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TCI HGL Harmonic Filters (HarmonicGuard Low Capacitance Series)

TCI's HGL HarmonicGuard Low Capacitance filter (enclosed model with PQconnect) provides advanced harmonic mitigation with minimal capacitive loading. This intelligent passive filter is designed to keep distortion under control even in generator-powered systems.

Modern variable frequency drives (VFDs) and other non-linear loads can draw highly distorted currents, leading to harmonics in the electrical system. These harmonics cause a range of power quality problems – **transformers and distribution equipment may overheat, circuit breakers can trip unpredictably, and sensitive electronics may fail or malfunction** [1]. In addition, excessive harmonics reduce the system's power factor and can incur utility penalties or violate standards like IEEE 519. Passive harmonic filters are a proven solution to this challenge: by adding a combination of reactors and capacitors tuned to trap low-order harmonics (typically the 5th), they **provide a low-impedance path that shunts harmonic currents and prevents them from flowing into the wider power system** [2]. According to industry data, a well-designed passive filter can **cut total harmonic distortion (THD) by around 80% – often bringing current distortion down to ~5% from typical levels of 30–40%** [3]. This dramatically improves power quality, helping facilities **meet the IEEE 519 limits (e.g. ≤5% TDD** for general systems with ISC/IL<20) [4] and **protecting equipment from harmonic-induced stress**. While alternatives like multi-pulse or active front-end drives exist, they are costly and complex – in many cases, using a standard 6-pulse VFD with an external passive filter is the most cost-effective and practical way to achieve compliance [5] [6].

Overview of the TCI HGL Series

TCI's HGL series (HarmonicGuard Low Capacitance filters) is a family of drive-applied passive harmonic filters engineered to deliver <5% current distortion while addressing the specific drawbacks of traditional filter designs. The HGL is part of TCI's HarmonicGuard product line of 5% passive filters, distinguished by its *"low capacitance"* approach [7] [8]. In essence, the HGL uses a smaller capacitive component (kVAR) relative to conventional 5% filters – this yields **the lowest kVAR per horsepower filter on the market, enhancing compatibility with generator power systems** [according to TCI's official specifications] [9]. By reducing reactive power draw, the HGL avoids the excessive leading power factor and over-voltage issues that can occur when running filtered VFDs on standby generators [10]. In fact, **TCI notes that the HGL enables a near 1:1 sizing of generator kVA to motor HP** – unlike standard filters which often force oversizing of generators to handle excess capacitance [11] [12]. This makes HGL an ideal solution for applications like remote oilfield installations, emergency backup systems, or mobile equipment where generator power is used and harmonic compliance must be met without compromising generator stability.

Despite its reduced capacitance, the HGL still achieves excellent harmonic mitigation performance. It is designed to **limit total harmonic current distortion (THID) to 5% or less at full load** (when applied to a typical 6-pulse VFD system under IEEE 519 worst-case conditions) [13]. This satisfies the stringent IEEE-519-2022 requirements for harmonic limits in low-voltage systems [14] [15]. The trade-off of the low-capacitance design is that at lighter loads the filter's performance will taper – whereas a standard filter

might hold THD ≤5% down to 50% load, the HGL is specified for 5% THD at **rated** load (with distortion rising somewhat at lower load levels) [16]. Even so, in real-world operation the HGL provides substantial harmonic reduction across the load range, improving true power factor and power quality for the drive. In fact, by both filtering harmonics (improving the distortion power factor) and supplying a bit of capacitive VARs (correcting displacement power factor), passive filters like the HGL **typically raise the system power factor to ~0.95–0.98** under load [17] – a dual benefit of harmonic mitigation. TCI explicitly notes that the HGL *"not only limits current distortion to <5% TDD, it also improves true power factor"* in the facility [18].

Key Features and Innovations

The TCI HGL series introduces several advanced features and options that set it apart from conventional passive harmonic filters:

- **Low Capacitance Design for Generator Compatibility:** As its name implies, the HGL uses a specially tuned low-kVAR filter circuit. This minimizes leading reactive current and prevents generator over-excitation or instability [10]. **Excess capacitance in traditional filters can cause leading power factor and high no-load voltages on generators**, but the HGL's design avoids these issues [19] [20]. Users can often size generators **horsepower-for-horsepower to the driven load** with HGL filters (a 1:1 HP:kVA ratio), rather than oversizing the generator by 30–50% or adding ancillary reactors [11]. This yields significant cost and efficiency benefits for generator-supplied installations. Additionally, the reduction of reactive power draw means **smaller, more cost-effective generators may be used without risking poor voltage regulation or trips** [21].

