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TCI KMG Sine Wave Filters (MotorGuard Series) – Comprehensive Overview

TCI's KMG MotorGuard Sine Wave Filters are high-performance output filters designed to condition the output of variable frequency drives (VFDs) into a near-perfect sinusoidal waveform. By smoothing the pulse-width modulated (PWM) signals from a VFD, the KMG filters protect AC motors and cables from the harmful effects of high-frequency voltage spikes and **dV/dt** (rate of voltage change) stress. This results in cooler, quieter motor operation and significantly extends the life of motors, especially in installations with long cable runs. The KMG series (often referred to as "MotorGuard") stands out for its **<5% total harmonic voltage distortion (THVD)** performance and its ability to allow **very long motor lead lengths** without voltage reflection issues. It is also offered with an optional **PQconnect** feature, providing advanced monitoring and connectivity for proactive maintenance. In this article, we delve into the technical specifications, features, and real-world applications of TCI's KMG Sine Wave Filters, highlighting how they solve common VFD motor issues and improve system reliability.

Why VFD Outputs Need Sine Wave Filtering

VFDs and the Reflective Wave Problem: Modern VFDs use fast-switching semiconductor devices (IGBTs) to create a PWM output waveform. While effective for controlling motor speed, PWM outputs have very rapid voltage rise times (high dV/dt) and produce a **train of voltage pulses** rather than a smooth sine wave. When these fast pulses travel down motor cables, especially over long distances, they can reflect at the motor terminals due to impedance mismatch. This **reflected wave phenomenon** causes voltage pulses to stack on top of each other, resulting in **overshoot voltages** far above the drive's nominal output. For instance, on a 460 V system, peak voltages at a motor terminal can reach on the order of **1200–1600 V** due to long-cable reflections – roughly 2.5–3.5 times the nominal voltage, which rapidly **breaks down motor insulation** and leads to premature motor failure [1]. On 575 V systems, peaks can exceed 2100 V, a severe stress for standard motor windings. These issues become pronounced for cable lengths beyond about 50–150 ft, and **beyond ~1000 ft of lead length a standard PWM drive is almost guaranteed to induce destructive reflected wave transients** if no filtering is present [2].

Motor Insulation and NEMA Standards: To mitigate PWM-induced damage, motor manufacturers have developed "inverter-duty" motors (per NEMA MG1 Part 31) with enhanced insulation that can tolerate higher dV/dt and peak voltages. However, inverter-duty motors are more expensive. A sine wave output filter like the TCI KMG offers an alternative solution: it **greatly reduces dV/dt and clamps peak voltages**, allowing the use of standard motors (NEMA MG1 Part 30) in VFD applications where otherwise a Part 31 motor would be required [3]. By bringing the waveform quality within the limits of NEMA MG1, Part 31, the KMG filter effectively lets you **protect standard AC induction motors on VFDs without special insulation**. (In fact, TCI is confident enough to guarantee that adding a properly sized KMG filter will bring an application into compliance with NEMA MG1 Part 31 standards, or they will refund the cost of the filter [4].)

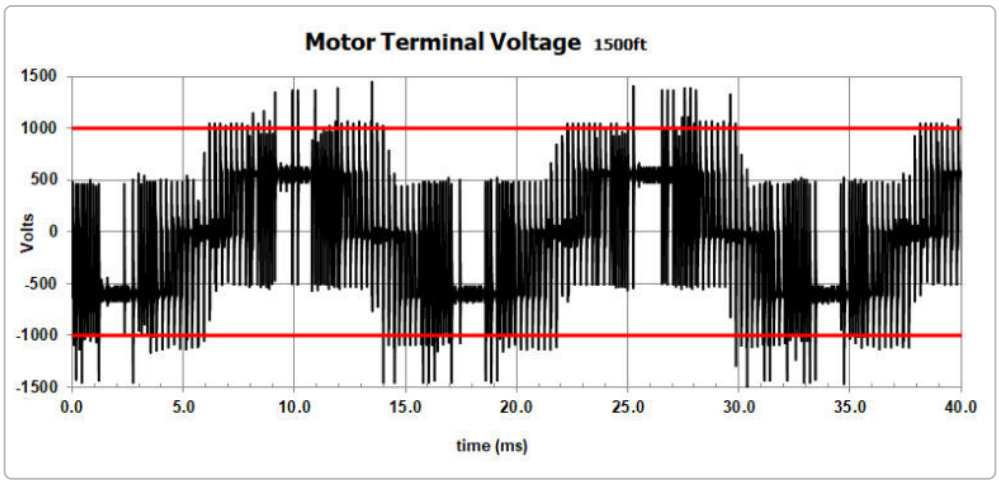
Other PWM Issues – Heat, Noise, and Bearing Currents: The high-frequency switching of VFDs also causes additional losses in motors (eddy currents, hysteresis losses) leading to **extra heat, audible noise,**

