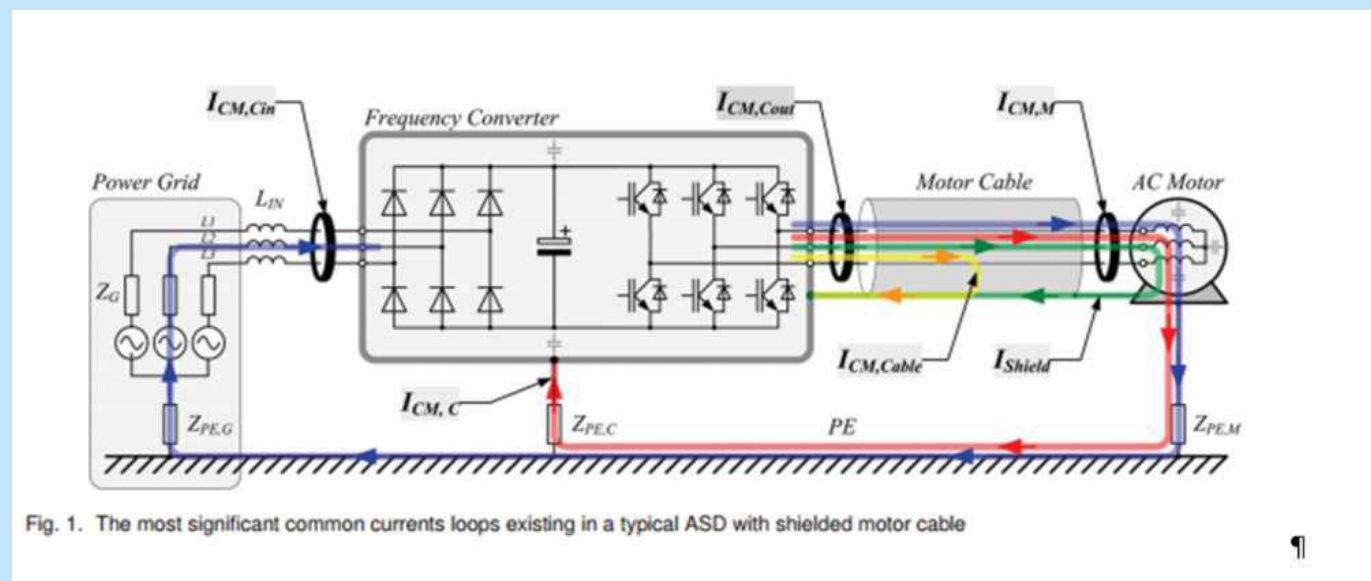
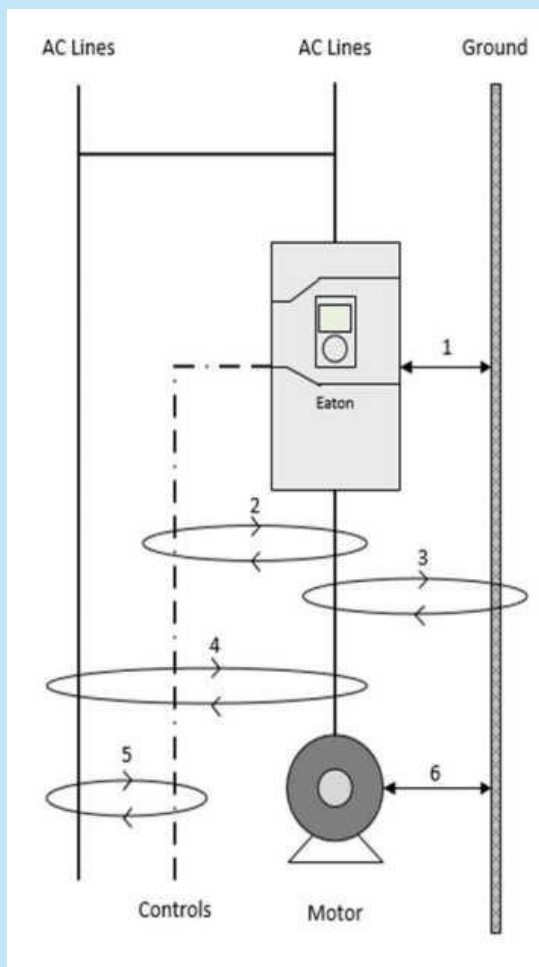
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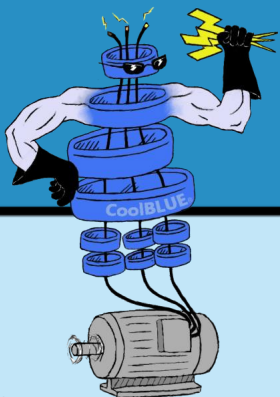


