



Power Quality Testing Guide



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About This Guide

Power quality testing logs voltage and current at a point of connection or inside a site for days, then analyses the record for voltage magnitude and unbalance, harmonics, flicker, dips, swells, interruptions, transients and frequency. This guide sets out what to measure, where the point of common coupling sits, how long to log, the safety framework for connecting to live switchboards, and how to judge the result.

What a Power Quality Test Is

A logged measurement of the supply over days with a power quality analyser, judged against the connection agreement, the network's planning levels and the standards. Also called a power quality survey, audit or monitoring.

When It Is Used

At a connection application, at commissioning of inverters, drives and new plant, as a baseline, after a change to the site, and when nuisance trips, failures or flicker complaints need a cause.

Why It Matters

Harmonics heat transformers, cables and capacitors; dips trip drives and processes; unbalance heats motors. The survey shows which side of the connection point the problem is on, with numbers both parties can compare.

Guide at a Glance

Measures

Voltage and current per phase and neutral: magnitude, unbalance, harmonics to the 50th, flicker, dips, swells, interruptions, transients, frequency.

Method

Four voltage leads and four flexible current probes on a live switchboard; 10 cycle windows aggregated to 10 minute values (IEEE 519-2022, clause 4).

Instrument

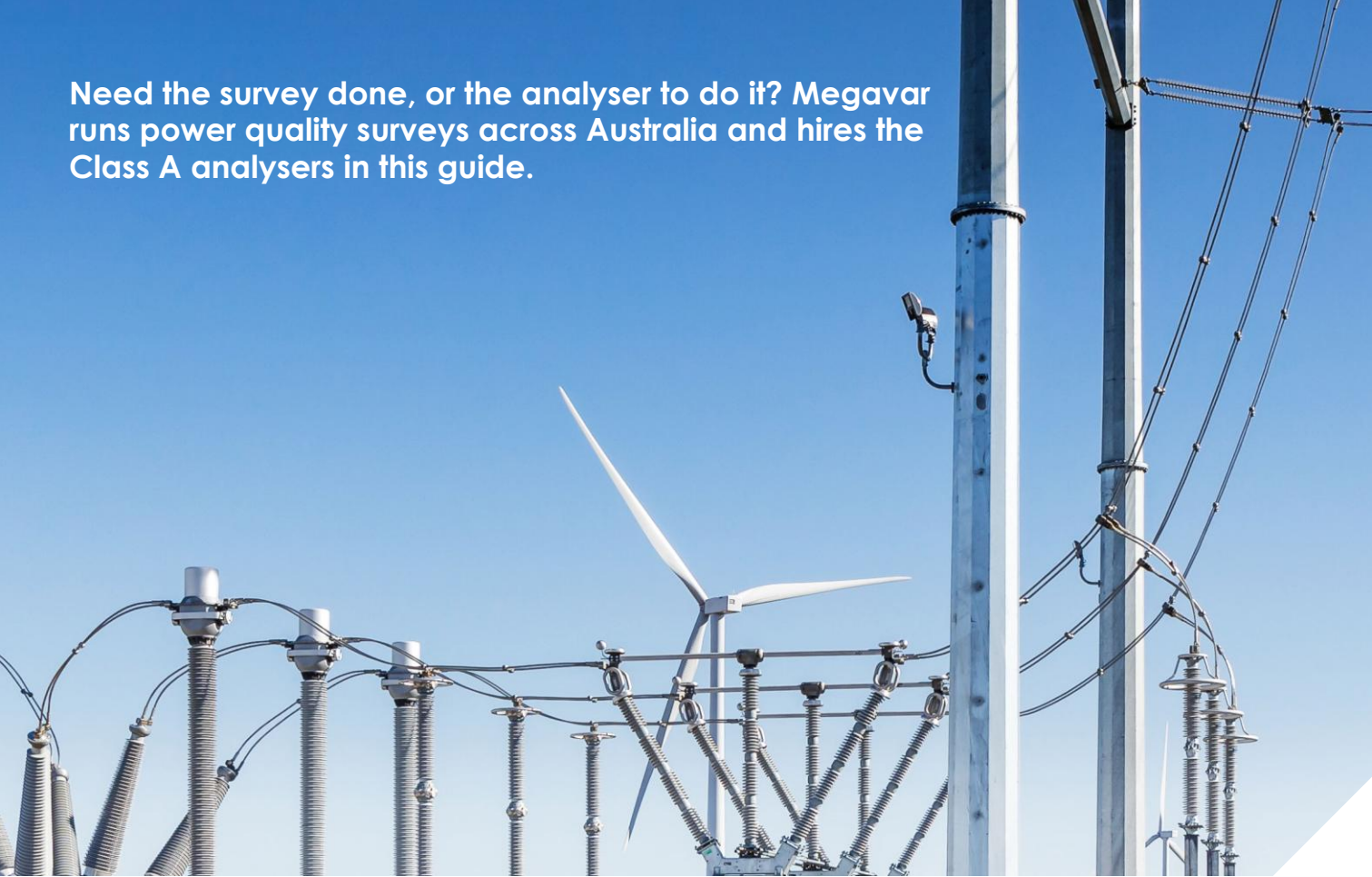
IEC 61000-4-30 Class A for compliance work; Class S for troubleshooting.

