CASE STUDY

AUSTRALIAN NATIONAL MARITIME MUSEUM

Installation of Active Harmonic Filters in the Electrical System

ENERGY systems & services

ANMM-background

The Australian National Maritime Museum is Australia's national centre for maritime collections, exhibitions, research and archaeology.

The Australian National Maritime Museum was planned and built more than 20 years ago as part of the massive Darling Harbour and Pyrmont redevelopment. The museum was the site's showpiece and remains the Australian Government's most visible national cultural institution in Sydney.

Australians have always had close links with the sea. In 1975 a museums inquiry commissioned by the Australian Government recommended that '... priority be given to a national maritime museum in Sydney'. In 1984 an ambitious Darling Harbour redevelopment program was unveiled. The museum would stand adjacent to the historic 1903 Pyrmont Bridge, now a pedestrian link to the city.

Prominent Australian architect Philip Cox AO designed the museum building and construction started in 1986. Prime Minister Bob Hawke opened the Australian National Maritime Museum on 29 November 1991.

-Extracted from www.anmm.gov.au-

Issues Identified

Measurements and data logging were carried out with power quality analysers at the incoming supplies and individual loads. As a result, high current harmonics were observed.

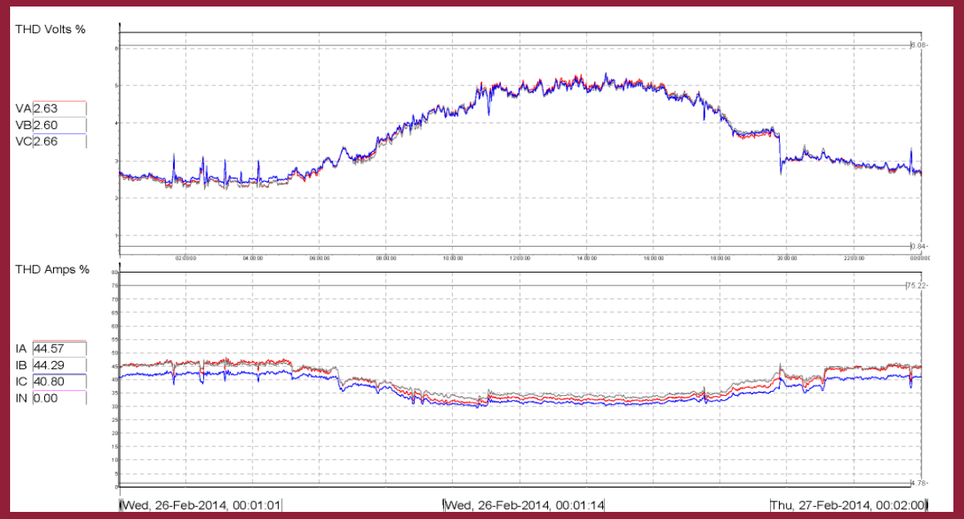

Figure 1: Incoming Supply Voltage and Current THD

In figure 1, the readings were obtained from main switchboard incoming supply, and it shows the THD (Volts) is between 2.5%-5.5%, and THD (Amps) is between 30%-45%.

A comprehensive investigation was carried out to identify the source of the harmonics and any other power quality issues at ANMM.

Figure 2: Plant room

Figure 3: Plant room

The harmonics were identified to be generated from the loads connected to the main mechanical switchboard which are mainly variable speed drives and chillers. A secondary mechanical switchboard that supplies sea water pumps was also identified to be the source of the harmonics.

Total Harmonic Distortion

Voltage and current signals can be characterised by their waveforms, which are ideally sinusoidal (figure 4), and by their frequency spectrums (figure 5). Harmonics are sinusoidal components of the periodic voltage or current waveforms at frequencies that are integer multiples of the fundamental frequency (50Hz in Australia). Harmonics distort the ideal waveform away from an ideal sinusoid (figure 6).

Total Harmonic Distortion (THD) is the ratio of the harmonic components to the fundamental frequency component of the waveform and is expressed as a percentage.

Excessive harmonic distortion may be harmful and is generally created from loads within the system itself, due to these loads drawing distorted current waveforms from the supply voltage. Sources of harmonics can include equipment such as motor starters and drives, lighting, power electronic equipment, printers and computers.

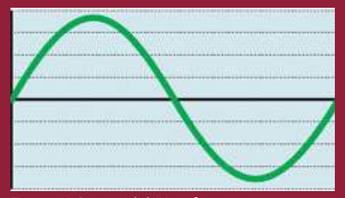

Figure 4: Sinusoidal Waveform

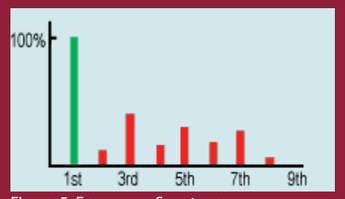

Figure 5: Frequency Spectrums

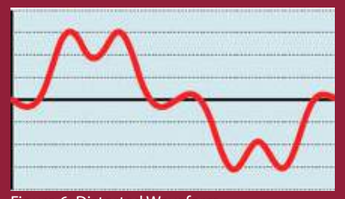

Figure 6: Distorted Waveform

The consequences of harmonic distortion can include:

- Overheating of the neutral or phase conductors
- Unwanted tripping of circuit breakers
- Burning out of motors and transformers
- Incorrect operation of electronic equipment

Some commonly used solutions include:

- Implementing filters
- Isolating sensitive equipment from harmonic generating equipment
- Derating transformers and system components

When considering possible solutions, it is important to verify that the proposed solution does not worsen the harmonic distortion within the system.