Grid with Impedances and Interaction of Noise



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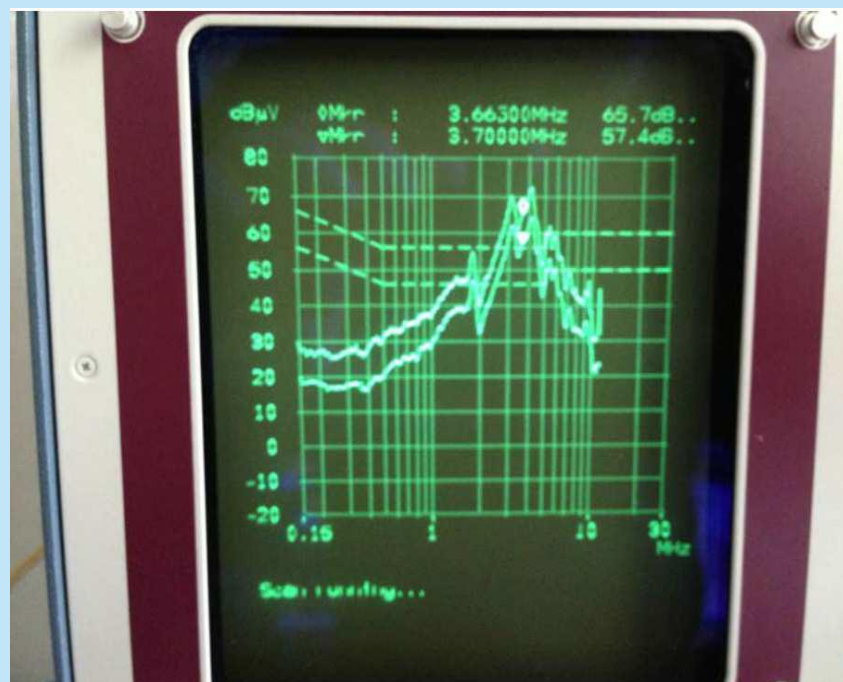


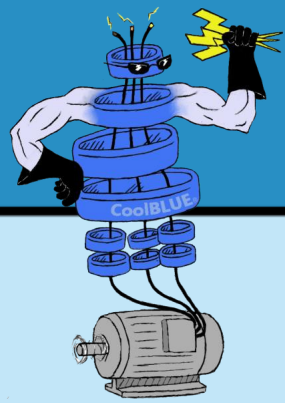
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Grid with Impedances and Interaction of Noise



In reality, this is what is going to the motor and ground in the field.



