



PQI HarMitigator™ Product Review

**Type PV Power TransFilter™
Medium Voltage, Dry-Type & Cast Coil Transformers
for High K-Factor, Phase-to-Neutral Connected Nonlinear Loads
with an integrated Type TPM Transformer Performance Meter™**

Product Description

Type PV harmonic mitigating Power TransFilters™ exceed all existing and pending energy efficiency requirements under nonlinear loading.

Type PV transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading (<15% FL). This benefit is achieved by using higher quality, grain oriented silicon core steel and full and step-lap miter-cut cores with reduced laminations per group.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses become significant at approximately 15% FL.

Excitation and Impedance Losses are approximately equal at 50% FL under linear loading. Type PV Power TransFilters™ exceed the efficiency requirements of DOE 2016 under linear loading. Optional e-Rated® units exceed these efficiency requirements under moderate nonlinear loading ($\leq K-13$). Type PV transformers' published efficiencies can be matched to anticipated or measured average loading above 50% FL, when required.

Type PV Power TransFilters™ are three-phase, single or multi-output power transformers that have been specifically designed to supply three-phase and single-phase-to-neutral connected, nonlinear electronic loads. When properly applied, these harmonic mitigating transformers reduce voltage distortion to less than 5% THD_V at their loads.

Type PV transformers cancel positive- and negative-sequence harmonic currents at their common primary bus or within their multi-output secondary windings. They are available in a number of standard primary-to-secondary phase-shifts so that they may be used to create twelve-, eighteen- or twenty-four-pulse systems. In addition, Type PV transformer's secondary windings are configured to cause the cancellation of all load-generated third-order zero-sequence flux in the core's magnetic circuit.

Type PV Power TransFilters™ may be used as 'stand-alone' mitigation solutions (i.e. without zero-sequence harmonic filters) if THD_I levels are less than 40% or transformer loading is $\leq 40\%_{FL}$.

Alternatively, Type PV units may be used at higher THD_I and load levels if I₀Filters™ zero-sequence harmonic filters are used to shunt zero-sequence harmonic currents at remote switchboards and/or panels. The application of I₀Filters™ will improve any limitations on circuit length and/or loading. These limitations are graphically detailed in two PQI Publications entitled: 'Neutral-to-Ground Voltage vs. Branch Circuit Length & Loading for Typical Nonlinear Electronic Workstation Loads' and: 'Neutral-to-Ground Voltage vs. Branch Circuit Length & Loading for Typical Nonlinear Electronic Gaming Machine Loads'.

Type PV units are cost-effective alternatives to K-Rated power transformers, which are only intended to survive in a harmonic environment, and de-rated power transformers. These conventional transformers cannot reduce harmonic related 'penalty losses' or voltage distortion. Type PV harmonic mitigating Power TransFilters™ provide the most attractive 'payback' and 'return-on-investment' in the industry

Application

Type PV Power TransFilters effectively reduce voltage distortion (THD_V) at their subsystem's loads, the principal cause of reduced load efficiency. Type PV Power TransFilters are ideally suited for new construction or when replacing older transformers with historically low efficiencies as part of a power system optimization and energy reduction plan.

Type DV e-Rated® Distribution TransFilter™ Ultra-Efficient, Low Voltage, Dry-Type Isolation Transformer for High K-Factor, Phase-to-Neutral Connected Nonlinear Loads with an integrated Type TPM Transformer Performance Meter™

Product Description

Type DV harmonic mitigating Distribution TransFilters™ exceed all existing and pending energy efficiency requirements under nonlinear loading.

Type DV transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading (<15% FL). This benefit is achieved by using higher quality, grain oriented silicon core steel in the Unicore™ cores of lower kVA ratings and in the full and step-lap miter-cut cores, with reduced laminations per group, in higher kVA ratings.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses increase rapidly above 15% FL; particularly when the transformer's loads are nonlinear. To maintain energy efficiency, Type DV Distribution TransFilters' ultra-low zero-sequence impedance flux cancellation windings maintain published efficiencies at 35% FL. Type DV transformers' published efficiencies can be matched to anticipated or measured average loading above 35% FL, when required.

