Power Quality Troubleshooting & Monitoring

Cawangan Kejuruteraan Elektrik

Power Quality Troubleshooting

Power Quality Troubleshooting

Start at the Scene of the crime

- To start as close to the “victim load” as possible
- Use of a sharp eye and take some basic measurements

Power Quality Troubleshooting

Voltage & Current Measurement Analysis

- Obtaining voltage & current measurements is the first step when troubleshooting power quality problems

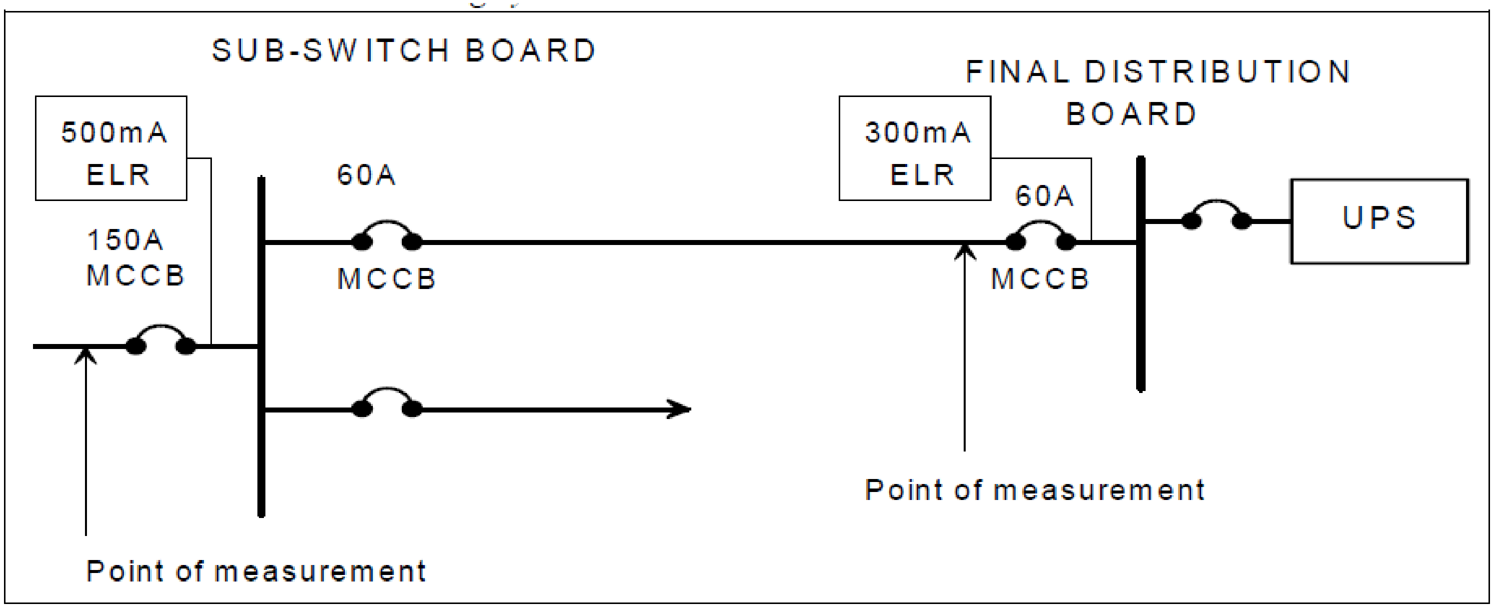
Power Quality Troubleshooting

Neutral-to-earth voltage

- Neutral-to-earth voltage measurements are commonly taken when troubleshooting PQ

Power Quality Troubleshooting

Neutral-to-earth voltage impulse



- If the value of the neutral to earth voltage at Final DB is lower (or slightly) than value at SSB, this indicates that the high neutral to earth voltage originate at upstream.

