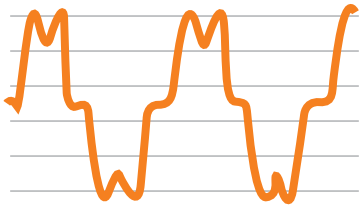
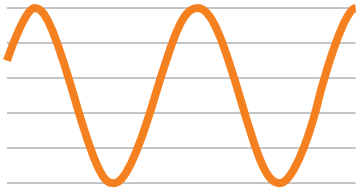
Power Quality

The term 'Power Quality' is used to describe the quality or 'fitness' of electric power that drives an electrical load and the load's ability to function properly. Without the proper power, an electrical device may malfunction, fail prematurely or not operate at all.



DIRTY POWER



CLEAN POWER

The term 'clean power' is used to describe electricity that is considered to be of good quality (see below) with particular reference to a very low harmonic content. Therefore, the term 'dirty power' is used to describe electricity that is considered to be of low quality (opposite to the above) with particular reference to a very high harmonic content.

Fuseco is committed to providing power quality solutions that represent great value – current generation technology applied with a practical, proven approach that represents a sensible value for money outcome.

The following list of characteristics are considered to be necessary for 'good power quality'.

1. **It must have a continuity of service (not be interrupted).**
   Contact Fuseco to discuss solutions that are often used to provide continuity of supply in the event of 'power outages'.

2. **It must have a very low harmonic content.**
   Harmonics can be created by non-linear loads such as variable speed drives, lighting and computer servers/data centers. Refer to pages 18-33 for information on harmonic mitigation solutions.

3. **It must have a very low variation in the voltage magnitude.**
   Voltage regulators are often used to provide a stable voltage supply in challenging electrical environments. Refer to pages 34-35 for more information.

4. **It must have very low transient voltages and currents.**
   In most cases, these phenomena are a by-product of the system load, especially environments with mechanical or high speed switching. Active Harmonic Filters (refer pages 18-23) and SVG units (refer pages 12-17) can provide improvements this area.

If we look beyond the power quality of the supply, there are also considerations regarding the power quality of a particular localised electrical environment. The power supply may be of good quality, however if the loads in a particular system are challenging (eg. non-linear, mechanical & high speed switching environments), the resulting power quality of that system may be poor.

In these cases, Active Harmonic Filters on pages 18-23 can be employed within a customised solution to improve the quality and efficiency of that particular electrical environment. Contact Fuseco for specific solutions to challenging electrical environments.

Power Quality – Applications

Solar Inverters can create RFI. RFI filters can be installed to eliminate or reduce the issues.

Hydraulic Systems Hydraulic Systems that manage the movement of water (eg, bathrooms, kitchens, waste and irrigation) incorporate pumps, motors and VSDs that propagate harmonics.

Lighting Systems can create RFI and harmonics due to operational high frequency switching.

HVAC Systems that manage heating, air ventilation and air conditioning incorporate pumps, motors and VSDs, resulting in the propagation of harmonics.

Vertical Transport Systems such as elevators, lifts and escalators incorporate VSDs, resulting in the propagation of harmonics.

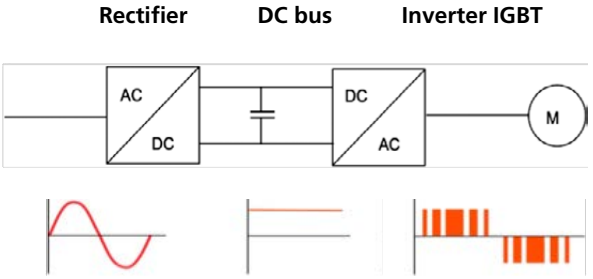
The Distribution Boards on each floor are a location where harmonic mitigation devices are often installed to reduce the system harmonic content.

The Main Switchboard is the location where Power Factor Correction Solutions are installed to bring the system power factor to unity and Active Harmonic Filters are installed to mitigate harmonics to comply with IEEE519-1992 and AS/NZS 61000.3.6

Data Centers & Computer Server Rooms utilise systems that can create harmonics and a leading power factor.