Application

Type DV Distribution TransFilters' ultra-low zero-sequence impedances effectively reduce voltage distortion (THD_V) at their subsystem's loads, the principal cause of reduced load efficiency. Type DV transformers are ideally suited for new construction or when replacing older transformers with historically low efficiencies as part of a power system optimization and energy reduction plan.

Type GY e-Rated® Distribution TransFilter™ Ultra-Efficient Transformers and Load Centers for 240V Phase-to-Phase Connected Gaming Machines with an integrated Type TPM Transformer Performance Meter™

Product Description

Type GY harmonic mitigating Distribution TransFilters™ exceed all existing and pending energy efficiency requirements under nonlinear loading.

Type GY transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading (<15% FL). This benefit is achieved by using higher quality, grain oriented silicon core

steel in the Unicore™ cores of lower kVA ratings and in the full and step-lap miter-cut cores, with reduced laminations per group, in higher kVA ratings.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses increase rapidly above 15% FL; particularly when the transformer's loads are nonlinear. To maintain energy efficiency, Type GY Distribution TransFilters, with ultra-low zero-sequence impedance flux cancellation windings, maintain published efficiencies at 35% FL. Type GY transformers' published efficiencies can be matched to anticipated or measured average loading above 35% FL, when required.

Application

Type GY Distribution TransFilters' 240-volt secondary windings are connected in a 'wye' configuration with the X_0 terminal solidly grounded. This configuration clamps phase-to-ground voltage at 139-volts ($240V/\sqrt{3}$) during phase-to-ground system fault. The transformers' 240-volt outputs reduce load current and all positive- and negative-sequence harmonic currents by 50%, when compared to a 120V, 60Hz source, or 4%, when compared to 231V, 50Hz source. Type GY transformers eliminates zero-sequence harmonic current, resulting in a significant reduction in heat and A/C loading.

Type GY transformers are ideally suited for new construction or when replacing older transformers with historically low efficiencies as part of a power system optimization and energy reduction plan.

Type SY *e-Rated*® Distribution TransFilter™ Ultra-Efficient, Phase Current Balancing Isolation Transformer for Phase-to-Phase Connected Server Loads with an integrated Type TPM Transformer Performance Meter™

Product Description

Type SY *e-Rated*® low voltage dry-type isolation transformers exceed all existing and pending energy efficiency requirements. Energy efficiency requirements are determined at 35% of the transformer's full load (FL) rating. As a result, manufacturers generally optimize their transformers' efficiencies at approximately 35% FL.

Type SY transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading (<15% FL). This benefit is achieved by using higher quality, grain oriented silicon core steel in the Unicore™ cores of lower kVA ratings and in the full and step-lap miter-cut cores, with reduced laminations per group, in higher kVA ratings.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses increase rapidly above 15% FL; particularly when the transformer's loads are nonlinear. To maintain energy efficiency, Type SY *e-Rated*® transformers' peak efficiencies can be matched to anticipated or measured average loading above 35% FL.

Application

Type SY transformers' 240-volt or 230-volt secondary windings are connected in a modified 'wye' configuration which is solidly grounded. This configuration clamps their phase-to-ground voltages at 139-volts ($240V/\sqrt{3}$) or 133-volt ($230V/\sqrt{3}$) during normal operation or a phase-to-ground system fault. The transformers' 240/230-volt outputs reduce their servers' load currents by 15.4% and I^2R losses by more than 33.2%, when compared to conventional 208-volt sources. This results in a matching reduction in generated heat and A/C loading, and increase in efficiency.

Operating the feeder circuits and transformer output at 240 or 230-volts will produce similar load current and I^2R loss reductions. Although most of these circuits are outside the rack enclosures, power and AC loads will be reduced.

