



MIRUS Harmony™ Series Transformer Cost Benefit Analysis - 112.5 kVA Harmony-2™

Harmonic distortion in electrical distribution systems caused by high densities of non-linear loads (such as personal computers and other electronic equipment) can create a number of overheating problems as well as many power quality related problems. These include:

- *Overheating of electrical equipment including neutral conductors and transformers*
- *Motor and PF capacitor failures*
- *False tripping of circuit breakers*
- *Premature hardware component failure*
- *Computer 'hangs' and other equipment operational malfunctions*
- *Increased equipment downtime*

Some of the harmonic distortion issues can be addressed by doubling the neutral conductor and specifying K-rated transformers. Although this approach should prevent the transformer and neutral conductor from overheating, it offers absolutely no treatment for the power quality related harmonic problems. In fact, it is possible that widespread use of K-rated transformers will indirectly **contribute** to the power quality problem. K-rated transformers, although capable of withstanding harmonic induced overheating, perform about the same as conventional delta-wye transformers with respect to the voltage distortion that they create. Typically a K-rated or conventional transformer will have more than 5% output voltage distortion when non-linear loading is greater than 50% of the transformers rated load. It is unlikely that more load would be added to a conventional transformer because it would be very hot even at half load. However, the cooler operating temperature of a K-rated transformer would encourage further loading and could raise voltage distortion to unacceptable levels.

MIRUS Harmony™ Series transformers have proven to be very effective in resolving **both** the overheating and the power quality problems related to harmonics. By canceling the harmonic fluxes within its windings, a Harmony™ transformer will maintain very low voltage distortion at its output even under heavy non-linear loading conditions. To demonstrate this advantage, modeling calculations have been prepared which compare a 112.5 kVA, K13 transformer with Harmony-1™ and Harmony-2™ transformers of the same rating. (See MIRUS document titled, 'Modeling the Non-linear Load Contributions to Voltage Distortion at the Output of Three Different Types of 112.5 kVA Transformers'). Voltage distortion at the output of the MIRUS Harmony™ Series transformers are substantially lower than at the K13 transformer under similar non-linear loading conditions. For example, fully loading the K13 transformer with a K factor load of 6.3 resulted in nearly 10% voltage distortion at the transformers output - well above the 5% maximum recommended by IEEE Std 519. Under the same loading, voltage distortion at the output of the Harmony-2™ transformer was only 3.5%.

Benefits of Using Harmony™ Series Transformers

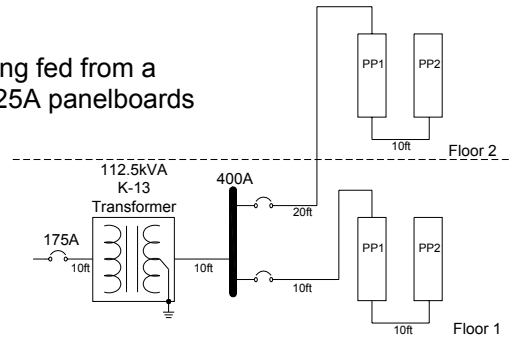
The benefits of using a Harmony™ transformer when servicing non-linear loads are many. By treating the harmonic currents within its secondary windings, the Harmony™ transformer reduces both overheating and voltage distortion. Since it is high voltage distortion that leads to most of the power quality problems listed above, the Harmony™'s ability to reduce voltage distortion will eliminate these problems. Cost benefits can include reduced repairs and equipment replacement, less production downtime and damaged product, improved computer availability and many more. The elimination of the potentially huge cost impacts of these problems would easily justify the use of Harmony™ transformers. These costs are often difficult to quantify however, so an alternate approach is suggested - **costing based on Usable kVA**. In this approach it is assumed that one of the design criteria is to maintain voltage distortion at less than 5% as defined in IEEE Std 519 - Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

Costing based on Usable kVA

Modeling has shown that keeping voltage distortion at less than 5% for a 112.5 kVA K13 transformer requires that its non-linear load be less than 50% of its full load rating. On the other hand, voltage distortion at the output of a Harmony-2™ will remain less than 5% even under fully loaded conditions. This means that the **Usable** rating of the K13 transformer is less than 60 kVA. Therefore it would take two 112.5 kVA transformers with associated distribution equipment to service a full 112.5 kVA of non-linear load. The following calculations show how the cost per Usable kVA favors the Harmony-2™ transformer. (Cost estimates include material and labour.)

Scenario 1: 112.5 kVA, 480-208/120V K13 transformer being fed from a 175A, 35kA circuit breaker and servicing 4 x 225A panelboards

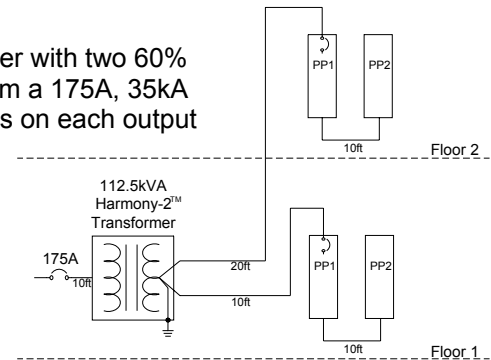
112.5 kVA, K13 Transformer.....	\$ 4,500
175A, 35kA, 3-pole CB.....	\$ 1,500
400A, splitter and CB's.....	\$ 900
4 x 225A panelboards	\$ 2,600
Wire and conduit.....	\$ 3,500
TOTAL.....	\$13,000



Since the Usable kVA for the K13 transformer is only 60 kVA, installed cost is **\$217 per Usable kVA**

Scenario 2: 112.5 kVA, 480-208/120V Harmony-2™ transformer with two 60% rated (67.5 kVA) secondary windings being fed from a 175A, 35kA circuit breaker and servicing 2 x 225 A panelboards on each output

112.5 kVA, Harmony-2™ Transformer...	\$10,300
175A, 35kA, 3-pole CB.....	\$ 1,500
2 x 225A panelboards c/w main CB.....	\$ 1,800
2 x 225A panelboards.....	\$ 1,300
Wire and conduit.....	\$ 3,500
TOTAL.....	\$18,400



Since the Usable kVA for the Harmony-2™ transformer is the full 112.5 kVA, installed cost is **\$164 per Usable kVA**

Summary

Areas with heavy concentrations of non-linear loads are very vulnerable to both power quality and overheating harmonic problems. K-rated transformers address only the overheating problem. Harmony™ Series transformers treat both sets of problems.

If the Usable kVA value is considered when designing an electrical distribution for non-linear loads, the advantages of using a Harmony™ Series transformer become clear. In the analysis above, the distribution system using the k-rated transformer cost about 30% less than with the Harmony-2™. However, the available capacity is only 50% of the rated capacity, when maintaining less than 5% voltage distortion is established as one of the power quality design criteria. In essence, this means that the Harmony-2™ solution is actually cheaper than the k-rated solution since servicing a fully rated 112.5 kVA load would require a second k-rated transformer and all of its associated distribution equipment.