CASE STUDY

POWEROHM RESISTORS

# Active harmonic filters for data center loads

PQS™

Power Quality Solutions

Achieving high power quality and reliability in today's energy-constrained world is a huge challenge. This is especially true for data centers and other critical process facilities that rely on quality reliable power for success. Data centers house a great deal of IT equipment like servers and computers, with load factors over 80%.

Facility owners and managers work to maximize factory uptime but they are highly susceptible to common of power quality problems. Even a simple voltage sag can be as disastrous as a power interruption. In a fraction of a second, power quality problems can cost millions in downtime.

Consequences of low data center power quality include:

- Revenue loss: Poor power quality and unreliable power supply put critical equipment and the entire infrastructure at risk. This can cause lost data, resources, and productivity.
- Failing customer service: Customer service levels go down with poor power quality and reliability. This ultimately impacts customer satisfaction, in turn affecting the client base of a particular facility.
- Service interruptions and downtime: Poor power quality and unexpected problems in data centers cause downtime, interrupting facility operations.

## 1. Requirements

### 1.1. Background

The largest data center in the Asia-Pacific region is in South Korea. It serves several global IT companies. The facility was suffering from severe harmonic distortion. The total floor area of the data center is 85,548 m2 and the power capacity is 165 MW/154 kV.

The owner of the building needed to secure the operations and eliminate harmonic distortions to maintain the quality and integrity of the business.

The project target was to improve the operation of the data center by reducing the harmonic distortion to comply with THDi under 5%.

### 1.2. System description

The electric power system of the data center is described in Figure 1.

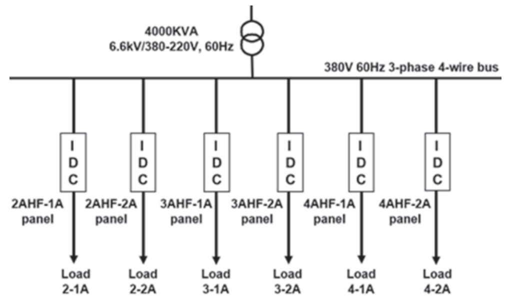


**Figure 1:** Data center electric power system

### 1.3. Challenges

Harmonic distortions were caused by the data center loads, mainly the double conversion static UPS systems (average power 10 kW), computers and LED lamps.

To develop a solution, power quality data was collected from six different switchboard panels within the data center over a period of time. This was done using a power quality analyzer.

## 2. Solution

### 2.1. Analysis of measurements

An extensive power quality analysis was completed for the whole facility. Based on the data, it was clear that an active solution was required to fix the harmonics problems. The decision was made to install the solution in the six different switchboard panels.

As an example, the existing power quality parameters at the panel 2AHF-2A before compensation were:

- Power factor: 0.82 (ind.)
- Average current: 83.12 A
- Average voltage: 394 VAC
- THDi: 59.6%

# Active harmonic filters for data center loads

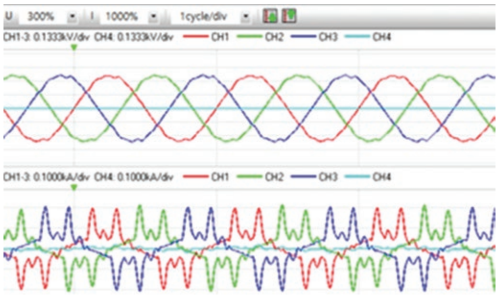


**Figure 2:** Existing voltage and current waveforms at 2AHF-2A panel

## 2.2. Proposed solution

Based on analysis of the data, it was possible to create a solution for the data center that would comply with the customer's requirements. The decision to install active harmonic filters (AHF) on each switchboard would reduce the entire installation to under 5% THDi.

| Panel | Location | Device |
|---|---|---|
| 2AHF-1A | Floor 2 server room TPS | AHF 380V 60Hz 100A |
| 2AHF-2A | Floor 2 server room TPS | AHF 380V 60Hz 100A |
| 3AHF-1A | Floor 3 server room TPS | AHF 380V 60Hz 100A |
| 3AHF-2A | Floor 3 server room TPS | AHF 380V 60Hz 100A |
| 4AHF-1A | Floor 4 server room TPS | AHF 380V 60Hz 100A |
| 4AHF-2A | Floor 4 server room TPS | AHF 380V 60Hz 100A |

**Table 1:** Proposed solution

Due to the nature of the loads, real-time harmonic filtering was required. That meant conventional solutions like passive harmonic filters or capacitor banks were not an option.

