



ALCAP EDUCATIONAL DOCUMENT | POWER QUALITY

Voltage Quality and Electrical Protection

Understanding sags, swells, imbalance, transients, interruptions, earthing, and coordinated protection

Electrical reliability depends on both supply quality and correctly engineered protection. Voltage events can disrupt sensitive processes, while protection must detect faults, isolate the right section, and keep people and equipment safe.

WHAT YOU WILL LEARN

- How common voltage disturbances differ
- Why sensitive equipment can trip even when the outage is very short
- What selectivity and protection coordination aim to achieve
- How event data, single-lines, settings, and operating context support diagnosis

PRACTICAL. INDEPENDENT. DECISION-FOCUSED.

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01 | THE ESSENTIALS

Build the right mental model

Power quality includes voltage magnitude, frequency, waveform, balance, interruptions, and transient events. Protection includes devices and settings designed to respond to abnormal electrical conditions.

Voltage disturbances

Sags are short reductions, swells are short increases, interruptions are loss of supply, imbalance means phase values differ, and transients are fast changes. Duration and magnitude determine equipment response.

Source and immunity

An event may originate on the utility network or inside the facility. Process impact also depends on equipment ride-through, controls, contactors, UPS design, restart logic, and electrical separation.

Protection coordination

Fuses, breakers, relays, earth-leakage devices, and surge protection must suit fault levels and work together so the nearest appropriate device clears the fault without exposing equipment or people.

SEPARATE THE EVENT FROM THE CONSEQUENCE

The same voltage sag may be harmless to one load and stop an entire line through a sensitive control relay. Record both the **electrical event** and the **process trip chain** before selecting a solution.

A QUICK REFERENCE

Phenomenon	Typical symptom	Evidence
Sag	Drives/contactors trip	Event magnitude and duration
Transient	Control or insulation stress	High-speed event capture
Imbalance	Motor heating/current mismatch	Phase voltage/current trend
Fault trip	Section outage	Relay/breaker records and settings

02 | PUT IT TO WORK

Turn understanding into action

A reliable investigation synchronises power-quality data with protection records and process logs. Without common timestamps, cause and consequence are easily confused.

1**Define the failure**

Record affected assets, exact time, operating state, lost production, alarms, and reset sequence.

2**Collect electrical records**

Obtain PQ events, relay targets, breaker trips, UPS logs, SCADA/BMS trends, and utility information.

3**Review the system**

Update single-lines, fault levels, protection devices, settings, earthing, surge protection, and critical control supplies.

4**Test coordination and immunity**

Compare calculated fault behaviour and time-current curves with equipment ride-through requirements.

5**Prioritise layered solutions**

Consider source correction, network changes, settings, control-power support, UPS/DVR solutions, separation, and process restart logic.

ILLUSTRATIVE EXAMPLE: NUISANCE PROCESS TRIP

A short upstream fault causes a voltage sag. Main power remains available, but a contactor drops out and requires manual restart. The lowest-cost solution may be control-circuit ride-through or revised process logic, not whole-site backup power.

A GOOD DECISION LOOKS LIKE

- Fault and protection work is completed by competent professionals with approved settings control.
- Power-quality remedies target the measured event and actual process vulnerability.
- Critical settings, test records, and single-lines are controlled documents.

03 | CHECKLIST AND NEXT STEPS

Use this before you proceed

- ☐ Maintain accurate single-lines and a protection/settings register.
- ☐ Record fault levels and verify equipment interrupting ratings.
- ☐ Synchronise PQ, relay, UPS, SCADA, and process timestamps.
- ☐ Inspect earthing, bonding, surge protection, and control supplies.
- ☐ Review selectivity when loads, transformers, generators, PV, or BESS change.
- ☐ Test trip, interlock, and restart functions under controlled procedures.

RED FLAGS

- Increasing breaker ratings to stop trips without a study
- Settings changed without approval or a controlled record
- Blaming the utility without event data
- Adding generation or storage without updating fault and protection studies

PLAIN-LANGUAGE GLOSSARY

Sag	Short-duration reduction in RMS voltage.
Transient	Fast, short-duration change in voltage or current.
Selectivity	Coordination so the nearest suitable protection clears a fault.
Fault level	Prospective electrical current available during a fault.
Ride-through	Ability to keep operating through a disturbance.

SOURCES AND FURTHER READING

- Eskom - Power quality advice
- NREL - Background on power quality
- U.S. DOE - Electricity Distribution System Baseline

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.

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