Duration

Seven continuous days minimum, so the weekly 95th and 99th percentiles exist (IEEE 519-2022, clause 4.4).

Judged Against

The connection agreement, the network's planning levels, AS 60038 and IEEE 519-2022 at the PCC, and the site's own history.



Need the survey done, or the analyser to do it? Megavar runs power quality surveys across Australia and hires the Class A analysers in this guide.

Why Measure Power Quality?

Power Quality Testing in Four Numbers

7 days

Logging needed for the weekly 95th percentile statistic (IEEE 519-2022, clause 4.4)

50th

Highest harmonic order a compliance survey must measure (IEEE 519-2022, clause 4)

+10% / -6%

Low voltage supply range about 230 V in AS 60038 (Queensland Government)

8%

Voltage THD above which malfunctions are probable (Schneider Electric CT199)

Why the Supply Shape Matters

Harmonics Heat Plant

Schneider Electric CT199 lists the effects: overheating of transformers and cables, third harmonic current adding in the neutral, capacitor overload and resonance. Malfunctions are probable above 8% voltage THD and possible between 5% and 8%.

Dips Stop Processes

A dip is a fall below 90% of the reference voltage for a few cycles to a few seconds. Schneider reports drives usually tripping on dips deeper than 15% and computer equipment being sensitive to dips deeper than 10%.

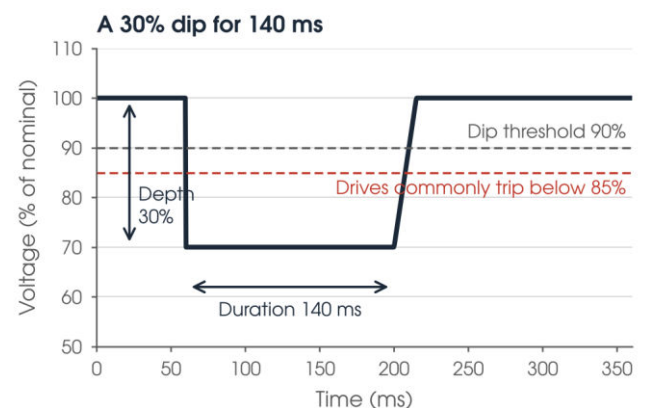
Unbalance Heats Motors

Negative sequence voltage drives negative sequence current in motors, raising losses without doing work (Schneider CT199, clause 2.6).

Whose Problem Is It

IEEE 519-2022 makes harmonic control a joint responsibility: the user limits current emission, the network limits voltage distortion (Clause 5). A logged week at the connection point is the evidence either side needs.

What a Dip Looks Like



A voltage dip is characterised by depth and duration, from the rms value over one cycle updated every half cycle (Schneider CT199, clause 2.2).

When to Test



Where Is It Used?

Measurement Points

Measurement point	What a bad result points to	Instrument and duration
Point of common coupling with the network	Harmonic, flicker or unbalance emission outside the connection agreement or planning levels	Class A, seven days
Solar, wind or BESS inverter connection	Inverter harmonic emission, voltage rise at light load, flicker from cloud or wind variation	Class A, seven days plus event capture
LV main switchboard or site incomer	Supply voltage outside its range, dips and interruptions arriving from the network	Class A or Class S, seven days
Motor control centre with drives	Harmonic current from six-pulse drives, neutral current, resonance with capacitors	Class S, one to seven days
UPS, data and control supplies	Dips, swells and transients that match equipment resets	Transient capture, until the event recurs
Capacitor bank or power factor correction	Switching transients, harmonic amplification from resonance	Transient capture, days

Choosing the Point and the Duration

IEEE 519-2022

The limits apply at the PCC only, not to individual equipment or inside the user's facility (Clause 5). For an industrial user on a dedicated transformer the PCC is the HV side; for a commercial user on a shared transformer it is commonly the LV side (clause 1.2).

The Weekly Statistic

Ten minute values are accumulated over one week and compared as the 95th and 99th percentiles (clause 4.4). Fewer than seven days and the statistic does not exist.