Type SY transformer core and coils are available for installation in Power Distribution Units. They can be configured to match virtually any requirement.

Type Z e-Rated[®] I₀Filter™ **Ultra-Efficient, Low Voltage, Zero-Sequence Harmonic Filter** **for High K-Factor, Phase-to-Neutral Connected Nonlinear Loads**

Product Description

Type Z e-Rated[®] I₀Filters™ are highly effective, three-phase, four-wire, passive electromagnetic filters with ultra-low zero-sequence impedances. These filters have been specifically designed to provide a parallel path for all zero-sequence harmonic currents that are generated by phase-to-neutral connected nonlinear electronic loads. Power quality benefits are optimized when filters are installed as close as possible to these electronic loads.

Type Z filters are normally installed at all sub-panels that supply single-phase nonlinear electronic loads via a three-phase circuit breaker. Whether specified at the design stage for new construction or applied in an existing sub-system, these filters are normally sized for potential zero-sequence harmonic current levels. This application philosophy eliminates the need to increase filter capacity as zero-sequence loading increases over time.

Type Z filters alone will normally achieve the recommendations and requirements of IEEE Std. 519-1992 in single-phase, nonlinear load environments. When it becomes necessary to also mitigate the power quality problems associated with positive- and negative-sequence harmonic currents, zero-sequence harmonic filters may be applied in combination with Type DY or DV Distribution TransFilters™.

Type YV directional I₀Filters™ are normally applied in series with sub-panels that supply single-phase nonlinear electronic loads. Whether specified at the design stage for new construction or applied in an existing sub-system, these filters are normally sized for connected kVA loading. Type YV filters may also be used to mitigate positive- and negative-sequence harmonic currents.

The application of zero-sequence harmonic filters will reduce the power quality limitations on branch circuit length and/or loading. These limitations are graphically detailed in two PQI publications entitled: (i) *'Neutral-to-Ground Voltage vs. Branch Circuit Length & Loading for Typical Nonlinear Electronic Workstation Loads'* and (ii) *'Neutral-to-Ground Voltage vs. Branch Circuit Length & Loading for Typical 120V Nonlinear Electronic Gaming Machine Loads'*.

Type Mini-Z[®] e-Rated[®] I₀Filters™

When branch circuits' neutral-to-ground voltages and voltage distortions cannot be economically controlled by other means, Mini-Z[®] zero-sequence harmonic filters may be applied at the load-end of three-phase, four-wire 'shared neutral' branch circuits or three-phase, six-wire branch circuits.

In 'landscaped' office environments, filters may be conveniently connected to pre-wired partitions via the partition manufacturer's standard wire-way connection cable as shown. Where the partitions are not

pre-wired or in private office applications, filters may be connected at branch circuits' 'home run' junction boxes.

The application of Mini-Z[®] filters in new distribution systems eliminates the need to oversize 'shared neutral' conductors or install separate neutral conductors for each phase in the branch circuit. Similarly, the application of filters in existing systems eliminates the need to replace branch circuits with undersized 'shared neutrals'. In either case, Mini-Z[®]s will eliminate the need to de-rate circuits or panels. The de-rating of conventional distribution transformers can be reduced from approximately 45% to less than 15%. As a result, filters significantly reduce capital costs and power costs while providing significant performance and power quality improvements.

Mini-Z[®] filters alone will normally achieve the recommendations and requirements of IEEE Std. 519-1992 in single-phase, nonlinear load environments. When it becomes necessary to mitigate the power quality problems associated with positive- and negative-sequence harmonic currents, these filters may also be applied in combination with Type 'DY' or 'DV' Distribution TransFilters.

Application

Type Z & Mini-Z[®] I₀Filters™, with ultra-low zero-sequence impedance flux cancellation windings, effectively reduce voltage distortion (THD_v) at their circuits' loads, the principal cause of reduced load efficiency. I₀Filters™ are ideally suited for new construction or as part of a power system optimization and energy reduction plan.