- **Automatic Tuning Circuit Contactor:** Each HGL filter can be equipped with an integral **isolation contactor on the filter's capacitor bank** [22]. This contactor, when enabled, allows the filter's tuning circuit (capacitor and auxiliary inductor branch) to be disconnected from the line under certain conditions. Uniquely, **the HGL with TCI's intelligence will autonomously control this contactor based on system conditions** [23]. If the load drops to a point where the filter's capacitance would drive the power factor leading or if excess VARs are detected, the HGL can automatically open the contactor – effectively taking itself offline or into a reactor-only mode. When load returns, it re-engages to provide harmonic filtering. This smart contactor control **ensures worry-free operation on generator power** and eliminates manual intervention to prevent leading power factor [24]. (For comparison, many passive filters rely on the user to electrically bypass or disable them at light loads to avoid issues – the HGL automates this process.) The contactor also provides a convenient means to **de-energize the capacitors for maintenance or during startup/shutdown sequences** as needed. This feature comes standard on certain models or can be specified as an option on others [22].

- **PQconnect Intelligent Monitoring and Control:** The HGL series is the **first passive harmonic filter line with built-in Bluetooth® connectivity and network communication capabilities** [25]. TCI's **PQconnect** module (optional on HGL filters) brings a host of smart features: it includes sensing electronics and a Bluetooth wireless interface, as well as ports for Modbus RTU and EtherNet/IP communication [26] [27]. Using the **PQvision** software (PC application) or mobile app, operators can connect to the filter to monitor real-time electrical parameters and filter status [28]. The system provides **live data on line and load voltages/currents, calculated THID and THVD (voltage distortion), harmonic spectra, and even waveform capture** [28]. Through these tools, maintenance personnel can observe how the filter is performing and verify harmonic mitigation in

real time. PQconnect also enables remote control – for instance, the filter's contactor can be toggled remotely, and alarm thresholds can be configured. **Industrial network integration** is supported via EtherNet/IP, allowing seamless communication with PLCs and SCADA systems for centralized monitoring [29] [30]. TCI provides an Add-On Profile (AOP) and EDS files for Rockwell/Allen-Bradley PLC platforms, so the HGL filter can be easily recognized and data tags auto-populated in a control system [31] [32]. This high-speed connectivity means **the HGL can continuously report its status and any faults or maintenance alerts** to plant operators. Notably, the PQconnect system will send **proactive alerts if a filter component is failing or a capacitor is nearing end-of-life** [33] – enabling predictive maintenance. In summary, PQconnect transforms the passive filter into a smart device that not only cleans your power but also provides valuable power quality insight and peace of mind about filter health.

- **High Harmonic Mitigation Performance:** The primary job of the HGL filter is to reduce harmonics, and it does so effectively. When applied at the input of a standard six-pulse VFD, a properly sized HGL filter will **limit current distortion to ~5% TDD at full load**, assuming the system short-circuit strength is within typical IEEE 519 design ratios (ISC/IL $\leq$ 20) [12]. In practice, this means taking a VFD input current that might have 30–50% THD and cleaning it to a level typically **5× to 10× lower**, dramatically flattening current waveforms. By filtering out the major low-order harmonics (5th, 7th, 11th, etc.), the HGL helps facilities **meet or exceed IEEE-519 (2014/2022) compliance at the point of common coupling** [9]. It is *"field-proven"* to keep distortion in check across varying loads [18] – for example, passive filters applied at a **municipal pump station were able to bring VFD harmonic distortion under 5% TDD** and maintain it even as pumps cycled on/off [34]. Furthermore, the HGL's action of filtering harmonics also improves the system voltage waveform (by reducing voltage THD on the bus) and alleviates stress on upstream equipment. Many users find that after installing harmonic filters, issues like transformer overheating and flickering lights are resolved. In short, the HGL provides a cost-effective path to achieve low harmonic distortion similar to more expensive active or 18-pulse solutions – **allowing continued use of standard drives from any manufacturer (ABB, Yaskawa, Eaton, etc.) while still meeting compliance** [5].