A Representative Cycle

Schneider CT199 says a portable survey must cover the operating cycle of the plant, for example one week. Fluke's guidance for an EN 50160 compliance check is also a full week.

Our Recommendation

Seven full days at the PCC with a Class A analyser, 10 minute aggregation, with event capture on. Add in-plant loggers for diagnosis, not for compliance.

Shorter or Longer

Why Not Shorter

A working day and a weekend behave differently; voltage rises at light load and harmonic current falls. A two day log can pass on a Tuesday and fail on a Sunday.

When Longer

Intermittent events: log until the event is caught, with the trigger set to the complaint. Seasonal loads such as heating and air conditioning change harmonic levels (Schneider CT199, clause 2.3). Long term flicker Plt needs two hours per value.

Good to Know

Keep a site diary of what ran and when. A week of data without it cannot be matched to a cause.

Set the analyser clock before logging. Compliance statistics are timestamped to UTC in Class A.

How Does It Work?

What the Analyser Computes

Voltage and Dips

The rms voltage is calculated over one cycle and refreshed every half cycle, so a dip of a few cycles is caught with its depth and duration (Schneider CT199, clause 2.2).

Harmonics

A Fourier transform over 10 cycles at 50 Hz gives components every 5 Hz; each harmonic is the centre bin with its two neighbours. Values are aggregated to 3 s and 10 min (IEEE 519-2022, clauses 4.1 to 4.3).

Flicker and Unbalance

Flicker uses the IEC 61000-4-15 flickermeter: Pst over 10 minutes, Plt over two hours. Unbalance is the negative sequence voltage as a percentage of the positive sequence (Schneider CT199, clause 2.6).

THD and TDD

THD is the harmonic content as a percentage of the fundamental. TDD is the same content as a percentage of the maximum demand current IL, and it is TDD that IEEE 519 limits (clause 3.1).

Connection Rules

Four Voltage Leads

One per phase and one to the neutral, with the analyser earth to the switchboard earth bar. Line to neutral is what IEEE 519-2022 Table 1 limits.

Four Current Probes

Flexible probes on each phase and the neutral, with the arrow pointing to the load. A reversed probe gives negative power and a wrong phase angle (Fluke).

Match the Phases

The current probe on L1 goes with the voltage lead on L1. A mismatch gives impossible power factors and wrong harmonic phase angles.