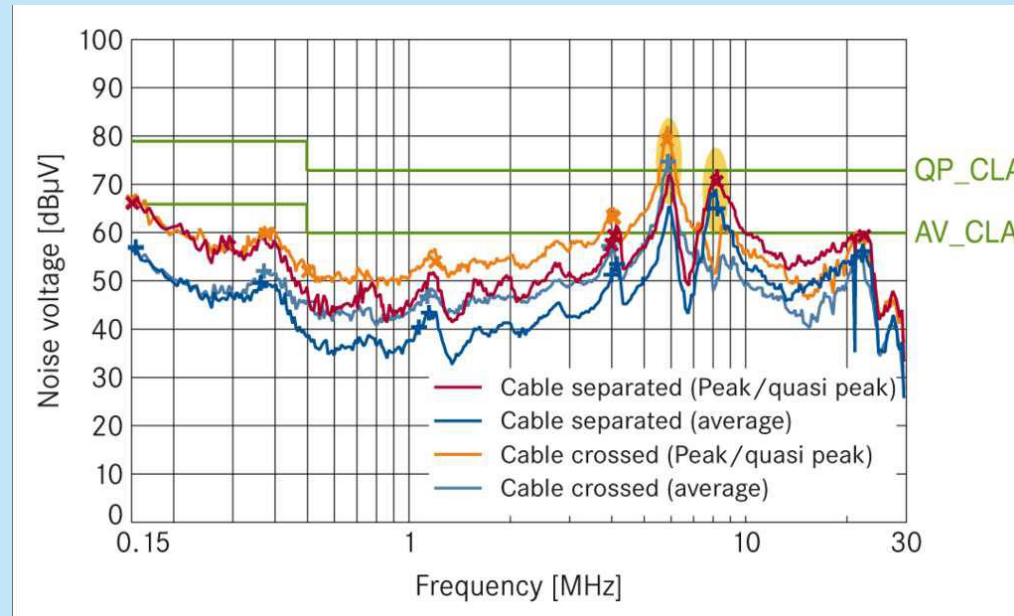


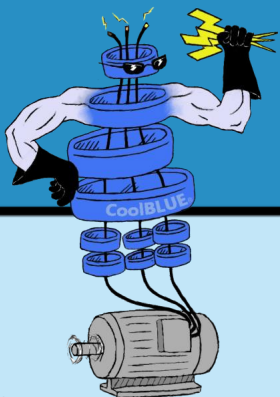
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Shielded Cable for Common Mode Noise



One option to reduce EMI is to use expensive shielded cable. Shielding is very important in frequency ranges between 5-30MHz (radiated).





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Why Use Shielded Cable?

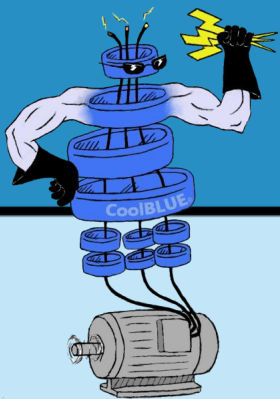


Two main issues in a VFD system are common mode currents (CMC) and electromagnetic interference. Both are generated as an unwanted by-product of the drive's high frequency pulse width modulated, or PWM, waveforms.

A properly installed and terminated shielded cable system in a VFD/Motor application will:

1. Provide a controlled path for the drive's CMC (limiting the current traveling through to the ground grid).
2. Provide a continuous shield over the entire cable from the inverter to the motor (minimizing the amount of EMI radiation that radiates from the cable which can cause interference with other systems).

Variable Frequency Drive (VFD) shielded cable can help minimize system issues. However, unless shielded cables are properly installed and terminated, much of the benefit derived from using VFD cable may not be realized.



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Why Use Shielded Cable?

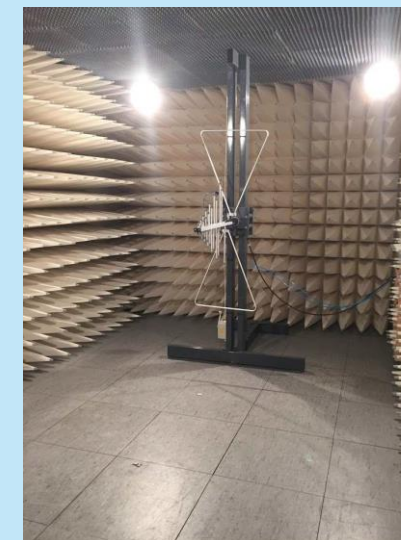


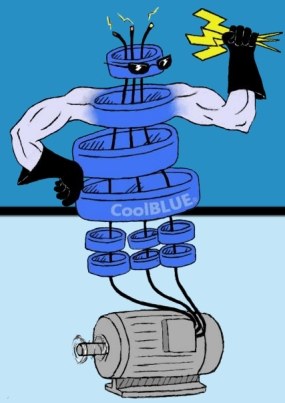
While EMC (Electromagnetic Compatibility) standards (along with practical lab testing) provide limits on allowed emission levels of equipment, once the equipment is installed along with other tools, the EMI levels in actual operating environments can be substantially different and therefore impact the equipment operation, performance, and reliability.