and vibration in the motor. High dV/dt pulses can induce capacitive coupling currents to motor bearings (common-mode currents), causing bearing EDM pitting and fluting over time. While **dV/dt output filters** (consisting of reactors and resistors) can mitigate some of these issues for moderate cable lengths (typically effective up to ~1000 ft) by slowing the voltage rise, they do **not actually re-form the waveform** into a sine wave [5]. **Sine wave filters** go a step further: by using a low-pass LC filter, they **attenuate the carrier frequency components** of the PWM completely, **outputting a smooth sinusoidal voltage** virtually free of high-frequency ripple. This eliminates the high-frequency common-mode voltages and significantly reduces motor shaft currents and noise. **In short, a sine wave filter addresses the root cause of PWM-induced motor stress by delivering near-utility-quality power to the motor.** According to industry literature, when a SineWave filter is added, *"the waveform is exactly what you would get from the utility on the output of the drive"* [6] – a dramatic improvement over the raw VFD output.

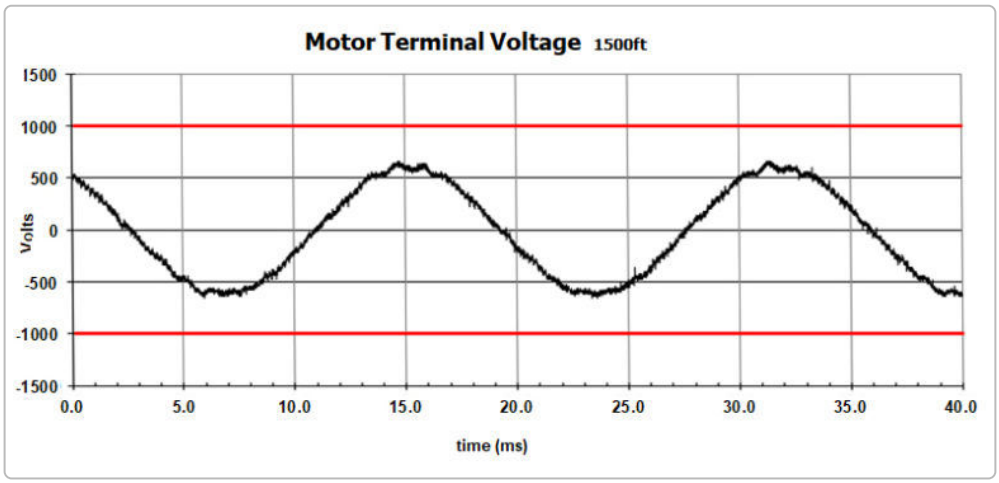
Design and Operation of the KMG Sine Wave Filter

Low-Pass Filter Architecture: The TCI KMG MotorGuard filter is essentially an engineered low-pass filter inserted between the VFD and the motor. Internally, it consists of **three-phase iron-core reactors (inductors) in series with the output and a bank of capacitors connected in a wye configuration** on the load side of the reactors [7]. The inductor-capacitor network is tuned to **filter out the high-frequency PWM carrier** (typically in the kHz range) while passing the fundamental drive frequency (0 to 60 Hz or higher). By "stripping away" the high-frequency components of the PWM, the filter dramatically slows the edges of the voltage waveform. The output voltage seen at the motor terminals becomes a smooth sinusoid with minimal ripple. **High dV/dt and voltage spikes are eliminated**, so the waveform **no longer has the sharp edges** that interact with cable capacitance to cause reflections [8]. In essence, the KMG filter recreates a near-sinusoidal voltage source, preventing the VFD from driving fast transitions into the motor/cable system. This not only protects the motor insulation and bearings but also prevents nuisance tripping of drives or other equipment due to stray high-frequency noise.