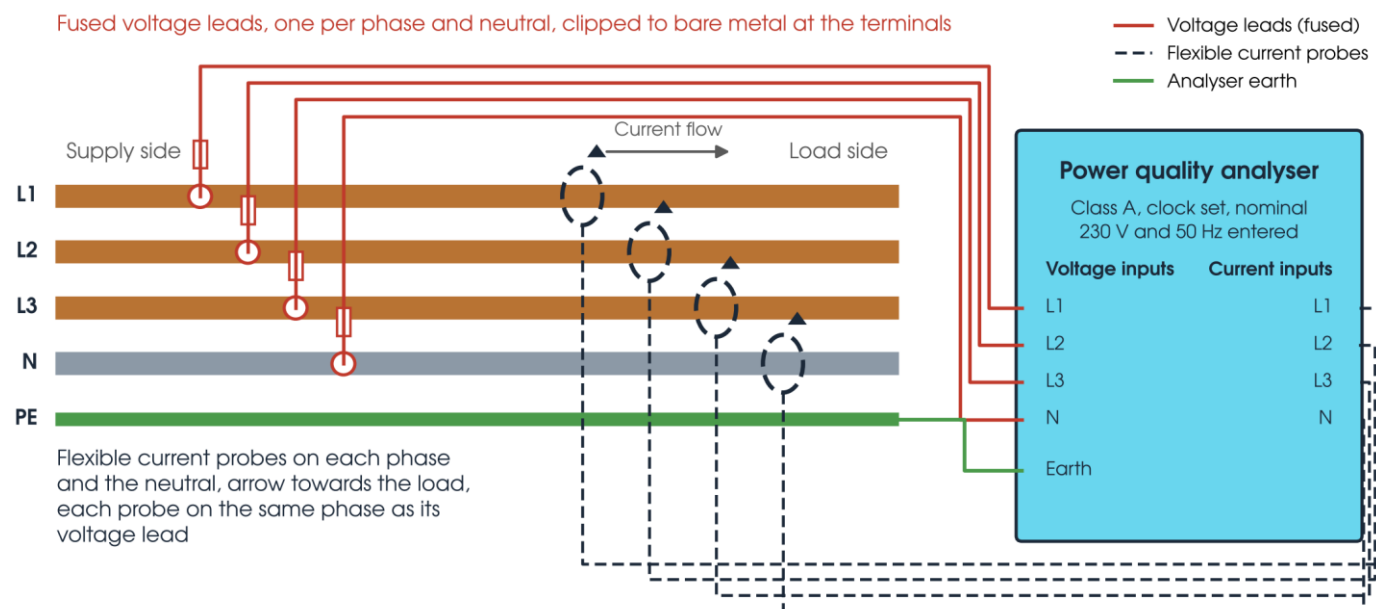
Class A

Class A sets voltage accuracy at 0.1% of the declared input and fixes the aggregation intervals and timestamping, so two instruments agree (Fluke, as summarised). IEEE 519-2022 Clause 4 requires Class A to the 50th order.

Good to Know

Run the analyser's wiring check before logging. Fixing a reversed probe on a live board a week later costs the week.

Connection Arrangement



Three-phase four-wire connection on an LV switchboard. Fused voltage leads to each phase and neutral; flexible current probes on each conductor with the arrow towards the load.

How Do I Set Up Safely?

Authorisation, Permits and PPE

1 It Is Energised Electrical Work

Connecting leads to live busbars is energised electrical work: the Safe Work Australia code requires a recorded risk assessment, a safe work method statement, a competent person with tested tools and PPE, and a safety observer unless the work is testing only with no serious risk.

2 The Asset Owner's Rules

Work under the asset owner's live work rules and switchboard access permit, with the point of isolation marked and clear.

3 Arc Flash PPE

Wear PPE rated to the incident energy at that board from the site's arc flash study. With no study, treat the board as high energy and raise it.

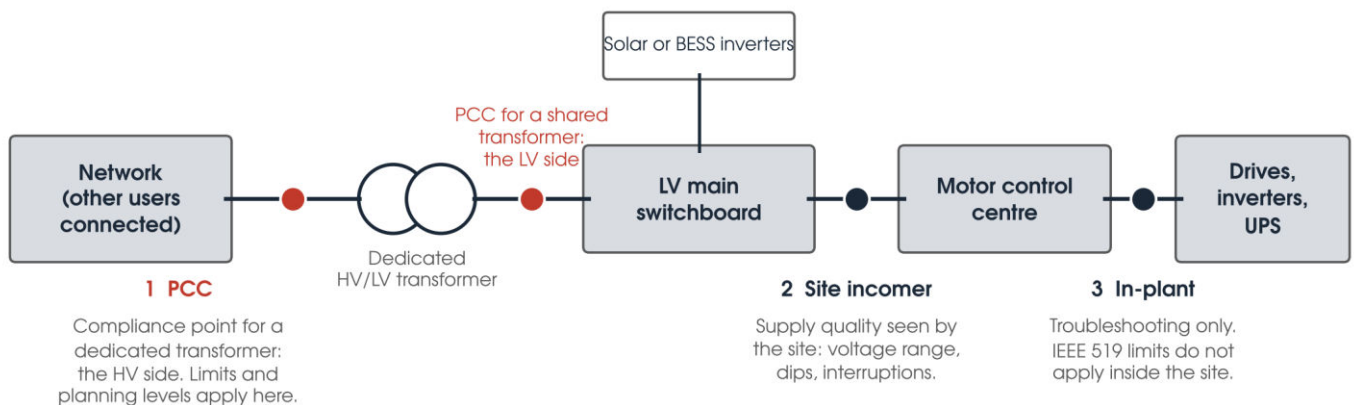
4 Rated Instrument and Leads

Analyser and leads rated Category III or IV for the point of connection (SWA code, clause 8.4, citing AS 61010.1). Fused voltage leads, shrouded clips, probes that cannot bridge phases.

Who Should Test

Competent, authorised testing personnel under the asset owner's rules. At Megavar, assessed testers; others under direct supervision.

Where to Measure on the Plant



Source of the PCC rule: IEEE 519-2022, clause 1.2 and Clause 5.

Limits apply at the PCC: the HV side of a dedicated transformer, the LV side of a shared one. In-plant points are for finding the source.

Important

This guide describes general practice for competent HV testing personnel. It is not a work procedure. Work under the asset owner's safety rules, the access permit and a site-specific safe work method statement. Manufacturer and asset owner criteria take precedence over the general guidance here.

Test-Specific Hazards

Flexible Probes on Live Busbars

Check the probe's voltage rating against the busbar, keep the loop clear of adjacent phases, and fit it where a closing door cannot push it into a gap.

Never Open a CT Secondary

If the site's metering CTs are used instead of probes, the secondary must be shorted at the test block before any lead is moved. An open CT secondary produces lethal voltage.

