Quantum Automation TECH CORNER with Adam Bermudez

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How to Reduce Electromagnetic Interference in Motor Drive Systems

In real life what do you do when…

Your home is located in a flood-vulnerable area? Or when you purchase a car? Or when you make any other investment that you want to preserve and protect? Well that's where obtaining appropriate insurance comes into play. This same logic goes for industrial process systems that play a critical role in an organization's goal-reaching activities. One aspect of a process system is that of the motor. In today's industrial environments the implementation of motors abounds. From municipalities using motors to control their pumping systems to a batch-process production at a manufacturing factory, motors are fulfilling their respective mission-critical duties. As you most likely are aware, however, motors must be protected against electromagnetic interference. This month's Tech Corner will focus on what electromagnetic interference (EMI) is, its potential effects on a motor system, and what can be done to alleviate negative effects so that your production equipment can have maximum uptime.

What is EMI?

In short EMI is the following: when an electrical conductor carries electrical current, by nature, it is known to emit an external magnetic force from its surface. This magnetic force does not mix well, so to speak, when exposed to other forces of the same type. As a matter of fact it *interferes* with neighboring electrical conductors (regardless of the type i.e. 4-20mA/0-10V). This magnetic force's interaction with other magnetic forces translates into the degradation, obstruction, or interruption of these other signals. But is electrical interference likely to only originate from your industrial electrical devices? Perhaps one day but for the meantime we must also protect the electrical system of our industrial equipment from voltage transients stemming from *capacitor bank switching* done at utility sites. But what exactly is "Utility Capacitor Bank Switching"?

Utility Capacitor Bank Switching

Think about the last time you drove by an electrical substation. We know that substations serve for power distribution and stepping up and/or down voltage to cater to different consumer's needs. Inside the substation among what may seem like a miniature jungle of tall electrical contraptions (known as "switchgear") are large capacitors connected in series, known as "capacitor banks". See below for what a capacitor bank looks like from up close and afar, respectively:

You'll note that these capacitors above are connected in series. A phase and neutral line is connected to each capacitor so that it can fulfill its role of correcting the power factor of the system. Although a capacitor bank plays a crucial role in a substation there are some drawbacks associated with their use.

For instance, high-frequency and magnitude inrush current as well as transient overvoltage often occur as the capacitors are engaged. A similar negative effect is produced when a capacitor bank is de-energized. Said high inrush current levels and transient voltages unfortunately are transferred to the power lines exiting the substation. As you can imagine, that means those undesirable side effects make their way to the electrical grid fed to consumers.

Yes, by simply supplying power to your industrial equipment it is being exposed to potential harm. Herein lies the criticalness of wisely investing in electrically protective components for your motor system. But what protective measures can be taken? The following short paragraphs will consider what can be done so that your motor system can be protected and provide years of service.

Why EMI and Harmonics Should Be Reduced

In several motor applications today a variable-frequency drive (VFD), or adjustable frequency drive, AC drive or inverter drive is commonly utilized. We know that a VFD serves to regulate an alternating current motor's speed and torque by manipulating the input frequency and voltage being supplied to the motor. This regulation of voltage translates into a more efficient operation of the motor and consequently savings in energy usage. Furthermore, a reduction in inrush current, correction of poor motor power factor, and less mechanical stress when starting are additional benefits a VFD provides.

Much like utility capacitor bank switching, however, a VFD's usage is also accompanied by undesirable side-effects. These side-effects are known as *harmonic voltages and currents*. Harmonic voltages and currents are a repeated power distortion phenomenon occurring in 60

Hz cycle systems. These distortions come about when a *non-linear load* is connected. A non-linear load can be thought of as a load that causes the line voltage being supplied to it to vary disproportionately. In other words, the electrical load does not draw voltage evenly from the power source. A VFD is a perfect example of a non-linear load. When put into context with its purpose we can attest to this fact given that a VFD, in essence, is controlling the supply of incoming voltage. Therefore it does not necessarily pull voltage in a *linear*, or consistent, fashion.

What real-life consequence can be expected from these side-effects? Harmonics in a system can translate into a surplus of current in your motor system. Extra current in a system generates unneeded heat; excess heat can damage a system. With these harmful factors in mind let us now consider what remedies are readily available.