Comparison to Line/Load Reactors: It's worth noting that a simple line reactor (inductor) on a VFD output can only partially address voltage transients – it will slow the rise time somewhat but **cannot fully remove the PWM carrier**. dV/dt filters add a small resistor-capacitor network to dampen ringing, but still the waveform remains a pulse train. The KMG's **L-C topology** actually reshapes the waveform. The inclusion of capacitors means the filter will draw a small reactive current and must be properly sized to the drive, but the payoff is a **clean output waveform**. Many VFD manufacturers recognize this solution; in fact, sine wave filters are often referred to as "**long lead filters**" because they are specifically recommended for installations with very long motor leads. TCI's KMG filters have been used in applications up to 15,000 feet of motor cable.



Without a sine wave filter, a VFD's PWM output (shown here at a motor 1500 ft away) contains high-frequency pulses and overshoot voltages that can reach ~3× the nominal voltage, stressing motor insulation [1] .



With a TCI KMG Sine Wave Filter in place (same 1500 ft cable), the output voltage is smoothed into a near-ideal sinusoidal wave. The filter removes the carrier frequency, preventing reflective wave spikes and virtually eliminating dV/dt stress on the motor [6] .

(The red horizontal lines in the above oscilloscope traces indicate the nominal peak of the fundamental voltage. The first trace shows how PWM pulses and reflections cause peaks far beyond this level, whereas the second trace with the KMG filter stays within limits.)

As demonstrated above, the difference is profound. **Without filtering, the motor sees a rapid train of spikes** – in this example, the 480 V drive's output peaks at around 1200 V due to a long lead, which would eventually destroy a standard motor. **With the KMG filter, the motor terminal voltage is a clean sine wave** (few percent THD), staying within safe voltage limits. This yields immediate benefits: **motor heating is reduced, audible noise is nearly eliminated, and torque delivery is smoother** (no torque pulsations from PWM harmonics). Additionally, because the voltage waveform is clean, **stress on the motor's turn-to-turn insulation is minimized**, enabling standard motors to run full speed on VFDs without insulation failure.

Key Features and Benefits of TCI KMG Filters

The TCI KMG MotorGuard series is engineered to deliver robust performance across a wide range of VFD applications. Key features and their benefits include:

- **Near-Sinusoidal Output (< 5% THVD):** The filter produces an output voltage with **< 5% total harmonic voltage distortion** at full load, essentially a smooth sinusoidal waveform [9]. This dramatically reduces **torque ripple** in motors and prevents overheating caused by harmonic currents. The near-sine wave output allows motors to run as if they were on utility power, improving efficiency and longevity.

- **Elimination of Voltage Spikes (dV/dT Protection):** The KMG filters **eliminate high dV/dt transient voltage spikes** that occur at the motor terminals. By attenuating the PWM carrier, the filter limits the motor terminal peak voltage to about **1.7 p.u.** of nominal (approximately 815 V peak for a 480 V system) and caps the voltage rise time around **5 V/µs** [10]. This ensures **optimal insulation protection** for both motor windings and long cable runs. Problems like **voltage wave reflection** and ringing are effectively solved, even for cable distances reaching several kilometers.

- **Reduced Motor Noise, Heat, and Vibration:** With the high-frequency content removed from the waveform, motors run **cooler and quieter**. The annoying whining noise often associated with VFD-driven motors (caused by PWM switching frequencies) is virtually eliminated. Mechanical vibration is also reduced due to the smoother torque output. This translates to longer bearing life and overall improved reliability of the motor-load system.

- **Universal Compatibility:** The KMG series has **universal application** – it can be used with almost any standard three-phase AC induction motor and is agnostic to cable length or cable type [11]. Unlike some solutions that impose strict limits, the KMG filters are effective on **virtually any lead length (including extremely long leads up to 15,000 ft)** and support a wide range of VFD **carrier frequencies from 2 kHz up to 16 kHz** [11]. This wide carrier-frequency range means the filters are compatible with both older drives (with lower switching frequencies) and modern high-frequency drives, without forcing you to derate the drive's switching frequency too much. The filters are also **independent of motor manufacturer or drive brand**, making them a flexible add-on to any system.

- **Long Lead Length Capability:** Specifically designed as **"long lead filters,"** KMG filters enable VFD installations with extremely long motor feeders. In specific applications they have proven to support distances on the order of **5,000 to 15,000 feet** between drive and motor [12]. This is crucial in industries like oil & gas (deep wells, remote pumps) and mining or municipal water systems, where VFDs must drive motors located miles away. By using KMG filters, system designers can avoid more expensive solutions like placing VFDs at the motor site or using special cable or transformers – the filter **allows centralized drive installations with long cables**.