- **Quality Construction and Safety Features:** TCI has engineered the HGL series to be robust and safe for industrial deployment. Key components – the reactors (inductors), capacitors, and resistors – are of high quality and selected to handle harsh electrical environments (including oilfield duty as described later) [35]. **All HGL units are UL Listed to UL-508A** as industrial control panels, and are cULus certified for use in the US and Canada [36]. Notably, UL 508A certification of the filter means **users or field technicians can perform maintenance (such as capacitor replacement) on the filter while maintaining compliance**, as the design is field maintainable [37]. In contrast, some filters (UL-508 certified) require factory-only maintenance to keep their listing [38]. The HGL filters carry a **true Short-Circuit Current Rating (SCCR) of 100 kA** when properly installed, meaning they can withstand high fault currents up to 100,000 A without enclosure rupture or hazard [9] [39]. (Models 40 HP and above achieve 100 kA rating standalone; smaller units can be fused in the field to attain equivalent SCCR) [40]. For protection, HGL filters **include integral fusing on the capacitor branches** [12] – this helps isolate and safeguard the filter if a capacitor fails or surges occur, preventing damage to other components. The enclosure designs are also focused on usability: HGL filters in the HarmonicGuard series feature **hinged doors for easy access** (on NEMA 1/3R models) and components mounted on back panels, so that **inspection and replacement of parts like fuses or capacitors is straightforward** [41]. TCI also offers accessories like **vibration-isolation pads to**

reduce noise (passive filters can produce an audible hum from the reactor) [22], and floor-mounting kits or stands for larger enclosures to simplify installation [22].

- **Wide Range of Configurations:** The HGL series covers a broad range of power ratings and application needs. Standard units are available for **common three-phase voltages (208 V, 240 V, 480 V, 600 V at 60 Hz, and 380–415 V at 50 Hz)** [42], covering motor sizes from approximately **5 HP up to 1250 HP** (5–1250 HP at 480/600 V, or roughly 4 kW to 1000 kW at 400 V) [43]. This makes HGL suitable for everything from small pump VFDs to large industrial drive systems. Three enclosure or packaging styles are offered: **Open chassis (IP00)** units can be integrated inside larger panels or MCCs, **NEMA 1 enclosed** filters are designed for indoor installations, and **NEMA 3R enclosed** versions are built for outdoor or demanding environments [44]. TCI specifically developed **"Oilfield Duty"** HGL models for use in oil & gas fields – these incorporate enhanced components (e.g. higher endurance capacitors, ruggedized reactors) to withstand the additional electrical stress of **cyclical loads and harsh temperatures**, and they come in 3R outdoor enclosures suitable for remote well pads [35] [45]. Oilfield duty HGL filters cover popular pump drive sizes (roughly 40 HP through 200 HP and above) and are engineered to handle rapid load changes without performance degradation [46]. In all cases, the filter packages are designed to be as compact and installation-friendly as possible. For instance, a 20 HP open chassis HGL module measures about 20″ H × 17″ W × 12″ D and weighs ~65 lbs [47], while larger enclosures include lifting provisions and optional floor stands for ease of handling. This flexibility in configurations means **users can select an HGL filter to fit virtually any VFD installation, whether it's retrofitting an existing cabinet or wall-mounting a standalone filter next to a drive**.

Technical Specifications

The table below summarizes key technical specifications of the TCI HGL HarmonicGuard Low Capacitance filter series:

- **Voltage & Frequency:** 208 V, 240 V, 480 V, 600 V AC (±10%) for 60 Hz systems; also compatible with 380–415 V AC for 50 Hz applications [42].
- **Power Rating:** Standard models cover **5 HP up to 1250 HP** at 480/600 V (approximately 4 kW to 1000 kW). At lower voltages (208–240 V), up to 200 HP is supported, and at 50 Hz up to ~1000 kW [43]. Multiple filter units can be paralleled for larger loads if needed.
- **Harmonic Mitigation:** Achieves **≤5% Total Harmonic Current Distortion (THID)** at full load on a 6-pulse VFD system (with drive input impedance present and ISC/IL ≤ 20) [12]. The standard HarmonicGuard filters maintain ≤5% THID down to ~50% load; the low-capacitance HGL version is optimized for full-load performance (THID rises at lighter loads but remains well below unfiltered levels) [16].
- **Efficiency & Losses:** Filter efficiency is high; losses are primarily from the reactor. For example, a 20 HP, 480 V HGL has about **234 W of loss** (approximately 1.5% of load) [48]. Larger units have proportionally similar loss percentages, and all heat is convection-cooled (no fans required in passive filters).
- **Power Factor Correction:** The HGL provides a small amount of capacitive reactive power (varies by model, e.g. ~3 kVAR for a 20 HP unit [48]) to offset the VFD's inductive demand. This typically raises displacement power factor to near unity. Combined with harmonic filtering (which removes distortion reactive power), the filter helps improve **true power factor** of the system (often to 0.95 or better under load) [18].