Perhaps you are familiar with the VFD accessory known as the *line reactor*. Line reactors, in short, act as an effective filter against electrical irregularities coming into the VFD system from the main power and VFD load side. An input line reactor protects against any overvoltage transients that may be coming into your VFD and is recommended for any application regardless of size. Output line reactors, or "load" line reactors safeguard against short circuits coming from the AC drive and Insulated Gate Bipolar Transistor (IGBT) reflective wave damage.

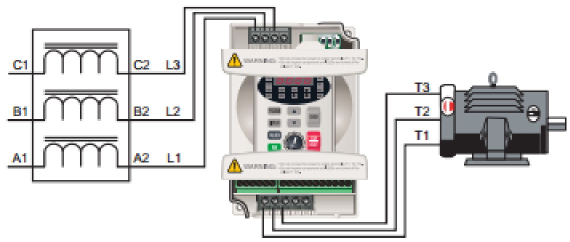
IGBT devices are now the standard in AC drive technology. Earlier versions of drives used power bipolar transistors (PBT). PBTs were manipulated by current. Just as today's drives have small hiccups in operation so did PBTs. From a small lag time during switching speeds to high voltage drops and loud motor noise it's safe to say PBT technology could be perfected. Even though in the present time IGBT devices offer much better performance than their earlier counterparts they can be troublesome at times in different applications.

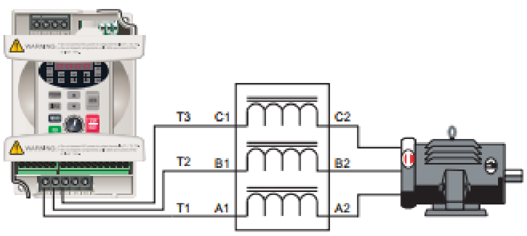
Since IGBT devices switch voltage faster this can result in greater common-mode, conducted, and radiated electrical noise. At the same time when VFD cable surge impedance does not match the surge impedance of the motor's windings a reflective voltage occurs. This reflected voltage wave translates into overvoltage transients that can cause motor damage. That's why installation of a line reactor, both on the power supply side and VFD load side, is a wise investment. Quantum Automation's VFD and line reactor solutions come in a vast variety that can surely fit your motor application.

Here are two diagrams of how a line reactor is installed on the input side of a VFD and the output side, respectively:

Input side of the drive

When installed on the input side of the AC drive, line reactors will reduce line notching, and limit current and voltage spikes and surges from the incoming line. The line reactor will also reduce harmonic distortion from the drive onto the line. Units are installed in front of the AC drive as shown.





Output side of the drive

When installed on the output side of the drive, line reactors protect the drive from short circuits at the load. Voltage and current waveforms from the drive are enhanced, reducing motor overheating and noise emissions.

Note: ***Single phase line reactors should NOT be installed on the output of the AC drive. Use only three-phase reactors on drive outputs, and only for three-phase motors.***

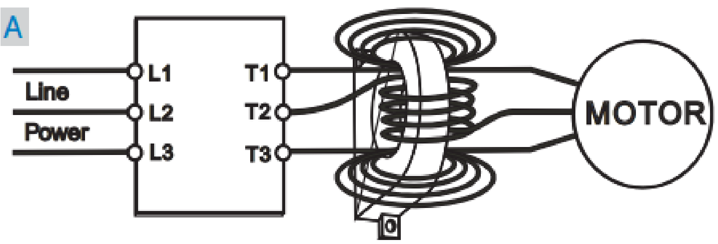
We can observe above the line reactor's placement relative to the motor. Imagine for a moment a transient voltage making its way to your controller or motor. Transients at times can be high voltage spikes. Field devices' electronics are designed to withstand a certain amount of fluctuations in power, but as you can imagine this insulation is not designed in a worst-case scenario fashion; the protection is minimal, if present at all. Costly damage may indiscriminately occur to a system given the right circumstances. Furthermore, any power variations in a motor or VFD system may trip a circuit breaker, thereby yielding a halt in production and/or processes.

Let's now briefly consider four other methods that can be used to protect against EMI and transient overvoltage: EMI filters, electrical chokes, zero phase reactors, load side VFD cable.