Power Quality Troubleshooting

Voltage Unbalance

- Should not exceed 2%
- Voltage unbalance has a very large effect on current unbalance, in the ratio of 1:8. In other words, a voltage unbalance of 1% can cause current unbalance of 8%
- Current unbalance will cause the motor to draw more current and degrades the winding insulation

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Voltage Unbalance

- Voltage unbalance can be caused by severe load unbalance, loose connections and worn contacts
- Example of voltage unbalance calculation:

$$\%V_{UNBALANCE} = \frac{Max\ deviation\ from\ average}{Average\ of\ 3\ phases} \times 100\%$$

1. R-Y = 444V, R-B = 446V, Y-B = 444V
2. Find the average = (444 + 446 + 444) / 3 = 445V
3. Find the max deviation from the average:
   This occurs on the R-B phase: 446 – 445 = 1V
4. Divide max deviation by average to find % unbalance: 1 / 445 = 0.2%

Voltage Unbalance

IEEE 1159	IEC 61000-2-2	TNB (ESAH)
2%	2%	2%

Problem solutions:

- By balancing the loads
- Notify the utility company

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Current Unbalance at the Installation

- Do the same calculation as for voltage unbalance
- Should not exceed 30% (IEEE 1159)
- Unbalance of load will result in a current flow on neutral. If the unbalance current exceeds the earth fault relay pick up current, this will cause nuisance tripping to the circuit breaker

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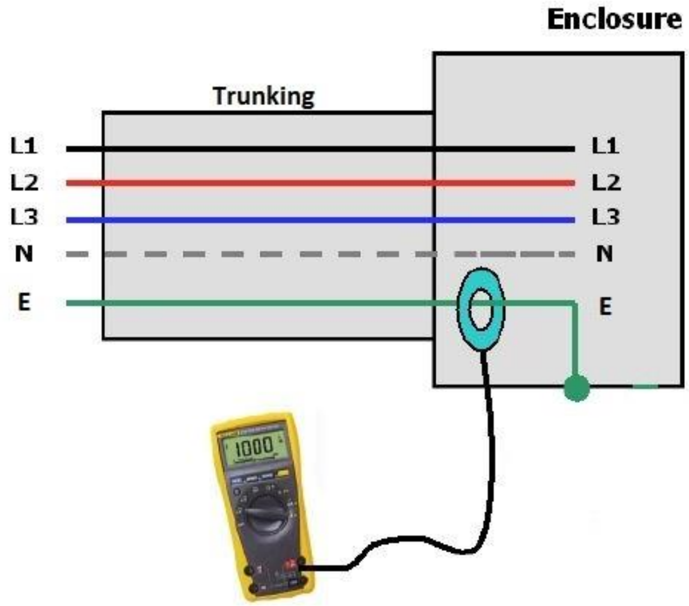
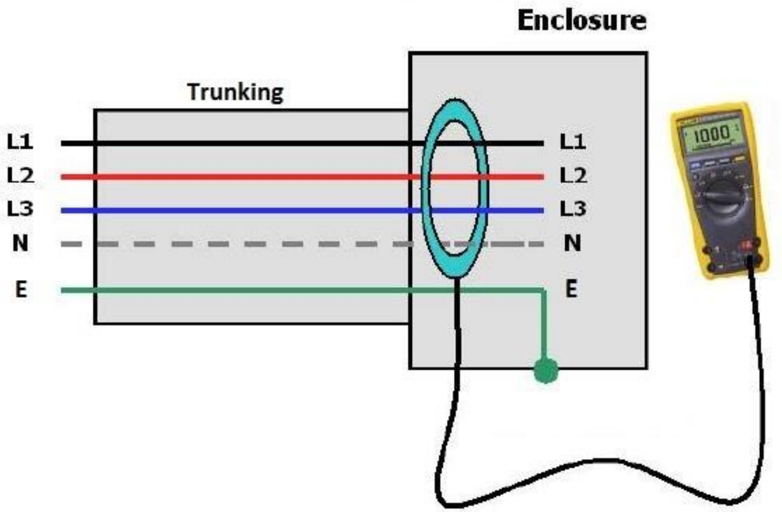
Current Unbalance at the motor

- Should not exceed 10%
- Can be tolerated if the high phase (leg) reading doesn't exceed the nameplate Full Load Amps
- If the voltage unbalance is within limit, high current unbalance can be an indication of damaged winding insulation