- **Enclosure Types:** Available as **Open Type (chassis mount)**, **NEMA 1 (ventilated indoor)**, or **NEMA 3R (outdoor-rated)** enclosures [22]. Open units are often panel-integrated, while NEMA 1 and 3R enclosures have hinged doors for access and can be wall or floor mounted. All enclosures are steel with durable finishes suitable for industrial environments.
- **Protection & SCCR:** Each filter includes a fused branch circuit on the capacitors for short-circuit protection [12]. The assembly is rated for up to **100 kA Short-Circuit Current** (when protected by proper upstream fusing or circuit breaker) [39]. This high SCCR facilitates use in facilities with large transformers or heavy industrial power systems. The filter's inductors also inherently limit surge currents, and the capacitors are discharge-protected.
- **Thermal & Environmental:** HGL filters are designed for a **-40°C to +50°C** operating ambient in open chassis format, or up to 40°C in enclosed (NEMA 1/3R) format without derating [49]. Altitude up to 2000 m is supported without derating; higher elevations can be accommodated with adjustments [50]. The filters are **naturally cooled** (convection air flow through enclosures); larger enclosed models include louvers and ventilation space but no fans (no moving parts for high reliability) [51].
- **Controls & Connectivity: PQconnect intelligent module (optional):** provides Bluetooth connectivity, **Modbus RTU (RS-485) and EtherNet/IP** communication for monitoring/data [29]. The Bluetooth range is suitable for near-field (maintenance personnel can connect via smartphone app on-site), while the EtherNet/IP allows integration into plant networks. PQconnect modules are powered by an internal control power transformer when installed.
- **Compliance and Certification:** UL 508A Listed Panel (cULus), CE compliant (for applicable models), and **RoHS/FCC compliant** for electronic components [36]. Meets IEEE-519 (2014 & 2022) guidelines for current distortion at PCC when properly applied [52] [53]. TCI is ISO 9001 certified, and HGL filters are built in the USA with full factory testing.

(Above specifications are based on TCI's product documentation and brochures. For detailed model-specific data, refer to the official TCI HGL datasheets and user manual.)

Typical Applications and Use Cases

HGL harmonic filters can be used anywhere six-pulse VFDs or other harmonic-producing devices are present and power quality needs improvement. Some **common applications** include:

- **Oil & Gas Fields and Remote Pumping Stations:** In oilfield operations, VFD-driven pump jacks or submersible pumps are often powered by diesel generators or microgrids. Here, the HGL filter's generator-friendly design is invaluable. For example, in multi-well pad drilling sites, using low-capacitance filters prevents leading power factor and allows **smaller generators to run multiple VFDs without voltage instability** [10] [54]. The HGL's outdoor-rated, ruggedized versions (with oilfield duty components) are built to handle these harsh, cyclical load conditions. By keeping harmonics under 5%, they also protect onsite transformers and equipment – avoiding the overheating and nuisance trips that unmitigated harmonics could cause in remote installations.

- **Water and Wastewater Treatment Plants:** Municipal pump stations and treatment facilities use many VFDs on pumps, blowers, and mixers. These sites must meet IEEE-519 limits to avoid penalization or interference with the utility. HGL filters (or their standard HGP counterparts) are frequently applied on each drive or at group MCC feeds. **Case in point:** a wastewater treatment plant in Indiana retrofitting its pump VFDs chose TCI passive filters with PQconnect so that the operators could centrally monitor harmonic levels and remotely control filter contactors [55] [56]. In

another project, passive filters on 125 HP and 350 HP pump motors successfully **reduced the total harmonic distortion to <5% TDD**, ensuring the upgraded stations met compliance [57] [34]. These filters solve issues like excessive transformer heating and help maintain voltage quality for other users on the same feeder. Water/wastewater applications often appreciate the HGL's high SCCR (since fault currents in utility pump stations can be very high) and the improved true power factor (which can reduce utility reactive charges).

