POWER QUALITY INTERNATIONAL

PRODUCT SHEET

Type SDV e-Rated® Smart Distribution TransFilter™

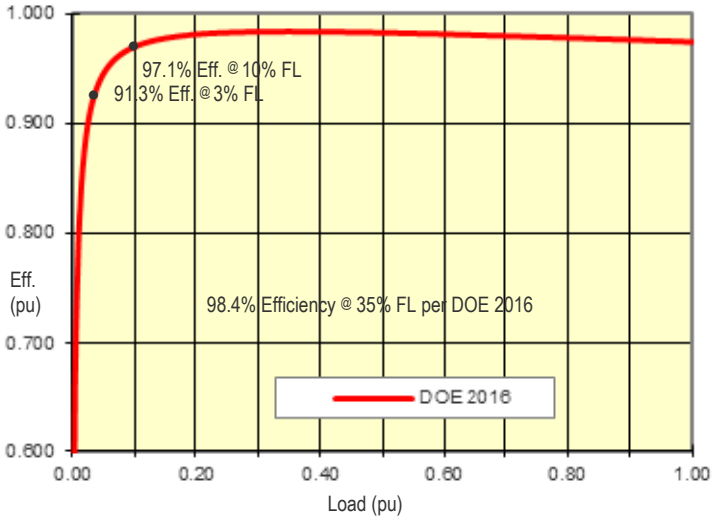
NEC compliant Harmonic Mitigating Transformer that automatically 'right size' to a lower kVA rating to optimize Energy Efficiency

The Transformer Efficiency Problem

A Load Factor survey, undertaken by The Cadmus Group Inc.in 1999, found that the average loading of low voltage, dry-type, distribution transformers in commercial, industrial and public buildings was in a range between 9% and 17% of their full load (FL) ratings. More recent surveys have shown even lower Load Factors, the result of upgrading to more energy efficient loads. California's 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, *Section 130.5 – Electrical Power Distribution Systems* compliance reduces transformer average Load Factors even further.

Transformer oversizing is a predictable outcome when meeting the requirements of the National Electrical Code (NEC). In addition to the higher capital cost of oversizing, the higher operating cost of a lightly loaded transformer can be significant.

Considering a more recent example of daytime and nighttime Load Factors, *Figure 1* shows that the efficiency of a 45kVA DOE 2016 compliant distribution transformer, with 98.4% efficiency at 35% FL, is only 97.1% at 10% FL and 91.3% at 3% FL.



DOE 2016 Compliant 45kVA Distribution Transformer Efficiency
Figure 1

The Smart Distribution TransFilter™ Efficiency Solution

To maximize energy efficiency and reduce operating costs, the optimum kVA rating of a distribution transformer can be determined by referring to CSA C802.4-2013 – *A Guide for kVA Sizing of Dry-Type Transformers* or the national**grid**® *Transformer Replacement Program Recommendations for Low Voltage Dry-Type Transformers.* However, the CSA guide and national**grid**® recommendations conflict with NEC requirements.

To resolve this conflict, Power Quality International has developed ultra-efficient, dual kVA rated Type SDV Smart Distribution TransFilters™ that, while meeting NEC's requirements, automatically 'right size' to their lower kVA rating to optimize energy efficiency. Smart Distribution TransFilters™ include code compliant primary and secondary circuit breaker protection, and self-contained fail-safe controls.

Conventional Distribution System vs. Smart Distribution System

Using the *Figure 2 & 3* examples, we can compare a conventional system, which includes a 480V riser that supplies four [one per floor] 45kVA distribution transformers with an alternative configuration that supplies the same loads with a dual rated 45/150kVA Type SDV Smart Distribution TransFilter™. While its higher rating has been selected to comply with NEC requirements, the smart alternative automatically 'right sizes' to its lower kVA rating to optimize energy efficiency.

The Conventional Distribution System (Figure 2) – With four 45kVA Distribution Transformers operating at 10% FL for 10 hours a day, 5 days a week at 97.1% efficiency and at 3% FL for 14 hours a day, 5 days a week and 3% FL on the weekend at 91.3% efficiency *(Figure 1)*, the average efficiency is 94.51% *(Figure 4)* and the average total losses are 528 Watts *(Figure 5)*.

Smart Distribution System (Figure 3) – With one 45kVA Distribution TransFilter™ operating at 40% FL for 10 hours a day, 5 days a week at 98.38% efficiency and at 12% FL for 14 hours a day, 5 days a week and 12% FL on the weekend at 97.42% efficiency, the average efficiency is 98.15% *(Figure 4)* and the average losses are 188 Watts *(Figure 5)*.

If the load on the 45kVA unit were to exceed 50% FL (22.5kVA), the load would be transferred from the 45kVA section to the 150kVA section, which would then be loaded at 15% FL. In this scenario, the load would transfer back to the 45kVA section if it dropped below 20.5kVA. Transfer settings are selectable but must maintain a 2kVA differential.