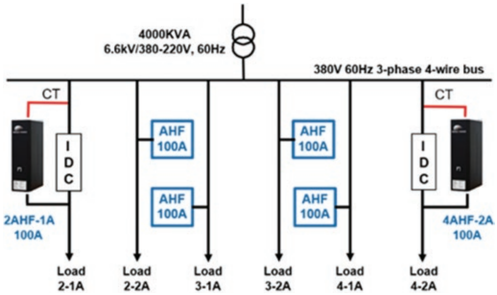


**Figure 3:** Proposed solution

## 2.3. Key features

Active harmonic filters are the ultimate answer to power quality problems and grid code requirements for a wide range of segments and applications. They provide high performance and flexibility. Compact, modular, and cost-effective AHF's deliver an instantaneous and effective response in low or high voltage electric power systems.

AHF's enable longer equipment lifetime, higher process reliability, improved power system capacity and stability, and reduced energy losses, complying with most demanding power quality standards and grid codes.

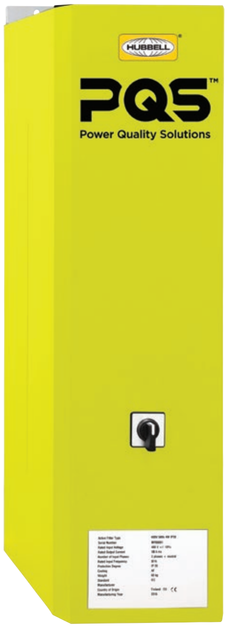


**Figure 4:** AHF module rated 380V 50/60Hz 100A

AHFs eliminate waveform distortions from the impacts of harmonics, interharmonics, and notching. In real time, they inject distorted current of the same magnitude but opposite phase to the electric power system. In addition, AHFs can mitigate several other power quality problems and grid ancillary services by combining different functions in a single device. Some of them are:

- Elimination of harmonics and interharmonics
- Power factor correction (lagging and leading)
- Reduction of voltage variations (sags and swells)
- Mitigation of voltage fluctuations (flicker)
- Load balancing in three-phase systems
- Controlled and selectable harmonic generation

# 3. Results

## 3.1. System configuration

Six AHFs were installed at the switchboard panels of the data center, one on each panel, two per floor.

# Active harmonic filters for data center loads

**Figure 5:** AHFs at the server room in the second floor

**Figure 6:** AHF 380V 60Hz 100A located at 2AHF-2A panel

The HMI of the AHFs was used to select different operation parameters and monitor power quality parameters such as current, voltage and power waveforms from both network and load side.


**Figure 7:** HMI showing voltages at 2AHF-2A panel

Based on the values monitored, it was decided to use the following settings on the AHF located at 2AHF-2A panel.

| | |
|---|---|
| **Power factor** | Target 0.98 (ind.). |
| **Voltage fluctuations** | Flicker mitigation was not necessary. |
| **Load balancing** | Reduction of unbalance between line currents to under 5%. |

**Table 2:** SVG's functions used

## 3.2. Measurements

The system was monitored with an external power quality analyzer to validate the AHF operation. The trend charts (recorded with one second intervals) were taken with the AHFs connected and disconnected. The measurements shown below came from panel 2AHF-2A where an AHF 380V 60Hz 100A was installed.


**Figure 8:** THDi at panel 2AHF-2A reduced from 59.60% to 17.36%


**Figure 9:** THDv at panel 2AHF-2A reduced by 16%

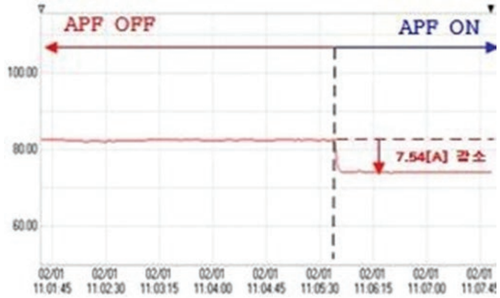


**Figure 10:** Load current at panel 2AHF-2A reduced from 83.12 A to 74.58 A

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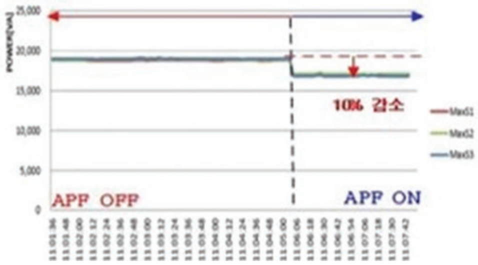