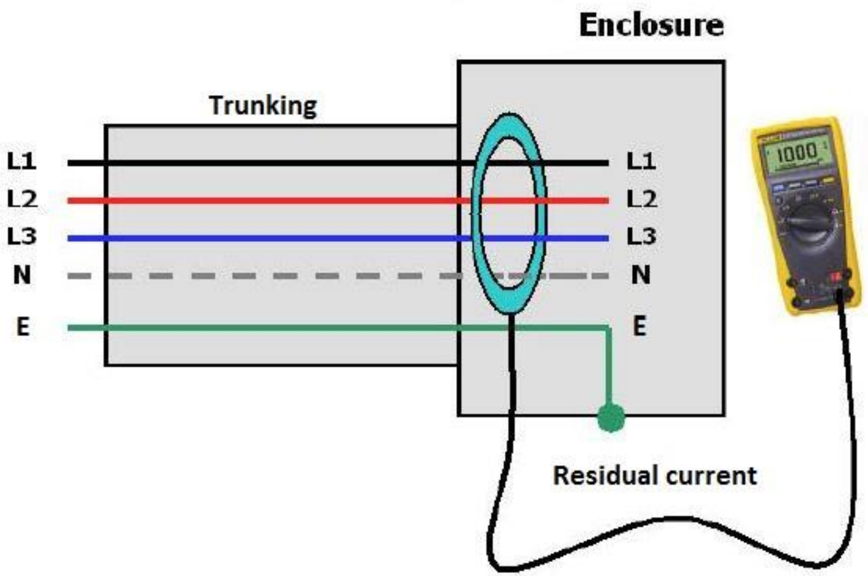
Leakage Current Measurement Basics

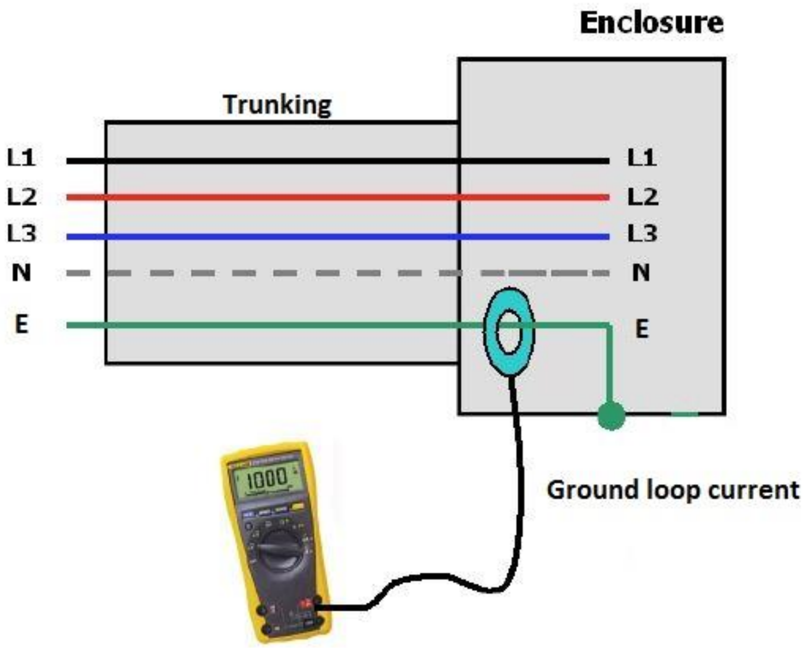
Theoretically	Practically
Leakage Current = Residual Current	Leakage Current ≠ Residual Current