A Logger Left for a Week

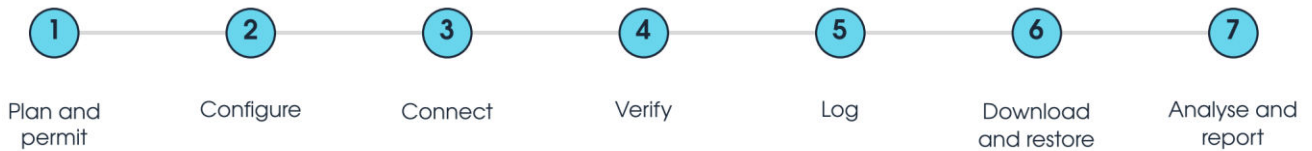
Secure the analyser inside the cabinet or a locked enclosure, strain-relieve the leads, close and label the door, confirm its supply, and leave the permit contact with the site.

Do Not Disturb the Process

Clip to terminals and bars, never across a contact or a protection device, and do not interrupt a control supply to power the analyser.

How Do I Make the Measurement?

Seven Steps



Steps 1 to 4

1 Plan and Permit

Fix the measurement point, the limits to test against and the duration. Obtain the live work authorisation, permit and arc flash rating of the board.

2 Configure

Enter nominal voltage and frequency, wiring type, probe range, Class A compliance mode, 10 minute aggregation, event thresholds and a start time. Set the clock.

3 Connect

Earth first, then voltage leads, then current probes with arrows to the load, each on the same phase as its voltage lead.

4 Verify

Run the wiring check: phase rotation, matching voltages and currents, power direction on every phase that fits the operating state (export can read negative), sensible power factor. Correct before logging.

Common Mistakes

Reversed Current Probe

Negative power on one phase and wrong harmonic phase angles.

Phase Mismatch

Current from L2 paired with voltage from L1: impossible power factor, wrong direction of harmonic flow.

Wrong Nominal Voltage

Dip and swell thresholds are set from the nominal, so events are missed or invented.

Class S for Compliance

Not comparable with the network's instrument and not what IEEE 519-2022 Clause 4 requires.

Steps 5 to 7

5 Log

Seven continuous days minimum. Secure the analyser, keep the site diary and check remotely or daily that it is still recording.

6 Download and Restore

Stop the record, download and back it up before touching a lead. Remove probes, then voltage leads, then earth, under the same permit conditions as connection.

7 Analyse and Report

Weekly 95th and 99th percentiles against the limits at that point, events matched to the diary, and the set-up recorded.

Good to Know

Record the probe serial numbers and ranges. A tenfold mismatch between probe range and analyser scaling gives a tenfold error, high or low depending on which setting is wrong.

More Common Mistakes

Too Short

No weekly percentile, and the light-load weekend is missed.

Wrong Point

A drive's terminal current compared with IEEE 519 Table 2 misapplies the standard; the limits are for the PCC.

Clock Not Set

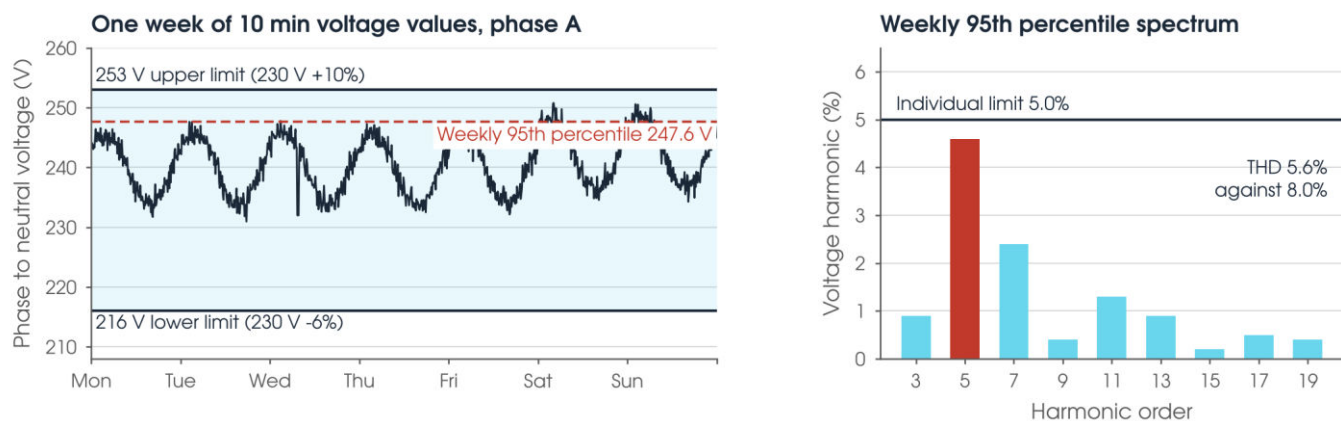
Events cannot be matched to the diary or to the network's own records.