For example:

1. Occasional transients induce "extra" pulses in rotary feedback of the servo motor which contributes to robotic arm's erroneous position eventually damaging the wafer.
2. Combination of high-frequency noise from servo motors and switched mode power supplies in the tool creates difference in voltage between the bonding wire/funnel and the device which causes high current and eventual electrical overstress to the devices.
3. Wafer probe test provides inconsistent results due to high level of EMI on the wafer chuck caused by a combination of several servo motors in the wafer handler.

This illustrates the gap between EMC test requirements and real-life EMI tolerance levels and its impact on semiconductor manufacturing and handling.





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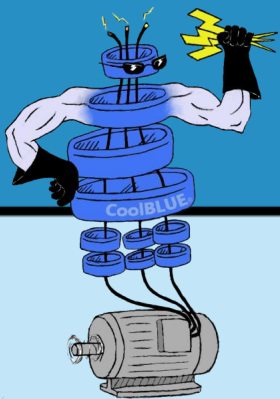
Why is Correct Termination of shielded cable so Important?



Perhaps the most critical component of a VFD cable is the cable shield which can consist of armor, copper tape, or a copper braid and aluminum foil combination. A good termination guide will provide certain recommendations with respect to terminating copper tape and copper braid/aluminum foil shielded cables. Most VFD manufacturers document proper installation and type of cable. The instructions include detailed guidelines for proper removal of the non-metallic jacket and sheath from the cable.

However...there is an alternative.

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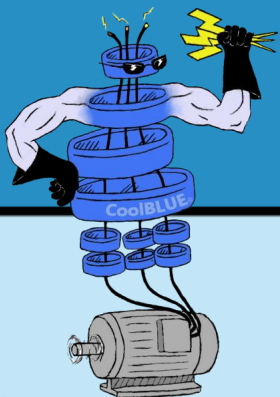
Cool/TUBE®



Why go to all that extra effort and cost of shielded cable when you can eliminate the noise at the source using **CoolTUBE®**!

And, even better...shielded cable does not absorb noise. **CoolTUBE®** actually absorbs the noise at the source.