- **HVAC Systems in Commercial Buildings:** Large HVAC installations – such as chillers, cooling towers, and air handlers in hospitals or high-rise buildings – commonly use VFDs to save energy. However, those VFDs can introduce harmonics that interfere with sensitive equipment (imagine harmonics affecting hospital imaging machines or data center operations). Installing HGL filters on these HVAC drive inputs helps maintain clean power in the facility. The filters also correct the facility power factor, which can be crucial in avoiding utility penalties on large commercial electrical services. Because the HGL filters are available in compact NEMA 1 enclosures, they can be wall-mounted in mechanical rooms. Facility managers benefit from the **PQconnect monitoring to track power quality metrics** and ensure the building stays within compliance. In one example, a potato storage warehouse with heavy cooling loads added passive (and active) filters after experiencing voltage distortion on a weak rural grid – after filtering, the plant **avoided utility penalties and no longer impacted neighboring businesses** with its VFD harmonics [58].

- **Industrial Manufacturing and Automation:** Any plant with a high concentration of motor drives, rectifiers, or DC power supplies can experience harmonic problems. Industries such as automotive manufacturing, metals processing, electronics, and printing have all implemented harmonic filters as a solution. The HGL filter's flexibility to work with any brand of drive is a big advantage – for instance, a plant could have ABB drives on some machines and Rockwell/Allen-Bradley on others, yet use a common TCI HGL filter on each to standardize harmonic mitigation. Because the HGL is a **stand-alone device installed on the line side of a drive**, it does not require any special integration into the VFD itself. This makes retrofitting existing equipment feasible without major changes. Moreover, compared to active harmonic filters, the passive HGL has no ongoing tuning or programming needs – once installed, it functions automatically. **General plant benefits** include reduced heat in transformers and switchgear, fewer unexplained breaker trips, and improved reliability of sensitive instrumentation. Many facilities also find that mitigating harmonics with filters extends the life of their motors and drives (since the filters also block some high-frequency disturbances and reduce DC bus ripple in the drives).

- **Backup Generator-Powered Systems:** Facilities that run critical processes on backup generators (such as hospitals, data centers, or marine vessels) often face a dilemma – VFDs are needed for efficiency, but generator voltage regulators can struggle with the poor power factor and harmonics from those drives. The HGL filter is an ideal solution in this scenario. By greatly reducing the harmonic content, it prevents generator voltage waveform distortion and controller instability. And by virtually eliminating leading VARs at no-load (especially with the contactor feature engaged), it avoids the dangerous over-voltage condition that can occur on lightly loaded generator-fed drives. In practice, this means, for example, an HVAC chiller VFD in a hospital can remain connected to an HGL filter at all times, even when the hospital switches to generator power – the generator sees a manageable, mostly resistive load from that VFD system [10] [23]. Many consulting engineers specify low-capacitance filters like HGL as part of emergency power system design to ensure compatibility. The **ability to monitor filter status via PQconnect over a building management system** is

another plus, providing confidence that the filter is active and effective when running on generator supply.

Conclusion

The **TCI HGL HarmonicGuard Low Capacitance filter** series represents a robust, innovative approach to harmonic mitigation. By combining proven passive filter technology (reactors and capacitors tuned for 5% THD performance) with an intelligent low-kVAR design, the HGL filters solve the perennial problems of harmonics **without introducing the side-effects (like leading power factor)** that have traditionally plagued passive filters on generators [19] [20]. Users gain the ability to **meet IEEE-519 harmonic standards** and eliminate nuisance power quality issues, all while maintaining compatibility with backup generators and **improving overall system power factor**. The HGL's **advanced features** – such as automatic capacitor disconnect, Bluetooth/Ethernet connectivity, and predictive health monitoring – bring passive filters into the modern era of smart power systems. They provide operators with insight and control over power quality in a way that was not possible with earlier "fit and forget" filter designs.

From oilfields and municipal plants to commercial buildings and factories, TCI's HGL filters are helping facilities around the world **prolong the life of electrical equipment and ensure reliable, clean power** [59] [60]. They allow engineers to **use standard 6-pulse drives (from any manufacturer) with confidence**, knowing that an HGL filter will mitigate the harmonics to acceptable levels and keep the network healthy [61]. In an era where energy efficiency and power quality are both paramount, the HGL harmonic filter provides an elegant solution that addresses both: it enables the energy savings of VFDs **without the drawback of harmonic pollution**. By choosing the HGL series, users get the best of both worlds – **cost-effective harmonic compliance and a smarter, more adaptable power quality device** that stands out among passive filters. In summary, TCI's HGL harmonic filters are a **comprehensive power quality solution** that helps customers **solve harmonic problems, protect their systems, and optimize performance** in a wide range of applications.

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