

## WAL-MART IN MEXICO

### Power factor improvement and harmonic considerations

#### Background:



Wal-Mart de Mexico is a major retail chain in Mexico. They operate 699 branches throughout 76 cities nationwide, including self-service stores, apparel stores, and restaurants.

Wal-Mart started a partnership 15 years ago with Aurrera, a Mexican company and the largest retailer in Mexico. Aurrera also owned department stores like, Sam's Club, Suburbia, and the Vips restaurant group beside others. Since 1997 Wal-Mart now owns 100%

of the aforementioned companies and has been growing by adding its Sam's warehouses.

Typical Power Factor (PF) of a store, without reactive power compensation, is below 0.80 lagging. In the USA, many utilities do not require that customers improve PF. Nevertheless, customers and their electrical systems would benefit from power factor improvement since internal losses will be reduced.

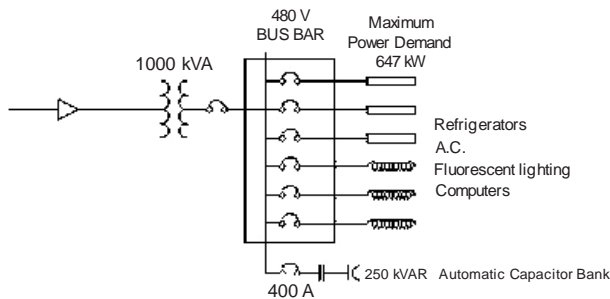
In Mexico, utilities demand that their customers maintain PF of at least 0.90 lagging. Arteche, through their distributor Cinemática de México, has been working with Wal-Mart to achieve and maintain this level of power factor. Arteche provides the engineering analysis of power factor and harmonics and provides for the proper selection and installation of Capacitor Banks in Wal-Mart stores throughout Mexico.

During October 2004, Arteche was assigned the project to analyze and improve power factor at the Sam's Club located in Campeche, a state in southern Mexico. At the time this Sam's Club was paying to the utility, Comisión Federal de Electricidad (CFE) an extra charge for low Power Factor (0.84 lag) of \$ 9,719.00 MXN each month.

It was critical that this unnecessary operating expense be eliminated. Cinematica and Arteche set out to analyze the electrical system for PF and to determine what if any harmonics were prevalent on the system. Harmonics could further reduce the system efficiency and power quality as well as create the potential for resonance problems. Cinematica performed an analysis of the complete electrical system and made the optimum selection for capacitor type, rating and placement in order to maximize savings (avoid losses).

### Wal-Mart's Power System:

The electrical system, for this case, consists of a 1,000kVA transformer having a 480Volts secondary. The transformer feeds a panel board which distributes energy to several loads through circuit breakers. These loads are typical of a shopping mall or department store (fluorescent lighting, air-conditioning, computer equipment and refrigerators, etc.). The simplified single line diagram is shown below.



### Proposed Capacitor Bank:

The recommended solution was to install an Automatic Capacitor Bank, at 480V, that would increase the PF to at least 0.96 lagging. The automatic capacitor bank was selected for its capability of matching the capacitor kVARs to the actual load requirements. Although the minimum requirement is 0.90 PF, a financial incentive existed for improvement above this level. As illustrated in the single line diagram above, the capacitor bank was connected on the secondary of the transformer and at the panel board. Capacitor bank overcurrent protection was provided by the MCB contained in the capacitor equipment itself.

The selection of the required Reactive Power is easy to determine with the following formula:

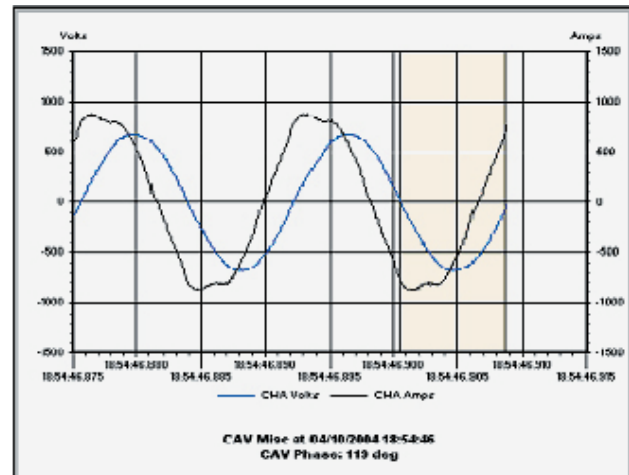
$$kVARc = kW \left( \frac{\sqrt{1 - PF_1^2}}{PF_1} - \frac{\sqrt{1 - PF_2^2}}{PF_2} \right)$$