FUSECO

VSDs and Harmonics

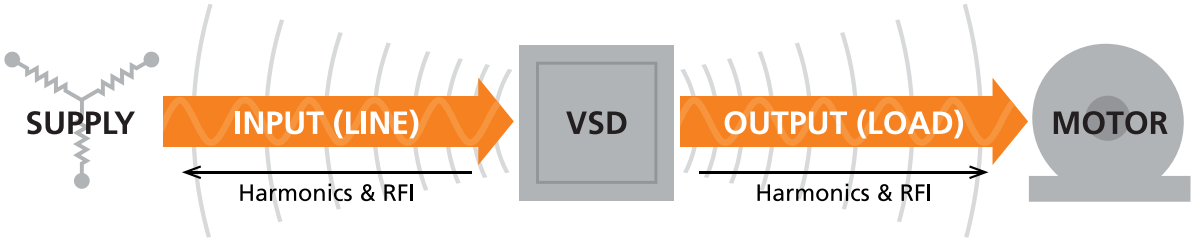


For motors to be used in a practical and useful way, we need to be able to control their speed of operation. A Variable Speed Drive (VSD), also known as a Variable Frequency Drive (VFD) is a programmable device that controls motor speed.

A VSD works by having a rectifier section at the input and this creates DC voltage on the DC bus (needed for switching). The inverter section at the output side provides the Pulse Width Modulation (PWM) waveform. A drive changes the speed of the motor by changing the frequency to the motor. As an aside, the impedance of the motor is determined by the inductive reactance in the windings, and it changes as the frequency changes.

PWM is employed to control the voltage and frequency to the motor drive. DC voltage is applied to the motor by controlled pulses at high frequency, which results in voltage that approximates a sine wave of the chosen frequency.

This PWM method creates harmonics in the system. The switching also creates radio frequency interference (RFI) and voltage spikes that can be up to 1200V at the motor terminals. The high switching frequency can also lead to 'capacitive bearing currents' that flow through the motor bearings and can damage the bearing surfaces. A portion of the harmonics are reflected back to the VSD by the motor, creating further issues in the electrical environment.



Harmonics in an electrical system can cause:

- Degradation of motors, especially the bearings and insulation = higher costs
- Significant reduction of the lifespan of equipment due to excessive heat = higher costs
- Although you will get billed for the power that you are supplied, a large percentage of that power may be unusable = higher costs
- Unusual events such as flickering lights, alarms going off, or MCB's, MCCB's, RCD's and Earth Leakage devices tripping for no apparent reason = more down time = higher costs

VSDs are prolific creators of harmonics in electrical systems and as a result, most of the harmonic mitigation effort focuses on the input side and output side of a VSD. For the mitigation of harmonics on the input side (line side) of a VSD we recommend Line Reactors, Passive Harmonic Filters and Active Harmonic Filters. For the mitigation of harmonics on the output side (load side) of a VSD we recommend Load Reactors, dV/dT Filters and Sine Wave Filters.

Sellers of VSDs please note:

- Customers are becoming more aware of the damage caused by VSD related harmonics. Harmonic mitigation products are now being offered to customers as a 'value-add', in essence as an 'insurance policy' against the detrimental effects of harmonically rich environments, enhancing the longevity of both the motors and the drives.
- These products are also used on the input side of a drive in situations where harmonics are causing issues and in cases where a site needs to comply to supply authority requirements for harmonic content coming back onto the grid.
- Harmonic mitigation products MUST be considered for applications with long cable runs and/or multiple VSDs in the one environment.

Harmonic Mitigation Solutions

SUPPLY

INPUT (LINE)

VSD

OUTPUT (LOAD)

MOTOR

Active Harmonic Filters

- Reduces harmonics to 5% or less
- Simultaneous compensation of 2nd to 50th harmonic order
- Provides leading & lagging power factor correction
- Load balancing
- Reduces supply sags & surges
- Meets AS/NZS 61000.3.6 standards and IEEE519 recommendations

Passive Harmonic Filters (Low Pass Filters)

- Reduces harmonics to 5%
- Reduces cable heating & energy losses
- Improves power factor and reduces system losses
- Minimises interference with other equipment
- Easy installation and operation
- Meets AS/NZS 61000.3.6 standards and IEEE519 recommendations

Line Reactors (Chokes, Inductors, Line Filters)

- Reduces harmonic distortion
- Reduces surge currents
- Virtually eliminates nuisance tripping
- Improves power factor
- Extends lifespan of semiconductors
- Meets AS/NZS 61000.3.6 standards and IEEE519 recommendations