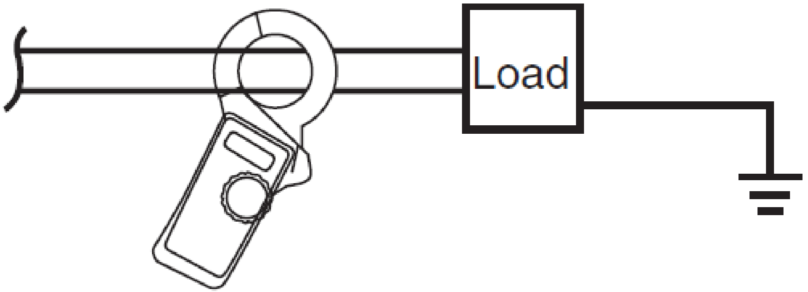


Leakage Current Measurement Basics





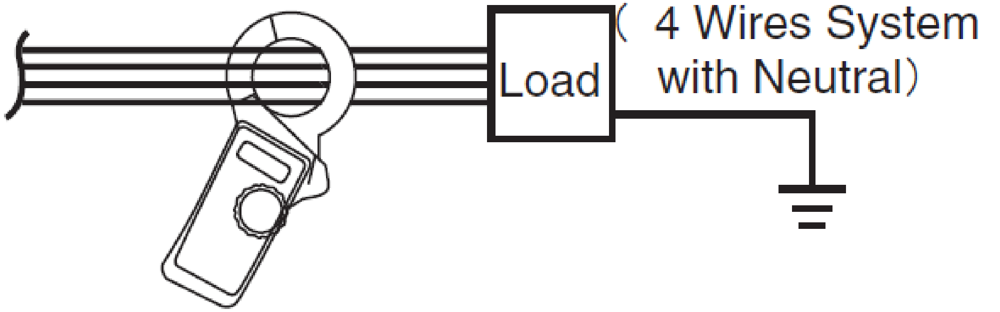
Leakage Current Measurement Basics



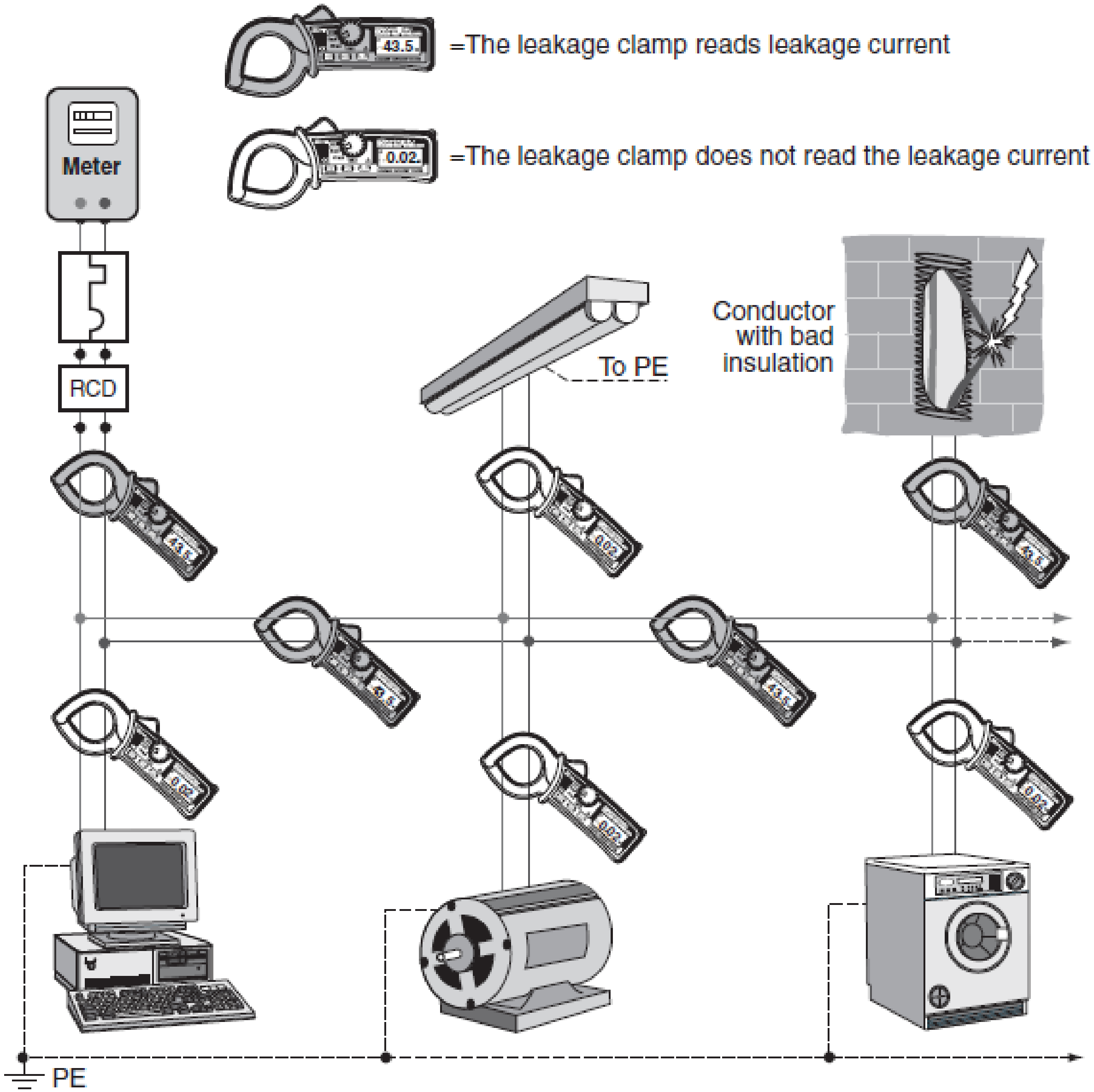
Leakage Current Measurements on the Single-Phase Systems