Neutral Not Measured

Third harmonic current in the neutral, the common cause of a hot neutral, is not seen.

How Do I Read the Result?

A Week of Voltage, and the Harmonic Spectrum



Illustrative values. Limits: AS 60038 range, IEEE 519-2022 Table 1 (V 1 kV or less, at the PCC)

The voltage stays inside 216 to 253 V all week, but the weekend peaks sit within 2 V of the limit. The 5th harmonic at 4.6% is inside the 5.0% line but close. Both warrant a note, not a pass.

Comparing the Result

Steady-State Voltage

AS 60038 sets the standard low voltage at 230/400 V with a margin of +10% / -6%, that is 216 V to 253 V, as stated by the Queensland Government in its 2017 voltage limits regulation; the same source gives AS/NZS 61000.3.100 a preferred range of 225 V to 244 V. The network's own connection standard governs.

Harmonic Voltage at the PCC

IEEE 519-2022 Table 1: for 1 kV and below, 5.0% per harmonic and 8.0% THD; from 1 kV to 69 kV, 3.0% and 5.0%; from 69 kV to 161 kV, 1.5% and 2.5%. The weekly 95th percentile of 10 minute values must be below the table and the daily 99th percentile of 3 s values below 1.5 times it (clause 5.1).

Harmonic Current at the PCC

Tables 2 to 4 in percent of IL by the short circuit ratio I_{sc}/I_L : for 120 V to 69 kV, TDD from 5.0% at I_{sc}/I_L below 20 to 20.0% above 1000. Weekly 95th percentile below the table, weekly 99th below 1.5 times, daily 99th below 2 times (clause 5.3). Generation is held to the lowest row (note c).

Australian Planning Levels

TasNetworks publishes planning levels from AS/NZS 61000.3.6 and the National Electricity Rules: voltage THD 7.30% at 0.4 kV and 6.61% at 11 to 33 kV load busbars, flicker Pst 1.0 and Plt 0.8 on LV, and the NER Table S5.1a.1 unbalance of 2.0% general at 10 kV and below. Other networks publish their own; use the one for the connection.

What a Bad Result Looks Like

Voltage High at Light Load

Weekend and overnight voltage near or above 253 V with solar exporting; a network voltage or tap setting matter, raised with the network.

5th and 7th Dominant

Six-pulse drives or rectifiers on site. Judge the likely source from in-plant loggers and load changes; direction alone does not prove it.

3rd Dominant With Hot Neutral

Single-phase electronic loads; triplen currents add in the neutral (Schneider CT199, clause 3.2).

Dips in Clusters

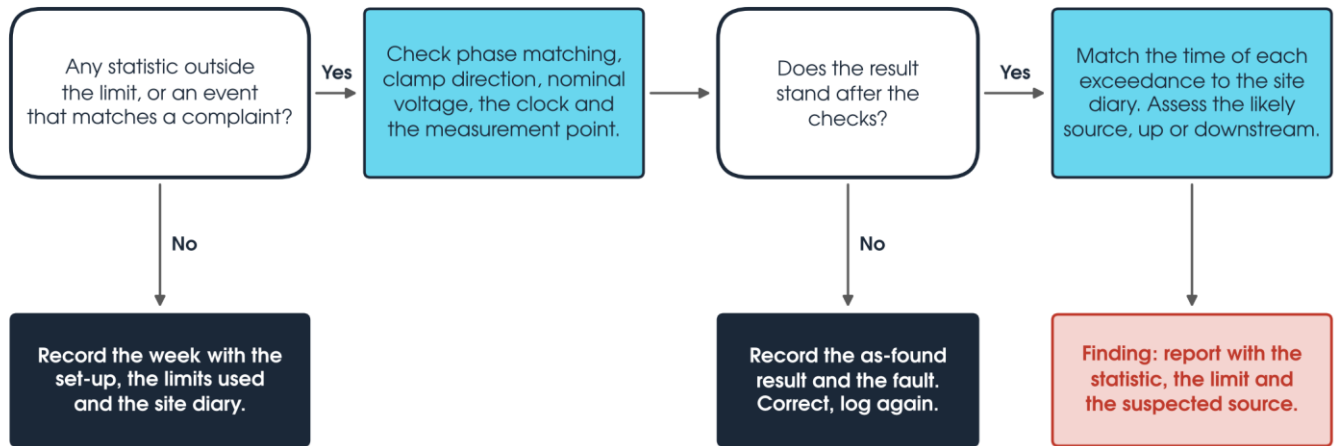
Network faults and reclosing, often in storms. Match times to the network's event records.