- **High Continuous and Overload Capacity:** The KMG MotorGuard filters are built to handle heavy industrial loads. They have a high continuous current rating (models range from 8 A up to 750 A, corresponding to fractional 5 HP up to ~600+ HP motors) [13]. They can also **withstand overloads of 150% current for 1 minute** (per 60-minute period) without damage [14]. This overload tolerance means the filter can handle motor inrush or transient conditions (such as acceleration, or short-

duration overloads) comfortably. In practical terms, the filter won't be the limiting factor when the drive system handles short surges or heavy startup currents.

- **Thermal Ruggedness and UL Certification:** KMG filters use **Class H (180 °C) or Class R (220 °C) insulation** in their windings and high-quality, **oil-filled capacitors** (PCB-free) for reliability [15]. They are designed for a **50 °C ambient** temperature rating (open panel) or 40 °C in enclosed units [16], suitable for harsh industrial environments. The filters carry **cULus (UL508A) listing** for both open-type and enclosed versions [17], which is important for industrial control panel compliance. Enclosure options include **open chassis (UL Open) for integration into cabinets, or UL Type 1 enclosed** units for general purpose indoor use [17]. (Outdoor-rated **NEMA 3R enclosures** are also available for many models, allowing use in outdoor pump panels or rooftop HVAC units.) All units include internal fusing and a monitoring circuit for protection [18], ensuring safe operation and simplifying installation (no need for separate output fusing in many cases).

- **Energy Efficiency (Low Voltage Drop):** Despite adding impedance, the KMG filter is designed to minimize losses. The typical **voltage drop across the filter is about 3% or less** at full load [19]. In terms of efficiency, this corresponds to roughly 97% efficiency under nominal conditions – a small trade-off for the tremendous benefits in power quality delivered to the motor. The filter's inductors and capacitors are optimized to avoid excessive heating; the power loss is mainly I^2R loss in the inductors and a small reactive loss in the capacitors. In most cases, the VFD can be programmed to compensate for this slight voltage drop if needed (by outputting a slightly higher voltage), but often it is negligible in practice.

- **Optional PQconnect™ Smart Monitoring:** TCI offers versions of the KMG filters equipped with **PQconnect**, an integrated electronics module that provides **Modbus RTU connectivity** and real-time monitoring of filter performance. (These models have a "P" suffix in the part number, e.g. KMG___P.) With PQconnect, users can access **filter status, operating parameters, and fault/alarm data** over a network, integrating the filter into plant SCADA or control systems. TCI provides a free Windows application called **PQvision** for the KMG filters, which allows users to visualize **real-time waveforms, voltage distortion (THVD) levels, filter temperature, component status, and more** [20] [21]. This data can be used for **predictive maintenance** – for example, detecting a degrading capacitor or an abnormal harmonic condition before it causes a failure. In critical systems (like HVAC in a data center or pumps in a municipal water system), such monitoring helps maximize uptime. The PQconnect feature essentially turns the passive filter into an **"smart" device** capable of **reporting power quality metrics and its own health**. This is a standout feature of TCI's offering, as most traditional sine wave filters are passive devices with no intelligence. With KMG + PQconnect, an operator can remotely adjust the drive or take action if power quality issues arise, and ensure the filter is always protecting the motor as intended [22].

Technical Specifications at a Glance

To summarize the technical capabilities of the TCI KMG MotorGuard Sine Wave Filters, the following are some key specifications (for the standard product line):

- **Voltage and Horsepower Range:** Models are available for **480 VAC** and **600 VAC** class three-phase systems [23]. Continuous current ratings range from **8 A up to 750 A** (approximately 2–3 A to 600 HP, depending on voltage) for a single filter [13]. This broad range means KMG filters can accommodate

everything from small pump motors to large 500+ HP compressors or fans. **Multiple units can be paralleled** for even higher currents if needed, or custom units can be built for special applications.

- **Supported VFD Output Frequency: 0 to 60 Hz** (fundamental) is fully supported at full load. In fact, the KMG is designed for standard power frequency output up to 60 Hz. It can be used up to **80 Hz output frequency** with slight de-rating [24] [25]. This covers the typical range of most industrial motors (including running motors at moderate overspeed). However, applications involving very high output frequencies (such as 200 Hz spindle drives) are generally outside the scope of sine wave filters, since the filter is tuned for line frequency. For the vast majority of 50 Hz or 60 Hz motor systems, this is not a concern.