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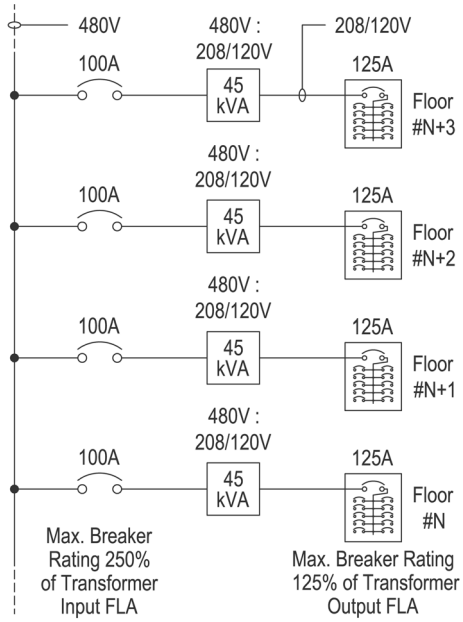
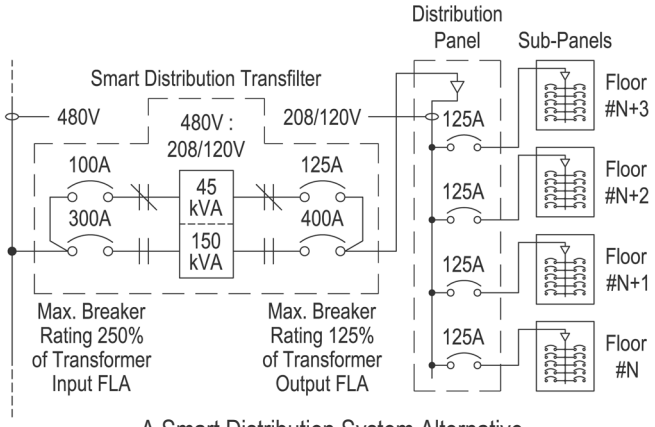
Conventional Distribution System vs. Smart Distribution System –The average efficiency improvement is 3.64% [98.15% - 94.51%] *(Figure 4)* while the Average Losses Reduction is 340W [528W - 188W] *(Figure 5)*. At $0.20/kWh, the Annual Power Cost Reduction would be $593.68 [$923.84 for Conventional vs. $330.16 for Smart Electrical Distribution Subsystem].



Conventional Subsystems
Figure 2

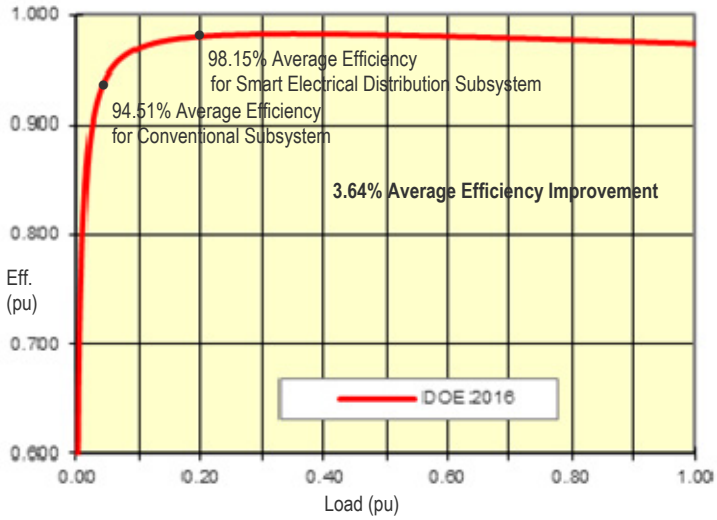


A Smart Distribution System Alternative
Figure 3

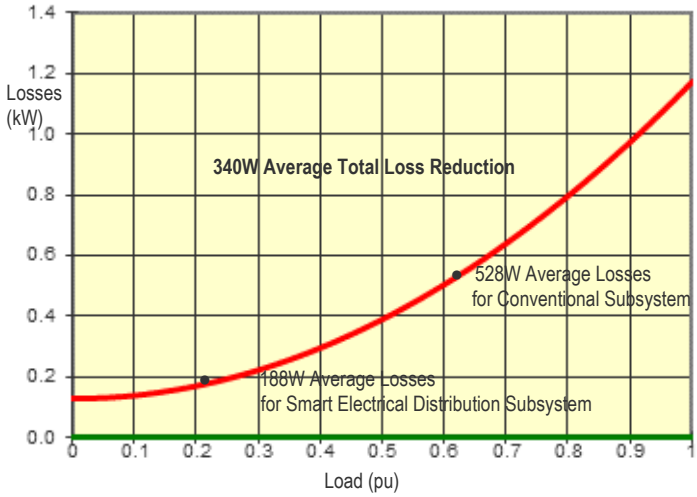
Note: The Smart Distribution TransFilter's™ input and output protection is based on the requirements of the National Electrical Code. That is, 250% maximum FL amperes at each input and 125% maximum FL amperes at each output.