Interharmonics at a Fixed Frequency

Ripple control signalling on Australian networks uses 168 Hz to 1350 Hz (IEEE 519-2022, A.2.2); it is a network signal, not a fault.

Is My Result OK?

Decision Path



THD, TDD and the Worked Example

THD divides the harmonic current by the fundamental at the time; TDD divides it by IL, the average of the monthly 15 or 30 min maximum demand currents over 12 months (IEEE 519-2022, clause 3.1):

$$TDD = \sqrt{(I_5^2 + I_7^2 + I_{11}^2 + \dots)} / IL \times 100\%$$

Worked Example

One 10 minute interval at a 415 V PCC: $I_5 = 40$ A, $I_7 = 20$ A, $I_{11} = 10$ A, other orders negligible, fundamental 300 A, IL 600 A. Harmonic rms is $\sqrt{(1600 + 400 + 100)} = 45.8$ A. THD is 15.3%; TDD is $45.8 / 600 = 7.6\%$, inside the 12.0% Table 2 allows at I_{sc}/IL 50 to 100, and I_5 is 6.7% against 10.0%. THD alone would have said it failed. Compliance is the weekly 95th percentile of TDD calculated interval by interval, not one interval.

What to Report

The Point and the Set-Up

Measurement point and why it is the PCC, instrument, class, probe types and ranges, wiring type, nominal voltage, clock source, and the logging period.

The Statistics

Weekly 95th and 99th percentiles and daily 99th percentiles for voltage, each harmonic to the 50th, THD, TDD, unbalance, Pst and Plt, against the named limit at that point.

The Events

Every dip, swell, interruption and transient with time, depth and duration, matched to the site diary and the network's records.

IL and I_{sc}

How IL was established and the network's stated fault level, since neither TDD nor the I_{sc}/IL row can be stated without them.

What About Harmonics From Inverters and Drives?

Where the Orders Come From

Pulse Number Sets the Orders

A rectifier with pulse number p produces characteristic harmonics at $(p \times n) \pm 1$: a six-pulse drive at the 5th, 7th, 11th and 13th; a twelve-pulse drive at the 11th, 13th, 23rd and 25th (IEEE 519-2022, equation 3).

Typical Current THD

Schneider CT199 gives 44% for an adjustable speed drive, 28% for a rectifier or charger, 53% for fluorescent lighting and 115% for single-phase data processing loads, whose 3rd harmonic adds in the neutral.

Inverter-Based Resources

IEEE 519-2022 sends solar, wind and BESS installations at 10% or more of the site's annual average load to IEEE 1547 or IEEE 2800 for current limits (Figure 1). In Australia the network's connection agreement, drawn from AS/NZS 61000.3.6 and the NER, governs.

Reading the Spectrum

Reward for Mitigation

Where the 5th and 7th are held below 25% of the Table 2 value, IEEE 519-2022 Table 5 allows the other orders 1.4 times the limit; 2.0 times when the 11th, 13th, 17th and 19th are also held.

Resonance

A capacitor bank whose natural frequency with the source sits near a harmonic order amplifies that order; capacitor impedance falls with order (Schneider CT199, clause 3.2).

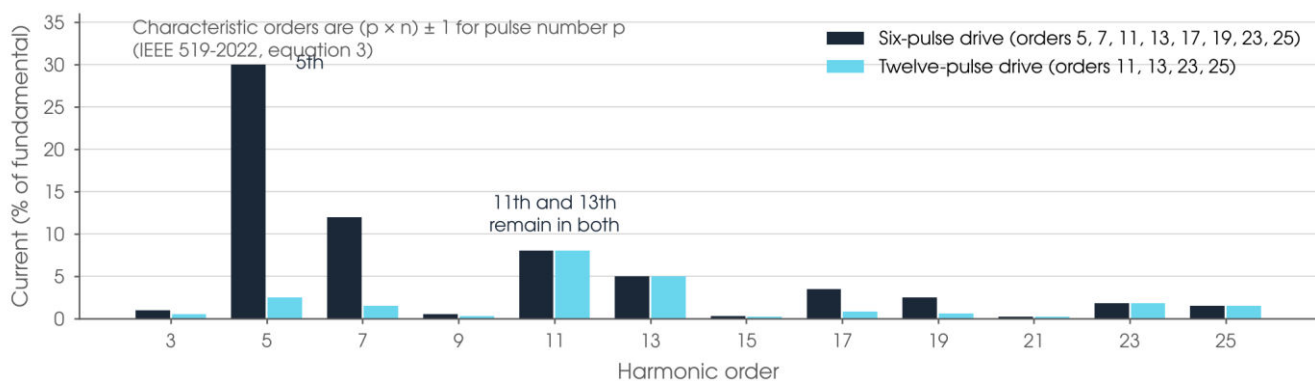
Inside Versus Outside

Compare the spectrum at the PCC with the spectrum at the drive: the same orders rising together with site load point inward; a background that does not change with site load points to the network.