- **VFD Switching Frequency:** Compatible with drive **carrier frequencies from 2 kHz to 16 kHz** [11]. This wide range ensures that even high-switching-frequency drives (which are common in newer VFDs to reduce noise) can be used. The filter's inductance/capacitance values are chosen such that it attenuates frequencies in this range effectively. **No retuning is required** – the standard filter handles the full range. (It is generally recommended to set the VFD's switching frequency to a moderate value like 3–8 kHz when using very long leads, to reduce filter heating, but the KMG will function across the spectrum. In practice, users have found around 3 kHz to be a good balance for long leads [26].)

- **Output Waveform Limits:** The filter limits the **peak output voltage** to approximately **815 V for 480 V systems, and 1018 V for 600 V systems** [27]. This corresponds to roughly 1.7 times the RMS line voltage (which is well within the safe level that standard motor insulation can handle repeatedly). The **maximum slew rate (dV/dt)** of the output waveform is specified as **5 V/µs (480 V) or 6 V/µs (600 V)** [10] – drastically lower than the hundreds of V/µs of an unfiltered drive. These values align with or exceed the recommendations of NEMA MG1 Part 31 for protecting motors. The resulting voltage distortion at the motor is typically under 5%, meaning the motor sees a very clean waveform.

- **Efficiency and Voltage Drop:** Insertion loss is low – about **3% voltage drop at full load** current is typical through the filter reactor [19]. For example, a 480 V drive might deliver ~465 V to the motor at full load due to the filter's impedance. The power loss is small (a few watts per amp). Efficiency of the filter is generally 96–99% depending on load. The filter is naturally a reactive device, so it does not consume significant real power; it mostly stores and releases energy each cycle. **Heat dissipation is modest**, but like any power component, the filter will warm up under load and requires adequate ventilation. TCI's designs are sized to limit temperature rise (115 °C rise for standard, or 155 °C in some models for heavy-duty) which ensures longevity of the coils [28]. Users should be aware of the slight voltage drop – in very sensitive applications one might raise the drive output voltage to compensate, but most motors tolerate a few percent voltage reduction without issue.

- **Transient/Overload Handling: 200% for 3 minutes** (older spec) or **150% for 1 minute** (latest spec) overload capacity is built-in [14] [29]. This means the filter can handle surges and short-term overcurrents such as motor starting, heavy load pickup, or rapid acceleration. The inductors won't saturate under these conditions, and the capacitors can handle the transient currents. This is an important specification – it assures that in abnormal but temporary situations (like a jam that clears, or emergency startup), the filter will ride through without damage. However, continuous overcurrent

beyond its rating is not allowed (like any device, it must be sized appropriately for the application's continuous current including any derating for ambient temperature or altitude).

- **Environmental Ratings:** The KMG filters are designed for **indoor or outdoor use** depending on the enclosure. Open-frame units (usually installed inside a drive cabinet or panel) are rated for up to **50 °C ambient** [16]. Enclosed units (NEMA 1 or 3R) are typically rated to 40 °C ambient, since the enclosure adds a slight thermal barrier [16]. Altitude is supported up to **2000 m (6600 ft) without derating** [30]. Above that, some derating or special designs might be needed due to thinner air for cooling. The filters can handle up to 95% humidity (non-condensing) and have a storage temperature range of -40 °C to +60 °C, indicating robust construction for a variety of climates [30].

- **Quality and Compliance:** Each KMG filter is **UL listed or recognized** (UL508 industrial control equipment) and comes with TCI's quality assurance. The design uses **high-endurance components** – for example, capacitors are self-healing, oil-filled types specifically chosen for many years of service under ripple current stress. There are **no PCB dielectric materials** and all materials meet modern environmental and safety standards [15]. The filter coils are often vacuum-impregnated to reduce noise (hum) and to secure the windings against movement. TCI also provides extensive documentation, including installation manuals and sizing tables. The **performance guarantee** (mentioned earlier) is a unique offering: if the filter doesn't achieve the promised results in cleaning up the waveform to MG1 standards, TCI will take it back [4]. This guarantee underlines the filter's effectiveness and TCI's confidence in their product.

In summary, the technical specs position the KMG MotorGuard filters as **heavy-duty, industrial-grade solutions** for conditioning VFD outputs. They cover the full spectrum of typical motor drive requirements and do so with minimal drawbacks.