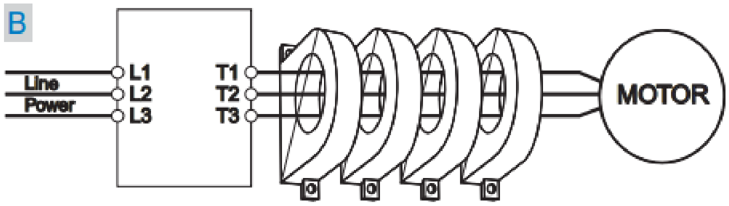
Regarding *EMI filters*, some VFDs are designed to include an input filter, or shield, against electrical interference. An example of this would be AutomationDirect's GS1 AC drives. For drives that do not include a built-in EMI filter there are several cost effective filter options available. A *DC choke* has been often referred to as a "donut-shaped" inductor. DC chokes effectively filter out AC and let DC pass into the circuit. Our Hitachi product line carries different options for DC chokes. Coupled with these chokes are *zero phase reactors* (aka RF noise filters). RF (Radio Frequency) noise occurs when neighboring electrical equipment shares its data transmission via the same radio frequency band as your VFD. Zero phase reactors are implemented by means of running the inverter wiring (can be done on both input and output side) through the opening; the wiring can even be looped several times through the opening for substantial RF filtering.

The diagram below shows two ways on how a zero phase line reactor can be incorporated:

A



B



Additional protection against EMI can be gained when adequately insulated, high quality VFD (load side) cables are made use of. Load side VFD cable of a first-rate performance standard prohibits any miniscule EMI and transients that sneak their way past the line reactor from entering your load and causing damage. Our LAPP Cable product line carries robust solutions in this regard.

The Quantum Automation EMI Protection Solution

As many of you know, here at Quantum Automation we are Value-Added-Resellers of the AutomationDirect line of VFDs / line reactors / other EMI protection as well as the Hitachi brand offering of VFDs and line reactors. Our *Best Value Guide* includes the following comprehensive solution offering from our AutomationDirect line:

Catalog Number	HP	Voltage	Phase	Rated Amps	Line Reactor	Inverter Duty Motors
GS2 VFD or VSD						Marathon microMAX
GS2 Inverter						Constant Torque 20:1 TEFC
2 year warranty					*10 year warranty*	*3 year warranty*
GS2-10P2	0.25	115/230	1ph in - 3ph out	1.6		Y500 - 1800RPM - 56C
GS2-10P5	0.5	115/230	1ph in - 3ph out	2.5		Y360 - 1800RPM - 56C
GS2-20P5	0.5	230	1ph or 3ph in - 3ph out	2.5		Y360 - 1800RPM - 56C
GS2-21P0	1	230	1ph or 3ph in - 3ph out	4.2		Y364 - 1800RPM - 56C
GS2-22P0	2	230	1ph or 3ph in - 3ph out	7	LR-22P0	Y368 - 1800RPM - 145TC
GS2-23P0	3	230	1ph or 3ph in - 3ph out	11	LR-23P0	Y1999 - 1800RPM - 182TC
GS2-25P0	5	230	3ph in - 3ph out	17	LR-25P0	Y1372 - 1800RPM - 184TC
GS2-27P5	7.5	230	3ph in - 3ph out	25	LR-27P5	Y994 - 1800RPM - 213TC
GS2-41P0	1	460	3ph in - 3ph out	2.7	LR-41P0	Y364 - 1800RPM - 56C
GS2-42P0	2	460	3ph in - 3ph out	4.2	LR-42P0	Y368 - 1800RPM - 145TC
GS2-43P0	3	460	3ph in - 3ph out	5.5	LR-43P0	Y1999 - 1800RPM - 182TC
GS2-45P0	5	460	3ph in - 3ph out	8.5	LR-45P0	Y1372 - 1800RPM - 184TC
GS2-47P5	7.5	460	3ph in - 3ph out	13	LR-47P5	Y994 - 1800RPM - 213TC
GS2-4010	10	460	3ph in - 3ph out	18	LR-4010	Y996 - 1800RPM - 215TC

Use **LAPP Cable part number 731604** for all of the above drives for Load Side EMI Rated Cabling to the Inverter Duty Motors

GS2 drives are for simple Volts/Hertz control - PWM - IGBT - 150% rated current for 1 minute

All GS2 drives have RS-232/485 Modbus RTU communications

Electronic overload protection - Adjustable accel and decel ramps - Dynamic and DC braking circuit

Input Line Reactors protect the AC drive from transient overvoltage conditions and reduces harmonics.