Determine Type SDV Smart Distribution TransFilters™ Ratings

To determine a Type SDV Smart Distribution TransFilter™ high rating, calculate the minimum kVA required by the NEC [not the kVA rating of 'standard' transformer ratings that might have been selected] for each of the conventional system's four Distribution Transformer connected loads. Use the sum of these minimum ratings to determine the required kVA rating of the Smart Distribution TransFilter's™ high rating. Do not oversize.



45kVA DOE 2016 Distribution Transformer Efficiency
Figure 4



45kVA DOE 2016 Distribution Transformer Losses
Figure 5

To determine the low kVA rating of the Smart Distribution TransFilter™, sum the anticipated or measured maximum Load Factors of the conventional system's four Distribution Transformers. By calculating the lower rating of the Smart Distribution TransFilter™ in this manner, an automatic transfer to the higher rating may be infrequent.

The actual number of conventional system Distribution Transformers that could be replaced by a single Type SDV Smart Distribution TransFilter™ is somewhat flexible. The limiting factors are typically the feeder and branch circuit Loading Factors and lengths. Consideration must also be given to the load's harmonic current profile. PQI's *'Neutral-to-Ground Voltage vs. Branch-Circuit Loading & Length Graphs'* will provide useful guidance. The Smart Distribution TransFilter™ lower kVA rating can also be decreased to allow more frequent transfers if calculated outcomes show a benefit.

Harmonic Current Mitigation

Type SDV Smart Distribution TransFilters™, with zero-sequence flux cancellation secondary windings, have ultra-low zero-sequence

impedance. This characteristic significantly reduces voltage distortion at the loads, increasing the load's energy efficiency. Type SDV units are also available in a variety of primary-to-secondary phase-shifts. This design feature allows for the mitigation of positive- and negative-sequence harmonic currents on their common 480V riser, if two or more Smart Distribution TransFilters™ or Type DV Distribution TransFilters™ are applied.

Type SDV Smart Distribution TransFilter™ Applications

Type SDV Smart Distribution TransFilters™ provide cost-effective design alternatives. It is also anticipated that in most cases the capital cost of a Smart Distribution System will be the same as or less than a Conventional Distribution Subsystem.

Smart Distribution Systems, providing harmonic current reduction in the distribution system and voltage distortion improvement at the loads, will save energy and reduce utility costs. Given a facility's proposed or 'as built' electrical distribution system drawings and panel schedules, PQI engineers can develop a Smart Distribution System alternative design. If accepted, PQI will guarantee a range of savings and IEEE Std. 519-1992 and CSA C802.4 or nationalgrid® compliance.

Product Description

Type SDV Smart Distribution TransFilters™ exceed all existing and pending energy efficiency requirements under nonlinear loading.

Type SDV 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 SDV Distribution TransFilters' ultra-low zero-sequence impedance flux cancellation windings maintain published efficiencies at 35% FL. Type SDV transformers published efficiencies can be matched to anticipated or measured average Load Factors above 35% FL, when required.

Required vs. PQI Energy Efficiencies [1]

kVA Rating	*NEMA TP 1 2002 [2] CSA C802.2*	*NEMA Premium [2]*	*DOE 2016 [3]*	***PQI Z3** exceeds CSL 3 [4]*	***PQI Z3+***	***PQI Z4** exceeds CSL 4 [4]*
15	97.00	97.90	97.89	**97.97**	**98.25**	**98.43**
30	97.50	98.25	98.23	**98.29**	**98.52**	**98.68**
45	97.70	98.39	98.40	**98.45**	**98.66**	**98.81**
75	98.00	98.60	98.60	**98.64**	**98.82**	**98.95**
112.5	98.20	98.74	98.74	**98.77**	**98.93**	**99.05**
150	98.30	98.81	98.83	**98.86**	**99.01**	**99.12**
225	98.50	98.95	98.94	**98.97**	**99.10**	**99.20**
300	98.60	99.02	99.02	**99.04**	**99.16**	**99.26**
500	98.70	99.09	99.14	**99.16**	**99.26**	**99.35**
750	98.80	99.16	99.23	**99.24**	**99.33**	**99.41**
1000	98.90	99.23	99.28	**99.29**	**99.38**	**99.45**

Notes: *[1] Efficiency values are measured at 35% of nameplate rating.*
[2] The efficiency of transformers manufactured after January 1, 2007, but before January 1, 2016 must meet the efficiency requirements of NEMA TP 1-2002 (US) or CSA C802.2-12 (Canada).
[3] The efficiency of transformers manufactured after January 1, 2016 must meet the US DOE 2016 efficiency requirements.
[4] PQI Z3 & Z4 efficiencies exceed the requirements of DOE Candidate Standard Level 3 & 4 (CSL 3 & CSL 4) respectively.

Technical Specifications

Technical specifications for Type SDV Smart Distribution TransFilter™ magnetics may be found in the Type DV Distribution TransFilter™ PRODUCT SHEET, which is available at www.powerqualityinternational.com.

e-Rated®