Typical Applications and Real-World Use Cases

Sine wave output filters like the TCI KMG are used whenever a VFD-driven motor needs extra protection or when the installation has challenges that a standard drive cannot handle alone. Some **typical applications** include [31] [32]:

- **Long Distance Pumps and Wells:** Remote water pumps (irrigation pumps, oil & gas well pumps, submersible pumps in deep wells) often require running motors hundreds or thousands of feet from the VFD. For example, in oil fields or farm irrigation, it's not uncommon to have **cable runs of 1000–5000 ft (and in cases up to 15,000 ft)**. Sine wave filters are essential here to prevent reflected wave damage. **Real-world case:** A municipal water authority had multiple well pumps located 3,000–4,000 feet from centralized VFD panels. By installing KMG Sine Wave Filters on each drive, they were able to protect standard 480 V motors at the wellheads from voltage spikes. The filters allowed reliable operation over **nearly 1 mile of lead length**, something otherwise impossible with conventional drives. One integrator on an automation forum reported using TCI MotorGuard filters on **all submersible pump VFD applications with 1000–15,000 ft leads**, noting that *"the TCI filters work quite well"* for eliminating reflected wave issues [33]. In that scenario, standard motors with 1000 V insulation were able to survive on 480 V drives thanks to the filter (normally 1000 V insulation would be marginal for such a VFD application, but the filter made it viable) [34]. The only adjustments needed were to set the VFD switching frequency to around 3 kHz (to minimize heating) and use good VFD-grade cabling – the filter handled the rest [26]. The user also observed about *2% voltage drop*

across the filter and roughly *2% additional heating*, which was manageable [35]. In the end, the pumps ran smoothly without the overvoltage trips or motor failures that plagued the system before the filters were added.

- **Multiple Motors on One Drive:** In some industrial systems, a single VFD may feed multiple motors in parallel (for instance, a single VFD driving several conveyor motors or a set of exhaust fans). In such cases, the total cable length is the sum of all branch lengths, and the capacitance seen by the drive is larger – increasing the risk of waveform distortion and reflective waves. A sine wave filter at the drive output is an excellent solution here: **one KMG filter can protect multiple motors downstream, as long as it's sized for the total current and the combined cable length**. The filter effectively isolates the drive from the complex impedance of multiple motor/cable combinations. For example, a packaging plant had one inverter running three small motors on a distribution system; adding a MotorGuard filter eliminated nuisance faults and overheating issues across all motors. Industry experts note that sine wave filters *"are a great choice for multiple motor applications,"* since they can handle the total distance of multiple leads (by filtering at the source) [36]. This simplifies system design compared to putting dv/dt filters on each motor or using special motor designs.

- **HVAC Systems and Building Services:** HVAC installations (large chillers, air handlers, cooling tower fans, etc.) benefit from sine wave filters to reduce motor noise and interference. VFDs in HVAC are often located far from the motors (e.g. drives in a mechanical room, motors on the roof). By using KMG filters, HVAC engineers have been able to **virtually eliminate audible noise** from VFD-driven fans and pumps [37] [38]. The resulting noise level is comparable to a motor on sine wave power, which is a big plus in commercial buildings or hospitals where noise is a concern. Additionally, HVAC systems sometimes use old or standard-efficiency motors that are not inverter-rated – adding a sine wave filter allows these existing motors to be put on VFDs for energy savings without replacing them. Another benefit seen in HVAC and data center applications is the reduction of **electromagnetic interference (EMI)**: a sine wave filter greatly cuts down the high-frequency emissions on motor leads, which can otherwise radiate and interfere with sensitive electronics or building automation systems. Some facilities have reported improved reliability of sensors and networks after filtering the VFD outputs (though in very high-EMI sensitivity situations, an extra common-mode choke might be added to tackle any residual common-mode currents).

- **Industrial Machinery and Test Stands:** Factories that retrofit VFDs on older equipment (like large milling machines, extruders, or test dynos) often use sine wave filters to protect legacy motors. In motor test stands or dynamometer setups, where precise load simulation is required, a sine wave filter can provide a **clean voltage waveform for more accurate testing** (and ensure the test motor isn't additionally stressed by the drive). Additionally, some industrial processes like **conveyors, blowers, and fans** with long wiring harnesses have seen significant maintenance improvements by installing sine wave filters [32] – motor failures due to insulation breakdown virtually disappeared, and the maintenance intervals for bearing greasing extended since pitting was reduced.