RFI Filters

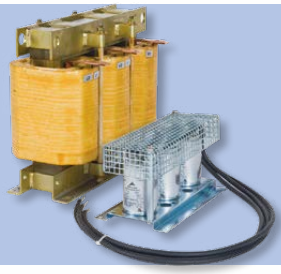
- Blocks radio frequencies that cause electrical interference
- Reduces inverter instability
- Improves radio & TV reception
- Reduces control systems interference

Load Reactors (Motor Chokes, Inductors, Load Filters)

- Reduces harmonic distortion
- Reduces surge currents
- Protects motors from long lead effects
- Reduces reflective currents
- Reduces motor temperatures & audible noise
- Meets AS/NZS 61000.3.6 standards and IEEE519 recommendations

dV/dT Filters

- Protects motors from long lead peak voltages
- Prevents voltage spikes from exceeding 1kV
- Increases motor bearing life & up-time
- Reduces common mode noise and currents
- Reduction of motor temperatures & peak voltages
- Meets AS/NZS 61000.3.6 standards and IEEE519 recommendations



Sine Wave Filters

- Allows for the use of unshielded cables (lower project costs)
- Allows for the use of longer motor cables
- Reduces eddy currents, stray flux losses & bearing currents
- Eliminates torque ripple & voltage wave reflection
- Reduces motor noise, vibration & heat
- Meets AS/NZS 61000.3.6 standards and IEEE519 recommendations

Power Quality Standards

Australian Standards

The relevant standard for harmonic voltage distortion in Australia is AS/NZS 61000.3.6 and it is compatible with the IEEE 519 recommendations. If the supply authority is dissatisfied with the degree of voltage distortion at the point of common coupling (pcc), harmonic filtering may be specified to comply with the Australian Standards.

Odd harmonics, non-multiples of 3		Odd harmonics, multiples of 3 (triplens)		Even harmonics	
Order, h	% harmonic voltage	Order, h	% harmonic voltage	Order, h	% harmonic voltage
5	5	3	5	2	2
7	5	9	1.5	4	1
11	3.5	15	0.3	6	0.5
13	3	21	0.2	8	0.5
17	2	>21	0.2	10	0.5
19	1.5			12	0.2
23	1.5			>12	0.2
25	1.5				
>25	0.2 + 1.1(25/h)				

NOTE: total harmonic distortion (TDHV) 8% max

IEEE 519

The IEEE is the Institute of Electrical and Electronics Engineers. IEEE 519 'Recommended Practices and Requirements for Harmonic Control in Electric Power Systems', was published in 1981. The document established the levels of voltage distortion that are acceptable to a distribution system and has been widely applied in establishing required harmonic correction throughout the electrical industry.