Type DD e-Rated[®] Drive TransFilter™ Ultra-Efficient, Low Voltage, Dry-Type Isolation Transformer for Medium K-Factor, Nonlinear Type 1 Motor Drives with an integrated Type TPM Transformer Performance Meter™

Product Description

Type DD harmonic mitigating Drive TransFilters™ exceed all existing and pending energy efficiency requirements under nonlinear loading.

Type DD transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading (<15% FL). This benefit is achieved by using higher quality, grain oriented silicon core steel in the Unicore™ cores of lower kVA ratings and in the full and step-lap miter-cut cores, with reduced laminations per group, in higher kVA ratings.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses increase rapidly above 15% FL; particularly when the transformer's loads are nonlinear. To maintain energy efficiency, Type DD Drive TransFilters™ maintain published efficiencies at 35% FL. Type DD transformers' published efficiencies can be matched to anticipated or measured average loading above 35% FL, when required.

Application

Type DD Drive TransFilters mitigate the power quality problems associated with three-phase, six- and twelve-pulse drives. Unlike conventional drive isolation transformers, which are only intended to provide positive- and negative-sequence impedance, and isolation, Type 'DD' transformers will cancel the 5th, 7th, 11th, 13th, 17th, 19th, --- positive- and negative-sequence harmonic currents on their common primary bus or within their multi-output secondary windings. They are available in a number of standard

primary-to-secondary phase-shifts so that they may be used to create twelve-, eighteen- or twenty-four-pulse systems.

Type MGF Motor Guard Transient Filter

The Problem

The steep voltage wave fronts of the Pulse Width Modulated (PWM) output of Adjustable Frequency Drives (AFD's) produce high frequency effects which may damage the insulation of motors operated by the drive. The problems result from two distinct effects.

1. High DV/DT Effects

The rapid rate of voltage rise (dv/dt) at the leading edges of each output pulse of the PWM inverter produces an uneven distribution of voltage within the motor windings. The result is a concentration of the voltage at the motor terminal end of the winding causing abnormal stress leading to the breakdown of the motor's insulation. This phenomenon has been described as "first coil breakdown" and is well documented.

2. Reflections in Long Lines and Cables

A long cable, in addition to resistance, has distributed inductance and capacitance, producing effects similar to a transmission line as shown in Figure 1.

The high frequencies present in the output of PWM waveforms cause reflections in long conductors connecting the motors to the drives as shown in Figure 2. Harmful effects with conductors as short as 10 meters have been observed. However, the effects are most severe with cables of lengths greater than 50 meters leading to more than doubling of the applied voltage. This can translate to voltage peaks approaching 1360V in 480V systems or 1600V in 575V systems.

The combination of these two effects stresses the winding insulation considerably beyond design limits and has been known to shorten the insulation life and in some instances lead to early catastrophic failure of motors.

The Solution

It has been demonstrated that these transient effects can be reduced by using filters placed at the output of the AFD's, thereby allowing safe operation of the motors and an expectation of full insulation life (see fig. 3). After years of experience and research, Power Quality International has developed a comprehensive line of state of the art output filters suitable for a wide range of prospective applications. The filters are constructed using optimized combinations of inductors and resistors.

Type ACR Air Core Reactor Cast Coil & Resin Impregnated Construction Up to 45kV, 200kV BIL

Product Description

Windings are manufactured with aluminum or copper, (strip or shaped conductors in parallel where necessary) arranged on layers or discs with special consideration given to minimize eddy current

losses. The insulating materials used during production are always UL listed systems. To suit various applications and environmental conditions PQI Dry Type Air Core Reactors are manufactured using our multiple VPI and Epoxy Impregnation system. For harsh conditions PQI offers Reactors that are solidly cast in epoxy in special molds filled under vacuum.

Reactors can be supplied either as single-phase coils individually supported on insulators or as three phase coils stacked vertically.