- **Step-Up Transformer Applications (Medium-Voltage Motors):** Occasionally, a low-voltage VFD is used to drive a medium-voltage motor via a step-up transformer (for example, a 480 V VFD powering a 2300 V motor). The KMG filter is often placed on the low-voltage side before the step-up transformer. Its filter action not only protects the motor but also the transformer from high dV/dt. By ensuring a sinusoidal input to the transformer, issues with transformer heating and insulation (from PWM voltage) are avoided [39] [7]. This approach has been used in pumping stations where

medium-voltage pumps are run with a combination of LV drives + step-up transformers to reduce cost. TCI specifically cites **"low voltage PWM supply to medium voltage motor"** as a target application for the KMG filters [40].

- **Marine and "Shore-to-Ship" Power:** Sine wave filters find use in marine drives and shore power converters. For instance, when providing 60 Hz power from a VFD-based source to a ship that might be docked with a long power cable, a sine wave filter can ensure the voltage is clean and spike-free. TCI mentions shore-to-ship power as a typical use case [38]. Similarly, in renewable energy or battery-storage inverters where a VFD might simulate grid power for some load, a sine wave filter can clean the waveform.

In all these cases, **the overarching benefit is increased system reliability and equipment longevity**. Motors run at near ideal conditions – cooler and quieter – and do not suffer unexpected failures from turn insulation breakdown. Cables are protected from excessive voltage stress, and even the drive itself benefits (by having a more stable load and less risk of faulting due to reflected energy). Users have reported significant drops in maintenance costs after installing sine wave filters: for example, one pumping station noted that motor replacement frequency went from annually (without filters) to **virtually zero failures in five years** after adding sine wave filters, while also eliminating several drive over-voltage trips per month. Another tangible benefit is that **standard motors and cables can be used**, avoiding the need for expensive "VFD-rated" 2 kV insulation cables or special inverter-duty motors in many cases [3]. This can offset the cost of the filter itself.

It should be noted that while sine wave filters address the electrical waveform issues, good installation practices should still be followed: use of proper grounding and, if needed, shaft grounding rings or isolation for very long motor systems to handle any remaining common-mode currents (the KMG filter significantly reduces but may not 100% eliminate common-mode voltage). In extremely sensitive situations (like prevention of bearing currents in high-horsepower motors), a combination of a sine wave filter and a supplemental common-mode choke can provide virtually complete mitigation [41]. For most applications, the KMG alone is sufficient to meet the goals.

Conclusion

The **TCI KMG MotorGuard Sine Wave Filter** is a proven solution for improving the power quality of VFD-driven motor systems. By converting the VFD's chopped PWM output into a clean, sinusoidal waveform, it **solves many of the challenges that plague VFD applications** – from reflective wave voltage spikes and insulation damage to motor overheating, noise, and vibration. The KMG series stands out in the market due to its high performance (capable of handling very long leads and high frequencies) and the added value of the **PQconnect** monitoring option, which brings smart connectivity features to what has traditionally been a passive device.

In practical terms, installing a MotorGuard filter is like giving your motor a gentle mains supply even though it's fed by a drive – the motor "doesn't know" it's on a VFD, and thus operates in ideal conditions. This **extends motor life, reduces downtime, and increases overall system reliability**. Additionally, by protecting cables and motors, the filter can enable **innovative system designs** (such as centralized VFDs with remote motors, multi-motor drives, etc.) that might not be feasible otherwise.

Industry adoption of TCI's sine wave filters is broad: many major VFD manufacturers either recommend using such filters for long lead applications or even offer rebranded versions (indeed, it's noted that in North America, **filters from specialists like TCI or MTE are often OEM packaged with drives by companies like ABB, Rockwell, Eaton, Yaskawa, and others** [42]). This wide acceptance speaks to the trust in the technology and its effectiveness. When compared to other mitigation methods – e.g. dv/dt filters, load reactors, or buying more expensive inverter-duty motors – the sine wave filter frequently proves to be the **most comprehensive solution**, addressing both voltage and frequency-related stresses in one package.