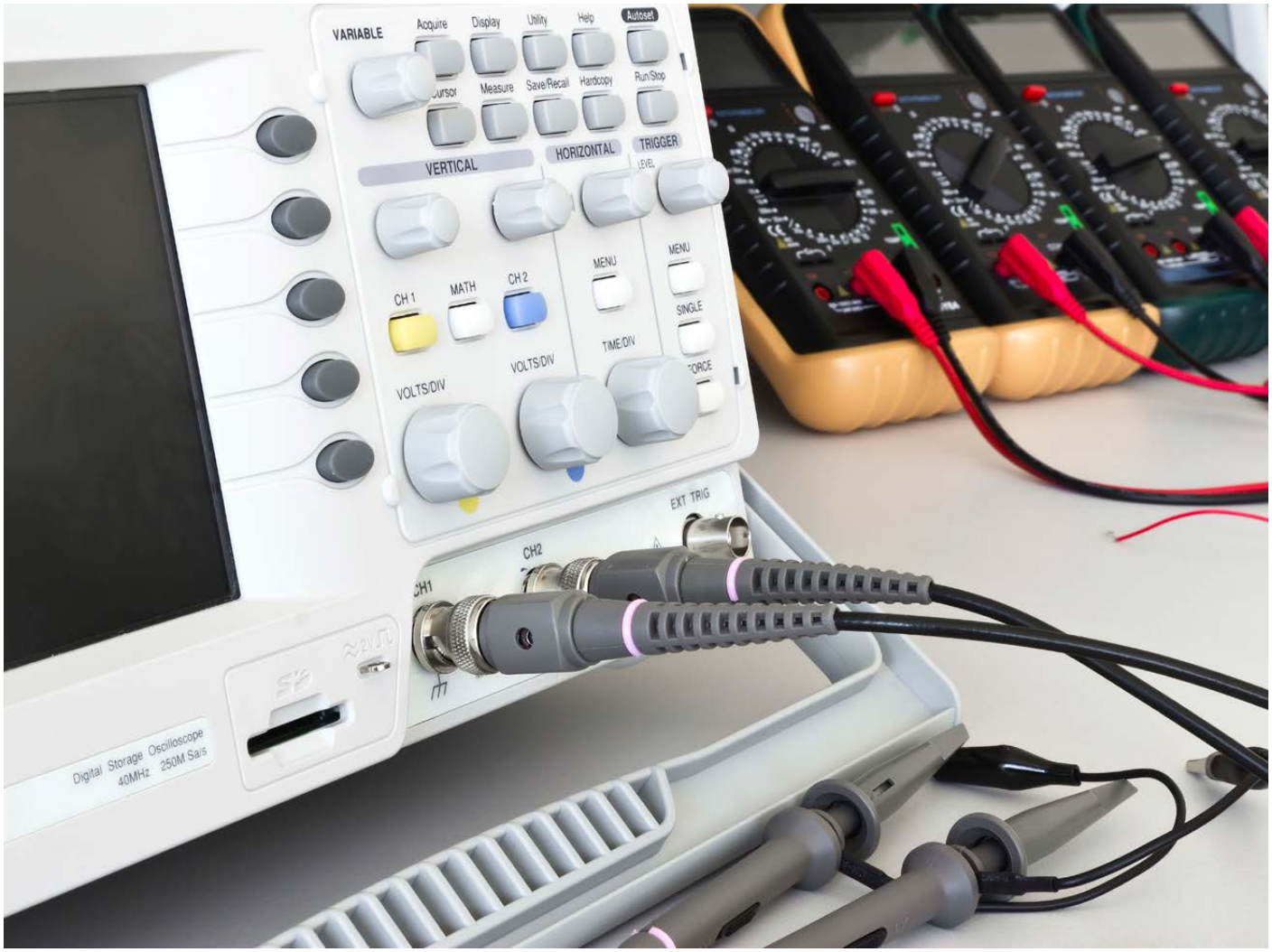
The new IEEE 519, published in 1992, sets forth limits for both harmonic voltages on the utility transmission and distribution systems and harmonic currents within the industrial distribution systems. Since harmonic voltages are generated by the passage of harmonic currents through distribution system impedances, by controlling the currents or system impedances within the industrial facility, one can control harmonic voltages on the utility distribution.

IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
Table 10-3 of IEEE Std 519-1992

ISC/IL	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	Total Demand Distortion
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

NOTE: • Current Distortion Limits for General Distribution Systems (120V through 69,000V) • Maximum Harmonic Current Distortion in Percent of I L • Individual Harmonic Order (Odd Harmonics) • Even harmonics are limited to 25% of the odd harmonic limits above • Current distortions that result in a DC offset, e.g. half-wave converters, are not allowed • All power generation equipment is limited to these values of current distortion, regardless of actual ISC/IL (ISC = maximum short-circuit current at PCC; IL = maximum demand load current, fundamental frequency component, at PCC)

Site Audit



A Power Quality Site Audit is a service offered by Fuseco to our customers and the industry. A power quality consultant visits your site and conducts a power quality audit of your electrical system.

This involves setting up sophisticated measuring equipment on site that monitors and records all of the electrical activity that is occurring within the system over a period of time. The equipment is compact, easily transportable to most locations and can be set up indoors or outdoors.

An analysis of the recorded data usually helps to reveal any harmful harmonics, voltage supply and power factor issues. Our consultant will consider the data and present you with a power quality report, outlining the observed issues and suggesting solutions if required.

Audits are useful in determining electricity usage inefficiencies and identifying damaging harmonics which occur in electrical systems.

Even correctly functioning power systems require routine auditing to ensure early identification of any potential issues and proactive servicing requirements to keep power equipment operating to its full potential and the electrical environment complying to the Australian Standard AS/NZS 61000.3.6 and compatible with the IEEE519 recommendations.

A correctly functioning system could save you upwards of 30% off your power bills. In some industries and installations, that could translate to significant increases to your bottom line. By running an efficient system, you also use less energy and therefore help the environment.

To discuss our site analysis service in more detail, please contact a power quality consultant at Fuseco.