Good to Know

Even harmonics and dc offset are not characteristic of a healthy converter; IEEE 519-2022 halves the even limits up to the 6th and does not allow dc offset (Tables 2 to 4, notes a and b).

Six-Pulse and Twelve-Pulse Drive Current Spectra



Recommended Solutions

Instrument	Class	Best used for
Fluke 435-II	IEC 61000-4-30 Class A	Compliance surveys at the PCC, generator and BESS connection verification, transient capture to 6 kV at 200 kHz, GPS time stamping
Fluke 434 Power Quality Meter	Class S	Troubleshooting, energy and harmonic audits inside the site, logging over days and weeks

Both analysers are supplied calibrated with flexible current probes, voltage leads and software, from Hobart, Launceston, Adelaide and Newcastle: [power quality analyser hire](#).

Frequently Asked Questions

Common Questions

How do I test power quality?

Connect a power quality analyser to the voltage and current at the point of connection, log for at least seven days with 10 minute aggregation, then compare the weekly statistics with the limits that apply at that point.

How is power quality measured?

By an analyser that calculates rms voltage every half cycle, harmonics over 10 cycle windows to the 50th order, flicker with a flickermeter and unbalance from sequence components, all aggregated to 10 minute values under IEC 61000-4-30.

What is the IEC standard for power quality?

IEC 61000-4-30 defines the measurement methods and Class A; IEC 61000-4-7 covers harmonic measurement and IEC 61000-4-15 the flickermeter. Emission limits in Australia come from AS/NZS 61000.3.6 and 61000.3.7 and the network's planning levels; IEEE 519-2022 is the limit set where a client or OEM specifies it.

What is a power quality analyzer?

A three-phase instrument that logs voltage, current, power, harmonics, flicker, unbalance and events over days. Class A analysers meet IEC 61000-4-30 for compliance work; Class S analysers are for troubleshooting.

Standards and References

IEEE Std 519-2022, IEEE Standard for Harmonic Control in Electric Power Systems.

AS 60038, Standard voltages; AS/NZS 61000.3.100, Steady state voltage limits in public electricity systems; as cited by the Queensland Government, Electricity (Voltage Limits) Amendment Regulation 2017.

AS/NZS 61000.4.30, Testing and measurement techniques: power quality measurement methods (IEC 61000-4-30); IEC 61000-4-7 and IEC 61000-4-15.

AS/NZS 61000.3.6 and 61000.3.7 (TR IEC 61000.3.6:2012 and TR IEC 61000.3.7:2012), emission limits for distorting and fluctuating installations.

National Electricity Rules, Schedule 5.1a, clauses S5.1a.4 to S5.1a.7 and Table S5.1a.1; TasNetworks, Power Quality Planning Levels, March 2022.

Schneider Electric, Cahier Technique no. 199, Power Quality, 2001.

Fluke, What does the IEC 61000-4-30 Class A standard mean to me; Why is there an arrow on your current clamp; How to collect data with a power quality logger.

Safe Work Australia, model Code of Practice: Managing Electrical Risks in the Workplace (Chapter 6, clause 8.4).

More Questions

Where is the point of common coupling?

The point on the network nearest the site where other users are or could be connected; the HV side of a dedicated transformer, or commonly the LV side of a shared one (IEEE 519-2022, clause 1.2).

How long should a power quality survey run?

Seven continuous days minimum, so the weekly 95th and 99th percentiles can be calculated (IEEE 519-2022, clause 4.4) and a full operating cycle is covered.

Do I need Class A?

For anything submitted to a network, used in a connection assessment or relied on in a dispute, yes. Class A results from two instruments can be compared; Class S results cannot be relied on for that.

Does Megavar survey as well as hire?

Yes. Our engineers run power quality surveys as part of commissioning and troubleshooting across Australia. Call 1300 730 499.

Hire or Have It Surveyed

Have It Surveyed

Megavar's engineers run power quality surveys within [high voltage testing](#), [BESS commissioning](#) and [substation commissioning](#) across Australia.

Next Step

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[Book a power quality survey](#)

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