$$kVARc = 647 kW \left( \frac{\sqrt{1 - 0.84^2}}{0.84} - \frac{\sqrt{1 - 0.96^2}}{0.96} \right)$$

$$kVARc = 229.2 \text{ kVAR} \approx 225 \text{ kVAR}$$

A careful approach must be taken when installing power factor capacitors. If harmonics are present on the power system, then power system resonance can occur, which will make the harmonic problems worse and even damage capacitors. It's important to note that Capacitor Banks should not be installed in environments with harmonics unless the magnitude and frequencies of the harmonics are quantified, and the capacitor bank is properly tuned (to filter specific harmonics) or detuned (to block harmonics).

In this case, analysis of the electrical system did not reveal harmonic distortion, which is normally associated with power electronic loads such as Variable Speed Drives (VSD), computers and high efficiency lighting. Therefore, it was not necessary to install a Harmonic Filter or detuned capacitor bank because the magnitude of harmonics on the system was extremely low and was determined not to be a problem. This is evidenced by the voltage and current waveforms (which are nearly sinusoidal) measured at the transformer secondary, as shown below.



Utility waveforms

The utility rate structure offers an economic incentive for PF improvement. While it may seem economically attractive to add more capacitors, considering the proliferation of harmonic generating equipment such as Variable Speed Drives (VSD), computers and high efficiency lighting, a very careful approach must be taken. Capacitors should never be installed without analyzing the harmonic level and power system resonant frequency. If harmonics are present, then capacitors must be installed in conjunction with tuning reactors, either as a harmonic filter or as a detuned capacitor bank.

After review of the analysis and recommendations, the technical department of Wal-Mart assigned

priority to the various stores and awarded the order to Cinematica and Arteche.

The overall scope of the project involved:

- Equipment
- Installation
- Commissioning
- Review after 72 hours of operation
- Assurance of 48 hours service nationwide
- 3 years product warrantee



## Conclusions:

The investment in the proper capacitors provided the following benefits to Wal-Mart:

- Avoid penalties for low power factor
- Benefit from the (high PF) economic rebates
- Improved voltage regulation
- Voltage closer to desired value
- Reduction of power loss since less current will flow in equipment. (Properly placed capacitors can reduce power loss as much as 4%).
- Longer life for electrical equipment (through temperature reduction). Each 10° Celsius of

increase in the temperature of electrical equipment reduces life 50%.

Once the power factor improvement capacitor system was operating, the system PF reached 0.99 lag, not only eliminating the PF charge, but also earning a rebate of \$ 7,752.00 MXN. The net benefit was \$17,471.00 MXN.

The total current reduced from 930Arms to about 780Arms, resulting in a reduction of I<sup>2</sup>R losses of 30%. Additionally, the electrical equipment, now operating at reduced current will experience longer life expectancy.

The energy costs savings achieved by the installation of this capacitor bank assured that the total equipment and installation costs would be repaid in less than 5 months.

Arteche has supplied over 180 Automatic and Fixed Capacitor Bank systems in a total of more than 120 Wal-Mart stores. This represents an installed base of Low Voltage Reactive Compensation Systems (240V & 480V), at Walmart stores alone, of more than 26 MVARs.

In March 2005, Wal-Mart confirmed its confidence in Arteche engineering and quality capabilities by awarding Arteche a new order for 32 additional stores requiring 6.8MVAR to improve their power factor and electrical power quality.

The total number of Wal-Mart stores in Mexico is 365. Arteche installations at Wal-Mart now totals about 33MVAR, in 221 Capacitor Banks, located in 153 stores, representing more than the 40% of the total in México. Through Arteche's unique experience and engineering and production capabilities, Wal-Mart stores have improved their power quality and reduced their power consumption by 15.4 million of kW/hr per year<sup>1</sup>, enough energy to provide electric power to 4,790 houses for an entire year.