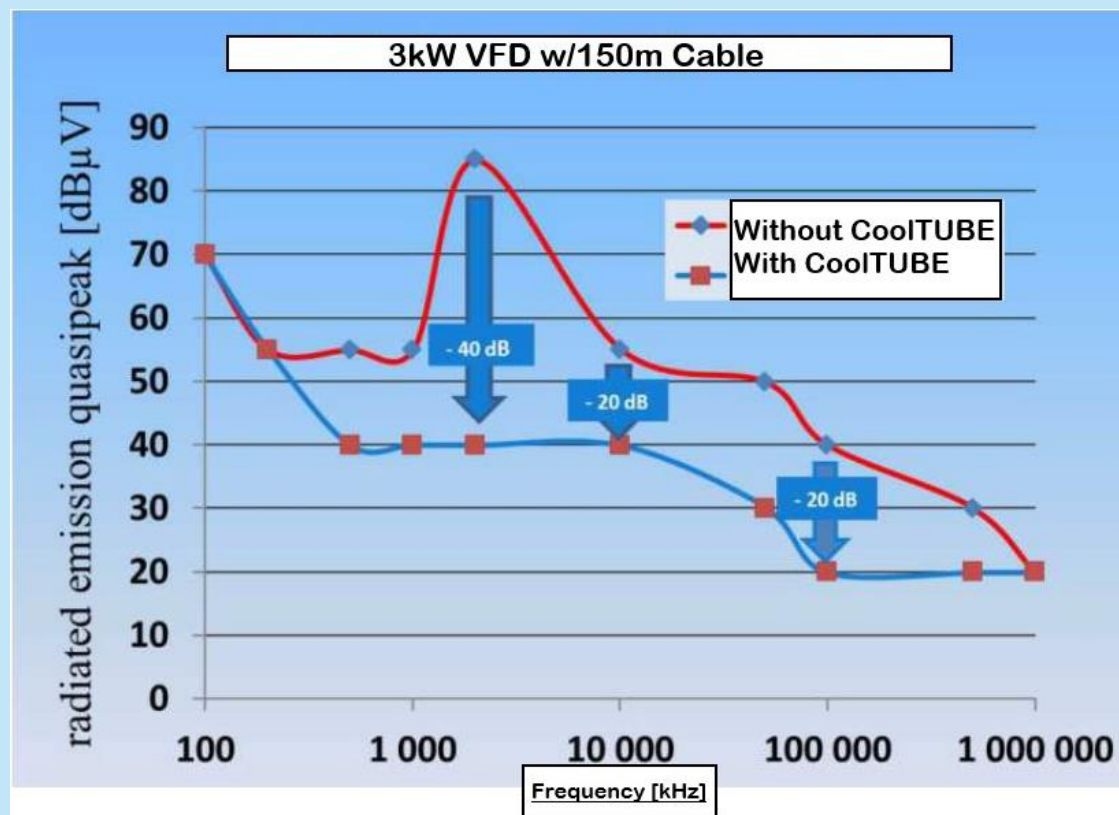


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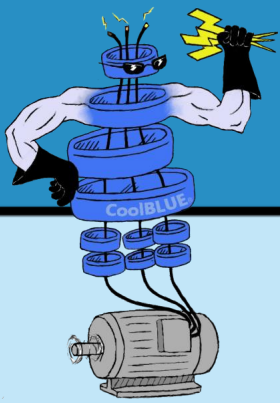
CoolTUBE®



3kW 50-150 meter motor cable



Frequency range 100 Kilohertz up to 1 Gigahertz



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CoolTUBE®



The following example of portable electronics will help better understand the function of CoolTUBE®.

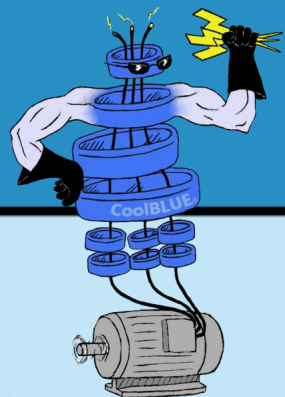
On every power cord, especially laptop computers, LCD monitors, etc. (may be built in or external), there is what is called a ferrite bead. Little barrel looking part (see picture on left). The ferrite bead (also called a ferrite choke) is used to make sure the wire doesn't unintentionally transform into a radio. Any long wire is effectively an antenna. That means it has the potential to transmit and receive radio waves. This can be bad for two reasons:

1.Unintentional transmitter. The device or power source that is connected to the wire may cause variations in the electrical flow of the wire. These variations could cause the wire to transmit radio waves and these waves could in turn interfere with nearby devices.

2.Unintentional receiver. Conversely, nearby devices could produce radio signals (intentional or otherwise) that get picked up by the wire. These signals could vary the electrical current in the wire which could in turn interfere with the connected devices.

The filter (choke) effectively eliminates the high-frequency noise on the wire and thus prevents it from transmitting/receiving radio waves. Technically speaking the radio waves are attenuated - they are reduced to such a low power as not to be noticeable or destructive.





