

The Voltage & Current Difference, Loss Measurement Method
 validates the CSA C802.5 Calculator™, The PQI Calculator™
 and the Type TPM Transformer Performance Meter™



under Linear or Nonlinear Loading, with an Efficiency Error of ±0.033%

Excitation (No Load) Losses

Impedance (Load) Losses

$$P_m \approx \frac{1}{T} \int_0^T (v_1 - v_2 K_t) i_2 dt + \frac{1}{T} \int_0^T i_{21} v_{1A} dt + \frac{1}{T} \int_0^T i_{21} v_{AC} dt$$

Resulting Efficiency Calculation Error

Total Losses Measurement Error

PQI Transformer Efficiency

PQI Power and Distribution Class Transformers meet or exceed the US DOE 2016 energy efficiency requirements. Ultra-efficient Z3 and Z3+ **e-Rated**® transformers meet or exceed DOE CSL 3 efficiencies, while Z4 **e-Rated**® transformers meet US DOE CSL 4 efficiencies.

PQI **e-Rated**® Power and Distribution Class TransFilters™ (harmonic mitigating transformers) meet or exceed the US DOE 2016 energy efficiency requirements under the nonlinear load profiles for which they are designed.

The 'real world' operational efficiency of any delta-wye connected transformer can be verified after installation by populating the **CSA C802.5 Calculator**™ with the Load Factor and Harmonic Current Profile obtained from the transformer's integrated Type TPM Transformer Performance Meter.

Similarly, the efficiency of any transformer, including harmonic mitigating transformers with zero-sequence flux cancellation and/or primary-to-secondary phase shifting, can be verified with **The PQI Calculator**™. This calculator can also compare the performance of any two transformers, including their Losses and Efficiencies, harmonic current-generated Penalty Losses, the Annual Savings produced by the more efficient transformer, the Financial Benefits (payback & ROI) and a Summary of EPA Environmental Benefits. Based on their load's harmonic profile, the calculator will also determine the load's %THD_i, K-Factor and HLF (Harmonic Load Factor).

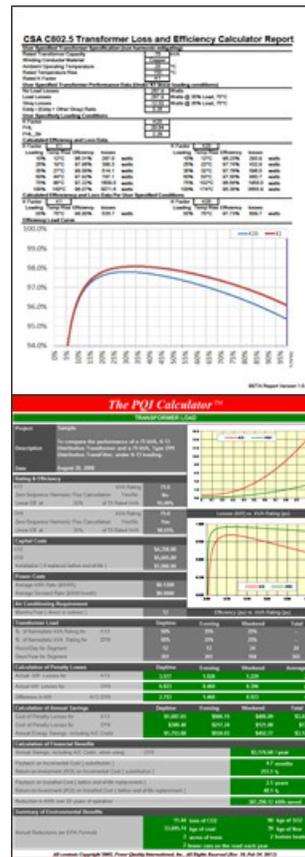
The PQI Solution™

IEEE Std. 519-1992 (*IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*) compliance is the first step in achieving power system optimization and energy efficiency improvement. The reduction of harmonic currents in the electrical distribution system and voltage distortion at its loads is essential.

In North America, 480V systems often supply three-phase motor drives and single-phase, phase-to-neutral connected lighting loads. Virtually all 208/120V system loads are single-phase, phase-to-neutral connected. These nonlinear loads generate positive- and negative-sequence harmonic currents. The phase-to-neutral connected loads also generate high levels of zero-sequence harmonic current.

Harmonic mitigating transformers and zero-sequence harmonic filters can be used to mitigate these load-generated harmonic currents and reduce voltage distortion at the loads. Filters can also provide phase current balancing and reduce neutral-to-ground voltage at the loads $\leq 5V$ per ITIC or $\leq 4V$ per International Gaming Technology (IGT) requirements.

Given a facility's electrical distribution system drawings, panel schedules and load types, PQI engineers can determine the nonlinear loads' probable impact on power quality and energy efficiency. Analysis software can be used to confirm the desired outcomes when system alterations and/or apparatus alternatives are recommended.



CSA C802.5 Calculator™



Distribution TransFilter™ with an integrated Type TPM Transformer Performance Meter™

The PQI Calculator™

PQI engineers use the **CSA C802.5 Calculator**™ or **The PQI Calculator**™ to quickly and accurately determine the total losses and efficiency of a specified or 'as found' transformer under its anticipated or measured nonlinear load profile. **The PQI Calculator**™ can then be used to compare this transformer with an alternative proposed by PQI in a substitution or before end-of-life replacement scenario. The CSA and PQI calculators are IEEE Std. C57.110 compliant.

Given the cost of each transformer, or a single transformer in a replacement scenario, and the utility rates, the software can calculate the annual energy savings, including A/C costs, payback and return-on-investment, and EPA environmental benefits.

Power Quality International offers these engineering services, in support of its potential product applications, on a 'no charge' basis to system designers. With the implementation of our proposals, PQI will guarantee compliance with IEEE Std. 519-1992 recommendations regarding the utility's 'point of common coupling' requirements and voltage distortion at the system's loads.

Given sufficient information in a new construction scenario, PQI will also estimate financial and EPA benefits. In transformer replacement scenario, PQI will guarantee a financial outcome and act on behalf of the facility owner to obtain rebates offered by their local electrical utility.