For customers of Precision Electric or any facility considering the **TCI KMG series**, the takeaway is that this filter can **dramatically improve the performance and longevity of your VFD-driven systems**. It is a well-engineered, robust add-on that often pays for itself by preventing costly motor replacements and downtime. Whether you're dealing with a long cable run to a submersible pump, a noisy fan motor in a building, or a critical compressor that you can't afford to fail, the MotorGuard sine wave filter is a highly effective tool to ensure **smooth, trouble-free operation**. It effectively future-proofs your motor against the harsher aspects of VFD power, allowing you to fully reap the energy-saving and control benefits of VFDs **without the reliability compromises**. In summary, TCI's KMG filters **help bridge the gap between power electronics and electromechanical equipment, ensuring they coexist in harmony for the long term**.

References

1. **TCI – *KMG Sine Wave Filter (MotorGuard) Product Page*** – TCI (Trans-Coil Industries) official product page for the KMG MotorGuard sine wave output filter. Describes the filter's purpose, features (including PQconnect), and general benefits in mitigating PWM waveform issues. *TCI, an Allied Company* (2025).

2. **TCI – *KMG MotorGuard Sine Wave Filter Brochure* (PDF)** – Technical brochure (Version 3.1, Aug 2021) for the KMG series. Contains detailed features, typical applications, part numbering, and a technical specifications table (including voltage, current range, THVD performance, dV/dt, frequency range, etc.), as well as the NEMA MG1 Part 31 compliance guarantee. *TCI Power Quality Products*.

3. **TCI – *Installation & Operation Manual: KMG Sine Wave Filter*** – (Not directly cited above, but a useful reference) Comprehensive IOM manual for the KMG series, covering safety, sizing, installation guidelines, and maintenance. Includes wiring diagrams and performance curves. *TCI, LLC – KMG Filter Manual*.

4. **PR Newswire – *"TCI Releases Sine Wave Filter with Connectivity"*** – Press release (Nov 16, 2020) announcing the KMG with PQconnect. Highlights the addition of real-time monitoring, Modbus communication, and mentions use-cases (protecting pumping systems, enabling process adjustments, etc.). *PRNewswire / Power Systems Design*.

5. **Valin Corp – *"Trans-Coil KMG High Performance Output Sine Wave Filters"* (PDF)** – A distributor's product bulletin describing the KMG filters. Contains a reflection on typical problems (reflective wave phenomenon) and lists key benefits: eliminating torque ripple, voltage wave reflection, extending motor life, allowing 15,000 ft leads, etc. Also mentions use of NEMA MG1 Part 30 motors in place of Part 31 due to the filter's protection. *Valin Online*.

6. **Rexel USA – *"Going the Distance: SineWave Filter Applications"*** – An industry blog post discussing when to use sine wave filters vs dv/dt filters. Provides rules of thumb (dv/dt filters for <1000 ft, sine wave for >1000 ft up to 15,000 ft) and outlines benefits such as reduced motor heating, reduced insulation stress, noise reduction, and long lead length capability. Also compares multiple manufacturers (TCI MotorShield vs MTE Guardian) and notes features like common-mode noise attenuation. *Rexel Energy Solutions Blog*.

7. **Mike Holt Forum – *Thread: "VFD with Sine Wave Filter on LONG Leads"*** – A discussion among electrical professionals (2011) about using sine wave filters for long motor lead applications. Includes first-hand insights: e.g., Yaskawa and Allen-Bradley recommending filters (Schaffner or TCI), experiences of using TCI filters on 1000–15000 ft submersible pump leads (with ~2% voltage drop and suggestion to use 3 kHz switching), and commentary that major VFD OEMs often private-label filters from TCI or MTE. *Mike Holt's Code Forum*.

8. **Yaskawa America – *Application Note: Guidelines on the use of output filters for step-up transformer applications*** – A technical note explaining how sine wave output filters are applied when a low-voltage VFD drives a motor through a step-up transformer. Describes the filter's composition (3 reactors + capacitors in wye) and how it prevents high dV/dt from stressing transformers and motors. Useful for understanding filter operation in specialized setups. *Yaskawa Document AN.AFD.08*.

9. **MTE Corp – *SineWave Filter Manual (Series A, 2–8 kHz)* (PDF)** – Reference from a major competitor, detailing similar sine wave filter performance. Confirms general capabilities of sine wave filters: e.g., maximum motor lead length 15,000 ft, insertion loss ~ up to 10% in worst case, and 150% for 1 minute overload. Provides an external point of comparison for the technical specs and reinforces the industry standard nature of these performance figures. *MTE Corporation*.

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