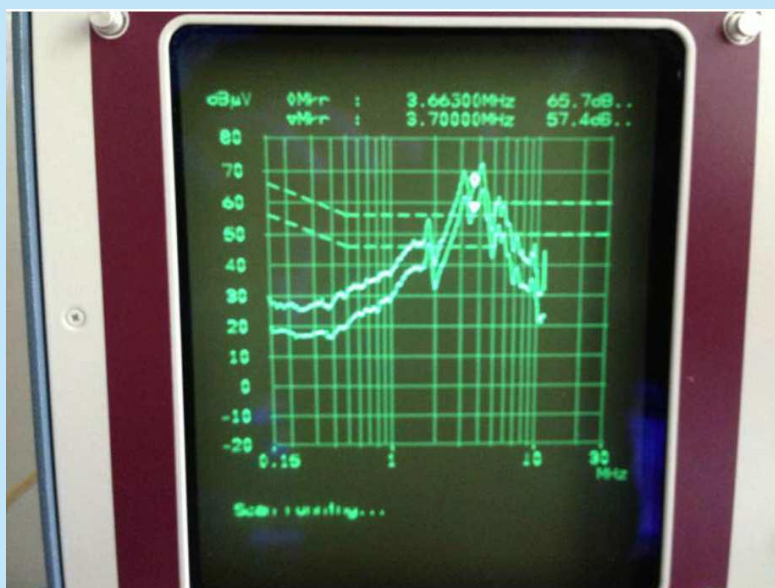
"CoolBLUE, Keeps Your Motor Running!"

Power supply side measurement at a VFD without shielded cable, and with CoolTUBE®



Goes well beyond Specified Standard limitations without absorber.

Well below Specified Standard Limitations with the use of M-1230 CoolTUBE®.

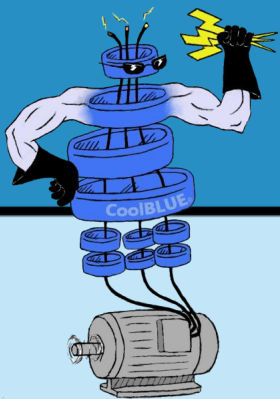


Note: Above data specified by the following:

EN55011 Class A (group 1) ratings 150KHz – 30MHz

EN61800-3 Cat 2, IEC (European) Standard Adjustable Speed Electrical Power Drive Systems (-3 is the German version)

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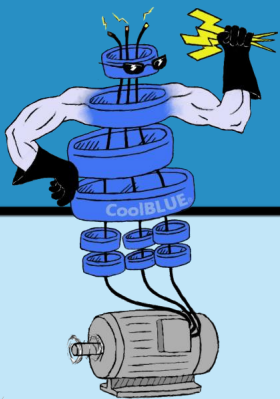
"CoolBLUE, Keeps Your Motor Running!"

What is *Cool*TUBE®



- Special stack of Nanocrystalline cores
- Annealed for high frequencies in the range up to 1 Gigahertz
- Easy to mount
- Function is the combination of an Inductor and an Absorber
- Changing dangerous emissions to safe thermal energy



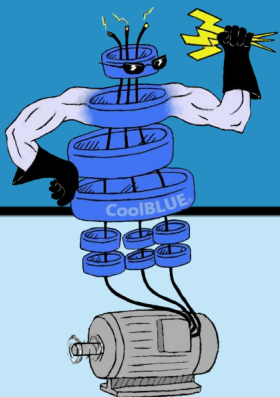


"CoolBLUE, Keeps Your Motor Running!"

Benefits of Using **Cool/TUBE®**



- Unshielded cables can be used to reduce cost of system, installation, and most importantly, operating life of the system.
- Exceeds EMC performance compared with shielded cable.
- Reduces both conducted and radiated emissions with the use of **CoolBLUE®** and **CoolTUBE®**.
- Motor operating life will be significantly increased as a result of using **CoolBLUE®** and **CoolTUBE®**.
- No maintenance...ever!
- Easy retrofit in the field.
- Old non-VFD systems that were not able to use shielded cables in the past because of limited space or availability, can now benefit from the use of VFD's.
- Five **CoolTUBE®** products cover all motor sizes, from ¼HP - 1632+HP (DC and servo included).