A variety of custom enclosure designs are available to shield and protect the reactors magnetically and environmentally.

Type 'HQ' Active HarmVAr Filter

Product Description

The PQI Type 'HQ' Active HarmVAr Filter optimizes power system performance by combining the use of proven IGBT technologies with leading edge DFT/FFT algorithms enabling the simultaneous and/or discrete execution of harmonic (VArH) and reactive (VArQ) compensation methods in real-time.

The active filter's unique design and unequalled performance enable it to be successfully applied in virtually any power distribution system where power quality, reliability and efficiency are necessities. Depending upon its location within the system, the filter can provide harmonic or reactive VAr compensation for the entire system or specific loads.

As a result, the filter can be credited with helping to reduce operation and maintenance costs by:

- Preventing the need to oversize power distribution equipment in anticipation of the presence of harmonic current and poor power factor
- Reducing harmonic current related 'penalty losses' and overheating of conductors, distribution equipment and transformers
- Reducing downtime associated with nuisance tripping of overcurrent protective devices (OCPDs) caused by thermal overload
- Increasing overall system reliability

Application

A solution for electrical distribution systems that demand stable, reliable power characterized by unparalleled power quality and efficiency. Applications where PQI Type 'HQ' Active HarmVAr Filters are often applied include commercial, industrial, institutional, military, mining, municipal, solar, wind turbine and many others.

Type TPM Integrated Transformer Performance Meters™ CSA C802.5 & IEEE Std. C57.110 Compliant for Nonlinear Load Performance LEED® Qualified for EA Credit Points

Product Description

Type TPM Integrated Transformer Performance Meters™ are installed on all PQI e-Rated™ Distribution Class Transformers. In addition to their revenue class metering and data logging

capabilities, these integrated meters, with CSA C802.5 compliant software, determine each transformer's Total Losses and Efficiency under their measured nonlinear loading profiles.

In addition, IEEE Std. C57.110 compliant software also determines each transformer's No-Load Losses and Load Losses, including its nonlinear 'Penalty Loss' component and EPA Environmental Benefits. In its 'transformer comparison mode', given the cost of each transformer and the cost of energy, the software will also compare the performance of any two transformers, including A/C costs, and calculate an annual saving, payback and return-on-investment, in a 'substitution' or 'before end-of-life replacement' scenario.

These best-in-class multifunction power and energy meters may be used as data gathering devices for intelligent electrical distribution systems or plant automation systems. All monitored data is available via a digital RS485 communication port running Modbus RTU and DNP 3.0 protocols. Additional communication options include Ethernet, Profibus DP, and BACnet. With its flexible, modular I/O and communication options, the Type TPM metering system is the most versatile and cost-effective solution available.

Application

Type TPM Transformer Performance Meters are factory installed on all e-Rated[®] low voltage, dry-type, harmonic mitigating and distribution class transformers, if specified by the system designer. Type TPM meters, with appropriate current transformers, are also available as a retrofit kit for installation on any transformer.

The meter enclosure, which is isolated from the transformer enclosure, contains current transformer shorting blocks, control power and voltage measurement HRC fused-switches, and a grounding terminal for the current transformers, meter and meter enclosure. Control power may be supplied from a separate secure or uninterruptable source, or from the transformer's secondary terminals, if within the meter's voltage range.

The separate meter enclosure allows the engineer or a qualified electrician to isolate, modify or remove the meter for any purpose, without exposure to the open transformer's energized components.

PQI Environmentalist™ Product Review

Type PY Power TransFilter™

**Medium Voltage, Dry-Type & Cast Coil Transformers
for Medium K-Factor Three-Phase Nonlinear Loads
with an integrated Type TPM Transformer Performance Meter™**

Product Description

Type PY harmonic mitigating Power TransFilters™ exceed all existing and pending energy efficiency requirements under nonlinear loading.

