ALCAP GROUP

ALCAP EDUCATIONAL DOCUMENT | POWER QUALITY

Harmonics and Power Quality

How waveform distortion affects equipment, how to investigate it, and how mitigation should be selected

Modern power electronics improve control and efficiency but can draw non-sinusoidal current. The resulting harmonics can distort voltage, add heating, interfere with equipment, and interact with capacitors and network impedance.

WHAT YOU WILL LEARN

- What harmonic frequencies and total harmonic distortion mean
- Which loads commonly create distortion
- Typical symptoms and why symptoms alone are not proof
- How measurement, standards, and engineering lead to mitigation

PRACTICAL. INDEPENDENT. DECISION-FOCUSED.
Written for South African commercial and industrial energy users. Prepared July 2026 | Version 1.0

01 | THE ESSENTIALS

Build the right mental model

In South Africa the fundamental AC frequency is 50 Hz. Harmonics occur at integer multiples such as 150 Hz (3rd), 250 Hz (5th), and 350 Hz (7th). Their magnitude and phase combine to change the waveform.

Sources

Variable speed drives, UPS systems, switch-mode power supplies, rectifiers, LED drivers, welders, and inverters are common non-linear loads. The mix and operating state matter.

Effects

Possible effects include extra conductor and transformer heating, high neutral current, capacitor stress, torque pulsation, nuisance operation, interference, and reduced equipment life.

Measurements

Voltage THD, current THD, individual harmonic spectrum, RMS current, neutral current, power, events, and the point of common coupling must be interpreted together. THD alone is not a diagnosis.

MEASURE AT THE RIGHT PLACE

Standards often assess distortion at a defined interface such as the **point of common coupling (PCC)**. Equipment troubleshooting may require measurements deeper inside the facility. The location and network strength change the result.

A QUICK REFERENCE

Symptom	Possible link	Also investigate
Hot transformer/cable	Harmonic RMS and losses	Loading, cooling, connections
High neutral current	Triplen harmonics	Phase balance, wiring
Capacitor failure	Resonance/overcurrent	Voltage, temperature, age
Nuisance trips	Waveform/peak effects	Settings, faults, coordination

02 | PUT IT TO WORK

Turn understanding into action

Do not begin with a filter product. Begin with a defined problem, a single-line diagram, representative measurements, and a target based on the applicable standard and connection agreement.

1. **Define symptoms and boundaries**
   Record affected equipment, timing, operating state, location, and consequence.
2. **Build a load inventory**
   Identify converters, drives, UPSs, inverters, capacitors, and recent changes.
3. **Measure representative states**
   Use a suitable power-quality analyser and capture steady-state distortion and relevant events.
4. **Model interactions**
   Assess transformer and cable impedance, capacitor resonance, background distortion, and the PCC.
5. **Select and verify mitigation**
   Options can include line reactors, multi-pulse or active front ends, passive filters, active filters, or system reconfiguration.

ILLUSTRATIVE EXAMPLE: CAPACITOR INTERACTION

A facility adds a capacitor bank to improve power factor. The capacitance and upstream inductance create a resonant condition near a dominant harmonic. Capacitor current rises and failures follow. The lesson is not that capacitors are unsuitable, but that harmonic conditions must be included in the design.

A GOOD DECISION LOOKS LIKE

- Limits are evaluated at the correct location and operating condition.
- Mitigation is sized from the spectrum, impedance, and future load plan.
- Post-installation verification confirms both compliance and equipment relief.

03 | CHECKLIST AND NEXT STEPS

Use this before you proceed

[ ]	Document the single-line diagram and intended measurement points.
[ ]	List non-linear loads, ratings, pulse/front-end type, and operating patterns.
[ ]	Measure voltage and current spectra, THD, RMS, power, and neutral current.
[ ]	Check power factor capacitors and reactors for resonance and loading.
[ ]	Agree the standard, limits, PCC, and test window before analysis.
[ ]	Retest after mitigation under comparable production conditions.

RED FLAGS

- Diagnosing from one THD number
- Applying a voltage limit directly to load current without context
- Installing filters without impedance or resonance analysis
- Ignoring background distortion and changing operating states

PLAIN-LANGUAGE GLOSSARY

Fundamental	The main system frequency, typically 50 Hz in South Africa.
Harmonic	A frequency at an integer multiple of the fundamental.
THD	Total harmonic distortion, a ratio combining harmonic content.
PCC	Point of common coupling used as a defined assessment interface.
Resonance	Amplification caused by interaction between inductance and capacitance.

SOURCES AND FURTHER READING

- IEEE SA - IEEE 519 harmonic control
- U.S. DOE - Electricity Distribution System Baseline
- Eskom - Power quality advice

IMPORTANT NOTE

This document is for general education only. It is not a substitute for a site assessment, electrical design, tariff review, safety study, or professional advice. Use the latest applicable standards, utility rules, municipal requirements, and manufacturer instructions. Work on electrical systems must be performed by suitably qualified and authorised persons.

Learn more at **alcap.co.za** or contact **admin@alcap.co.za**.