"CoolBLUE, Keeps Your Motor Running!"

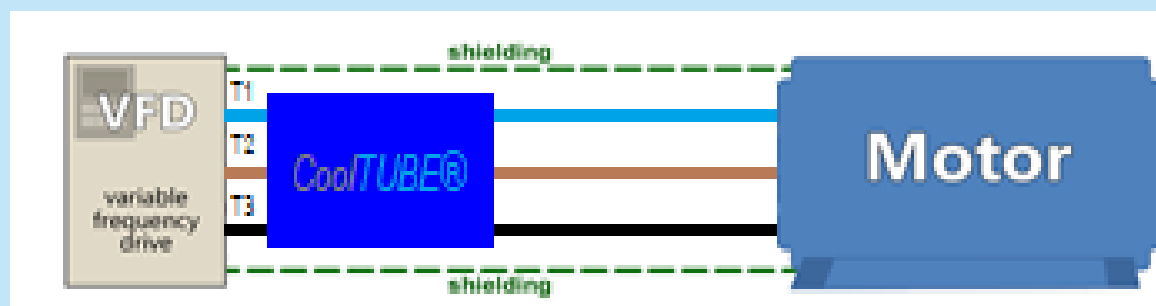
How to install CoolTUBE®

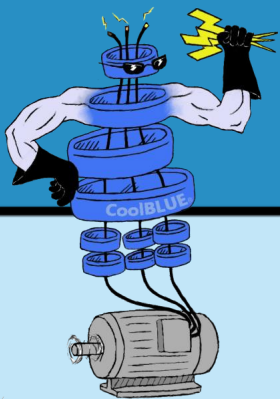


Using application guide below, choose by horsepower and cable length.

CoolTUBE® - All power cables must go through **CoolTUBE®** cores as shown below.
No grounding wire or shielding.

CoolTUBE®	Power Range			Number of CoolTUBE® per cable length (ft)			
Part #	HP	Finished Dimensions (in)	Isat	1-150	151-300	301-450	451-900*
M-1207	1/4-10	$\leq 1.42 \times \geq 0.7 \times \leq 5.31$	8	1	2	3	4
M-1230	11-40	$\leq 2.58 \times \geq 1.38 \times \leq 9.45$	14	1	2	3	4
M-1275	41-100	$\leq 3.54 \times \geq 2.13 \times \leq 14.17$	18	1	2	3	4
M-1231	101-428	See Datasheet	40	1	2	3	4
M-1212	429-1600	See Datasheet	50	1	2	3	4





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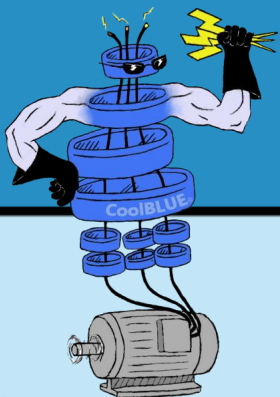
CoolTUBE®



- Specially designed Nanocrystalline Core set for replacing shielded motor cables.
- Simply put the **CoolTUBE®** over the UVW cables. No neutral, no ground. **CoolTUBE®** absorbs the high frequency noise.
- Unshielded motor cables can be used together with all variable frequency drives.
- Each **CoolTUBE®** can handle up to 50m motor cable. Example: If you have 150m motor cable you have to place 3 CoolTube over the cable in series.
- No limitation on the length of cable.
- **CoolTUBE®** can handle all VFD motors HP/kW.

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"CoolBLUE, Keeps Your Motor Running!"

Closing Comments



- **CoolTUBE®** continues it's successes in world wide installations.
- **CoolTUBE®** is a solution to costly shielded cable.
- **CoolTUBE®** is now being used and promoted by major OEM drive manufacturers, OEM's, HVAC/chiller equipment, wind turbines, and end users to keep their equipment functioning properly, and avoid downtime.
- Call MH&W for more info on **CoolTUBE®** today.

Have your VFD problems resolved permanently!