Type PY transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading (<15% FL). This benefit is achieved by using higher quality, grain oriented silicon core steel and full and step-lap miter-cut cores with reduced laminations per group.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses become significant at approximately 15% FL. Excitation and Impedance Losses are approximately equal at 50% FL under linear loading. Type PY transformers exceed the efficiency requirements of DOE 2016 under linear loading. Optional e-Rated[®] units exceed these efficiency requirements under

moderate nonlinear loading ($\leq K-9$). Type PY transformers' published efficiencies can be matched to anticipated or measured average loading above 50% FL, when required.

Type PY Power TransFilters™ are three-phase, single or multi-output power transformers that have been specifically designed to supply three-phase and single-phase-to-neutral connected, nonlinear electronic loads. When properly applied, these harmonic mitigating transformers reduce voltage distortion to less than 5% THD_V at their loads.

Type PY transformers cancel positive- and negative-sequence harmonic currents at their common primary bus or within their multi-output secondary windings. They are available in a number of standard primary-to-secondary phase-shifts so that they may be used to create twelve-, eighteen- or twenty-four-pulse systems.

Type PY Power TransFilters™ may be used as 'stand-alone' mitigation solutions (i.e. without zero-sequence harmonic filters) if THD_I levels are less than 40% or transformer loading is $\leq 40\%_{FL}$.

Alternatively, Type PY units may be used at higher THD_I and load levels if I₀Filters™ zero-sequence harmonic filters are used to shunt zero-sequence harmonic currents. The application of I₀Filters™ will improve any limitations on circuit length and/or loading. These limitations are graphically detailed in two PQI Publications entitled: 'Neutral-to-Ground Voltage vs. Branch Circuit Length & Loading for Typical Nonlinear Electronic Workstation Loads' and: 'Neutral-to-Ground Voltage vs. Branch Circuit Length & Loading for Typical Nonlinear Electronic Gaming Machine Loads'.

Type PY units are cost-effective alternatives to K-Rated power transformers, which are only intended to survive in a harmonic environment, and de-rated power transformers. These conventional transformers cannot reduce harmonic related 'penalty losses' or voltage distortion. Type PY harmonic mitigating Power TransFilters™ provide the most attractive 'payback' and 'return-on-investment' in the industry.

Application

Type PY Power TransFilters effectively reduce voltage distortion (THD_V) at their subsystem's loads, the principal cause of reduced load efficiency. Type PY Power TransFilters are ideally suited for new construction or when replacing older transformers with historically low efficiencies as part of a power system optimization and energy reduction plan.

Type EY e-Rated® Distribution Transformer Ultra-Efficient, Low Voltage, Dry-Type Isolation Transformer with an integrated Type TPM Transformer Performance Meter™

Product Description

Type EY e-Rated® low voltage dry-type isolation transformers exceed all existing and pending energy efficiency requirements. Energy efficiency requirements are determined at 35% of the transformer's full load (FL) rating. As a result, manufacturers generally optimize their transformers' efficiencies at approximately 35% FL.

Type EY transformers' ultra-low Excitation (no-load) Losses provide high efficiency during periods of light-loading ($< 15\% FL$). This benefit is achieved by using higher quality, grain oriented silicon core steel in the Unicore™ cores of lower kVA ratings and in the full and step-lap miter-cut cores, with reduced laminations per group, in higher kVA ratings.

Unlike Excitation Losses, which are constant from no-load to full-load, Impedance (load) Losses increase rapidly above 15% FL; particularly when the transformer's loads are nonlinear. To maintain energy efficiency, Type EY e-Rated® transformers' peak efficiencies can be matched to anticipated or measured average loading above 35% FL, when required.

Application

Type EY e-Rated[®] transformers provide ultra-efficient alternatives to conventional delta-wye or K-Rated distribution transformers. Type EY transformers are ideally suited for new construction or when replacing older transformers with historically low efficiencies as part of a power system optimization and energy reduction plan.

Note: These products are available at www.powerqualityinternational.com as pdf files.