8%

Voltage THD limit in LV system according to AS/NZS 61000.3.6:2001 standard

THD

Ratio of the harmonic components to the fundamental frequency component of the waveform and is expressed as a percentage

Solution

Harmonic Filters can be used to attenuate harmonic distortion.

Active Filter

Active filters neutralise the harmonics by identifying the amplitude and phase of the harmonics and inject the same but opposite harmonics to cancel it out.

Compare to passive filters, active filters have no resonance problems. It can eliminate any harmonics (not tuning), and regulate voltage, compensate reactive power, and it's operation is reliable.

Circutor's AFQ multifunction parallel active filters are the most complete solution to solve power quality problems caused, in either industrial or commercial facilities, not only by harmonics but also for current imbalance and reactive power consumption.

The available functions in all Circutor AFQ models are as follows:

- Reduction of current harmonics up to the 50th order (2500Hz). User-selection of harmonic frequencies to be filtered for a higher efficiency.
- Balances the current in each phase of the electric power system.
- Reactive power compensation. Either lagging currents (inductive) or leading currents (capacitive).

Engineering

A complete design and calculation was carried out to select the right active filter size. Measurements from data logging done earlier were used to determine the maximum demand of the loads. A 150A active filter (figure 7) was installed at the main mechanical switchboard and a 50A active filter (figure 8) was installed at the secondary mechanical switchboard.

Installation was carried out on a weekday after hours to have a minimal impact on the operation of the building. Furthermore, pre-works started before the actual installation to shorten the outage period. Data logging was carried out again post-installation to analyse the power quality.

Figure 7: Circutor AFQ 150A Active Filter

Figure 8: Circutor AFQ 50A Active Filter

Result

As a result of the installation of active filters, the total current harmonic distortion at the incoming supply has been reduced from an average of 30-50% to 4-6%. As you can see from figure 9, the individual harmonics especially the 3rd, 5th, 7th and 9th harmonics have reduced significantly. The current waveform is also observed to be less distorted (figure 10). Furthermore, the average total voltage harmonic distortion has also been reduced from an average of 5% to 2%.

WITHOUT ACTIVE FILTER	WITH ACTIVE FILTER
30%-45%	4%-6%
Average Current THD	Average Current THD

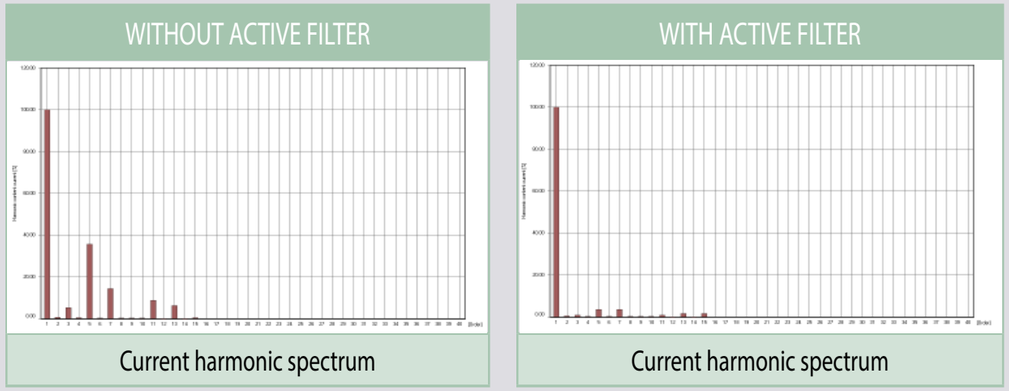

Figure 9: Current Harmonics Spectrum

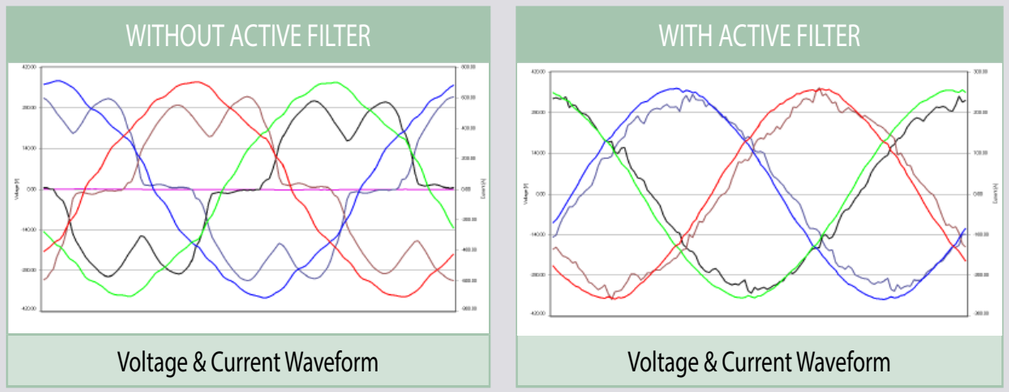

Figure 10: Voltage & Current Harmonics Waveform

Conclusion

In conclusion, when nonlinear loads, such as motor starters and drives, lighting, power electronic equipment, printers and computers, are connected to the system, current and voltage harmonics may be produced.

The harmonics can cause overheating, unwanted tripping, short equipment life, failure of communications and low energy efficiency and etc. Buildings with nonlinear loads installed are highly recommended to do a comprehensive power quality analysis to identify potential power quality issues caused by harmonics.

As a complete solution for harmonic mitigation, active filters can significantly reduce harmonics. Circutor AFQ model comes with additional functions, which include three phase current balancing and reactive power compensation.

The benefits of installing active filters include but not limited to reliable operation of equipment, less energy loss caused by overheating, increased productivity, longer equipment life time, less maintenance work, less costs associated with downtime resulting from the malfunction or failure of equipment which can be staggering.

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