**Figure 11:** Apparent power at panel 2AHF-2A reduced 10% from 18.9 kVA to 17 kVA


**Figure 12:** Reactive power at panel 2AHF-2A reduced 43% from 10.8 kvar to 6.1 kvar

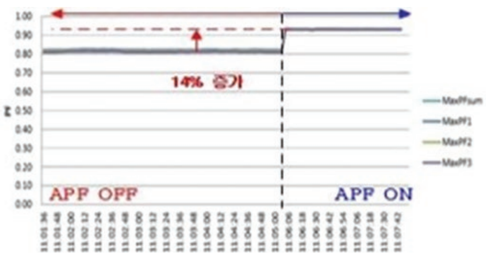


**Figure 13**: Power factor at panel 2AHF-2A improved from 0.82 to 0.93

| | Currents distortion (%) | | | Currents (A) | | |
|---|---|---|---|---|---|---|
| | **AHF Off** | **AHF On** | **Rate (%)** | **AHF Off** | **AHF On** | **Rate (%)** |
| **2nd** | 0.27 | 0.38 | 41.37 | 0.18 | 0.26 | 47.81 |
| **3rd** | 1.10 | 1.36 | 23.37 | 0.72 | 0.94 | 29.22 |
| **4th** | 0.31 | 1.00 | 221.22 | 0.21 | 0.69 | 235.12 |
| **5th** | 34.48 | 6.52 | -81.09 | 22.68 | 4.49 | -80.22 |
| **6th** | 0.58 | 0.83 | 42.25 | 0.38 | 0.57 | 48.52 |
| **7th** | 28.41 | 2.85 | -89.98 | 18.69 | 1.96 | -89.51 |
| **8th** | 0.63 | 0.90 | 43.06 | 0.41 | 0.62 | 49.65 |
| **9th** | 3.74 | 2.34 | -37.35 | 2.46 | 1.61 | -34.53 |
| **10th** | 0.40 | 1.04 | 160.52 | 0.26 | 0.71 | 172.19 |
| **11th** | 28.58 | 4.99 | -82.54 | 18.79 | 3.43 | -81.73 |
| **12th** | 0.53 | 0.80 | 50.72 | 0.35 | 0.55 | 57.67 |
| **13th** | 24.10 | 4.15 | -82.79 | 15.86 | 2.86 | -81.99 |
| **14th** | 0.41 | 0.49 | 19.26 | 0.27 | 0.34 | 24.64 |
| **15th** | 3.54 | 4.09 | 15.36 | 2.25 | 2.65 | 17.55 |

**Table 3:** Harmonic currents and distortion at panel 2AHF-2A

### 3.3. Benefits

Installing the AHFs reduced the harmonics in the data center, providing several benefits:

- Harmonics THDi reduced from 20% to below 5%
- Power factor improved from 0.82 to 0.99, achieving a reduction in kVA maximum demand, in losses and in the electricity bill
- All loads are balanced in the building, with less than 10% unbalanced
- Electrical equipment lifetime increased
- Load current reduced
- Capacities increased for power cables and power devices

## 4. Conclusions

The rise of nonlinear and other challenging loads in electric power systems present unique power quality challenges. Active power filters provide a quick and effective response to power system disturbances, enabling longer equipment life, higher process reliability and reduced energy losses, complying with most demanding power quality standards and grid codes.

Data centers have evolved to become large power consumers. Their supporting infrastructure, such as cooling and power distribution, consumes large quantities of electric power, and their IT equipment generates power quality problems that affect the secure and reliable operation of data centers. Therefore, power quality and efficiency are important topics that should be addressed carefully at the design and operation stage.

| | |
|---|---|
| **Country** | South Korea |
| **Segment** | Critical process facilities |
| **Application** | Data center loads (double conversion static UPS systems, computers and LED lamps) |
| **Requirements** | Harmonics mitigation to comply with THDi under 5%. |
| **Solution** | 6 units of AHF 380V 60Hz 100A |
| **Commissioning** | 2018 |

**Table 4:** Project summary


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