Output Line Reactors are recommended for operating "non-inverter-duty" motors

Output Line Reactors protect the motor insulation against drive short circuits & IGBT reflective wave damage

Output Line Reactors "smooth" the motor current waveform allowing the motor to run cooler

Hitachi Variable Frequency Drives (VFD/VSD/Inverter)

The following part number list is designed for your easy selection of not only what Hitachi VFD you may need but also the accompanying line reactor, Lapp cable, and variable or torque motor (depending on your application):

Hitachi Vector VFD	Voltage / Phase	Rated HP	Rated Amps	Line Reactor	Lapp Cable	Inverter 10:1 Duty Motors	Inverter 1800:1 Duty Motors
						Variable Torque	Constant Torque
SJ700-110HFUF2	480 VAC / 3ph	15	25	HRL120H	731204	E206 - 1800 RPM - 256T	Y552 - 1800RPM - 256TC
SJ700-150HFUF2	480 VAC / 3ph	20	32	HRL120H	731004	E207 - 1800 RPM - 284T	Y553 - 1800 RPM - 284TC
SJ700-185HFUF2	480 VAC / 3ph	25	38	HRL130H	730804	E208 - 1800 RPM - 286T	Y393 - 1800 RPM - 286TC
SJ700- 220HFUF2	480 VAC / 3ph	30	48	HRL140H	730604	E209 - 1800 RPM - 324T	Y513 - 1800 RPM - 324TC
SJ700-300HFUF2	480 VAC / 3ph	40	58	HRL150H	730404	E210 - 1800 RPM - 326T	Y514 - 1800 RPM - 326TC
SJ700-370HFUF2	480 VAC / 3ph	50	75	HRL150H	730204	E211 - 1800 RPM - 364T	Y515 - 1800 RPM - 364TC
SJ700-450HFUF2	480VAC / 3ph	60	91	HRL175H	760103	E212 - 1800 RPM - 365T	Y516 - 1800 RPM - 365TC
SJ700-550HFUF2	480 VAC / 3ph	75	112	HRL1100H	761103	E213 - 1800 RPM - 405T	Y517 - 1800 RPM - 405TC
SJ700-750HFUF2	480VAC / 3ph	100	149	HRL1125H	763303		
SJ700-900HFUF2	480 VAC / 3ph	125	176	HRL1150H	764403		
SJ700-1100HFUF2	480 VAC / 3ph	150	217	HRL1200H	763503		
SJ700-1500HFUF2	480 VAC / 3ph	200	260	HRL1250H	765003		
SJ700-1850HFUF2	480 VAC / 3ph	250 / 300	370	HRL1303H			
SJ700-2200HFUF2	480 VAC / 3ph	300 / 350	440	HRL1400H			
SJ700-3150HFUF2	480 VAC / 3ph	350/400/450	600	HRL1500H			

All drives include a RS-485 **Modbus-RTU** port standard

All drives can add a SJ-EN card for **Modbus/TCP** Ethernet Protocol

SJ700 drives can add a SJ-FB for **Encoder Feedback** option

All drives can use ProDriveNext **PC-base configuration software** (FREE) + use USB-CONVERTERCABLE

All drives should add a WOP - **Enhanced Digital Operator** - 5-line LCD display - stores 4 sets data

As a review, this month's Tech. Corner highlighted what electromagnetic interference is, how it can negatively affect your motor system, and how installation of circuit protecting solutions can ensure maximum uptime, efficiency and can significantly minimize EMI penetrating into your process equipment. We hope this month's tech corner proved to be useful for your applications. Interested in learning about a certain automation or networking topic? Please feel free to contact us with your idea.

Review Question:

How do electromagnetic interference and transient high voltages negatively affect your control equipment / motor?

ANSWER THE QUESTION FOR A CHANCE TO WIN A $100 AMAZON GIFT CARD!

» Click Here
http://www.quantumautomation.com/techcorner-questionnaire.html