Leakage Current Measurement Basics

Leakage Current Measurements on the Three-Phase Systems



Power Quality Troubleshooting



Power Quality Troubleshooting

Voltage Dips (Sags)

- The common mistake will be on the application and settings of the UVR to initiate the opening of CB and operation of standby genset during a power outage.
- During the occurrence of a voltage sag event, the CB will also operate and cause power interruption to the customers.
- In order for the UVR to operate properly, a time delay scheme must be part of the UVR.

Power Quality Troubleshooting

Voltage Dips (Sags)

- The recommended settings for an UVR is 70% with a time delay of 2-3 second.

Power Quality Monitoring

Power Quality Monitoring

- Power Quality Study
  - When there is a PQ problem on existing buildings already in operation.
- Power Quality Assessment
  - A health check on the quality of the power system. If there is a problem, then to find the source and nature of the PQ problem.
- Power Quality Audit
  - In-depth PQ survey the electrical distribution. Extensive monitoring of various electrical parameters at the MV switchgears, MSBs, SSBs and DBs.

SYSTEMATIC PQ MONITORING

Step 1:	Review of Electrical Disturbance Logs
Step 2:	Review of the Building's Single Line/Schematic Electrical Diagram
Step 3:	Site Survey
Step 4:	Equipment Documentation
Step 5:	Installation of Power Quality Monitoring Instruments
Step 6:	Analysis of Power Quality data
Step 7:	Report Writing

SYSTEMATIC PQ MONITORING

Step 1: Review of Electrical Disturbance Logs

- **Time of Event**
  What was the date and time of each electrical disturbance?
- **Equipment Affected**
  What equipment was affected, and what were the consequences? Note any equipment failures or data losses.
- **Length of Outage**
  This will help identify what type of electrical disturbance occurred.
- **Weather Conditions**
  Weather conditions such as wind, lightning or rain.

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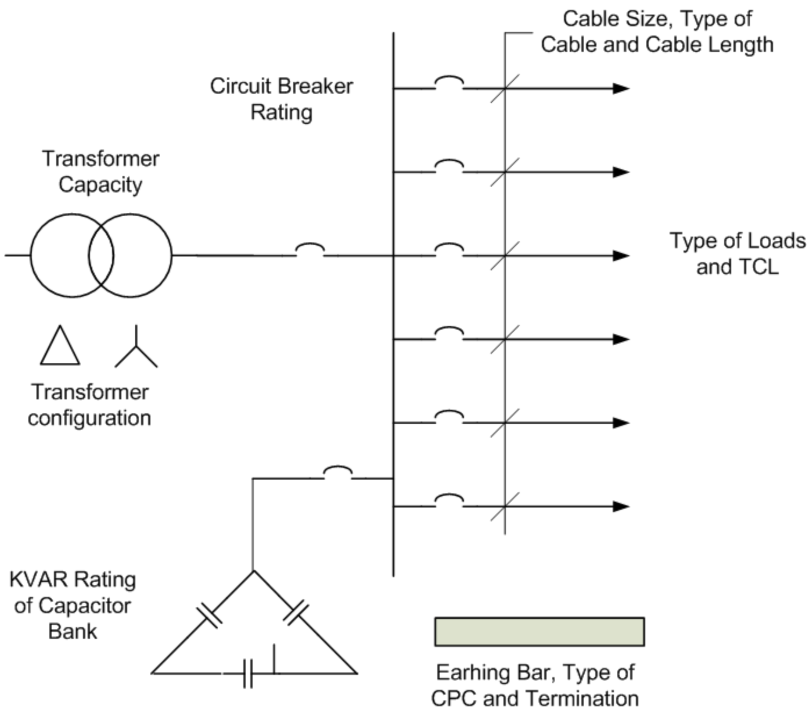
Step 2: Review of the Building's Single Line/Schematic Electrical Diagram

- Getting an up-to-date single line diagram means identifying new loads or other recent changes in the system
- Review an up-to-date single line diagram



SYSTEMATIC PQ MONITORING

Step 3: Site Survey

Objective

- Determine the condition and adequacy (proper) of the wiring and earthing system
- Determine the quality of the AC voltage at the utilization point
- Check for loose connections

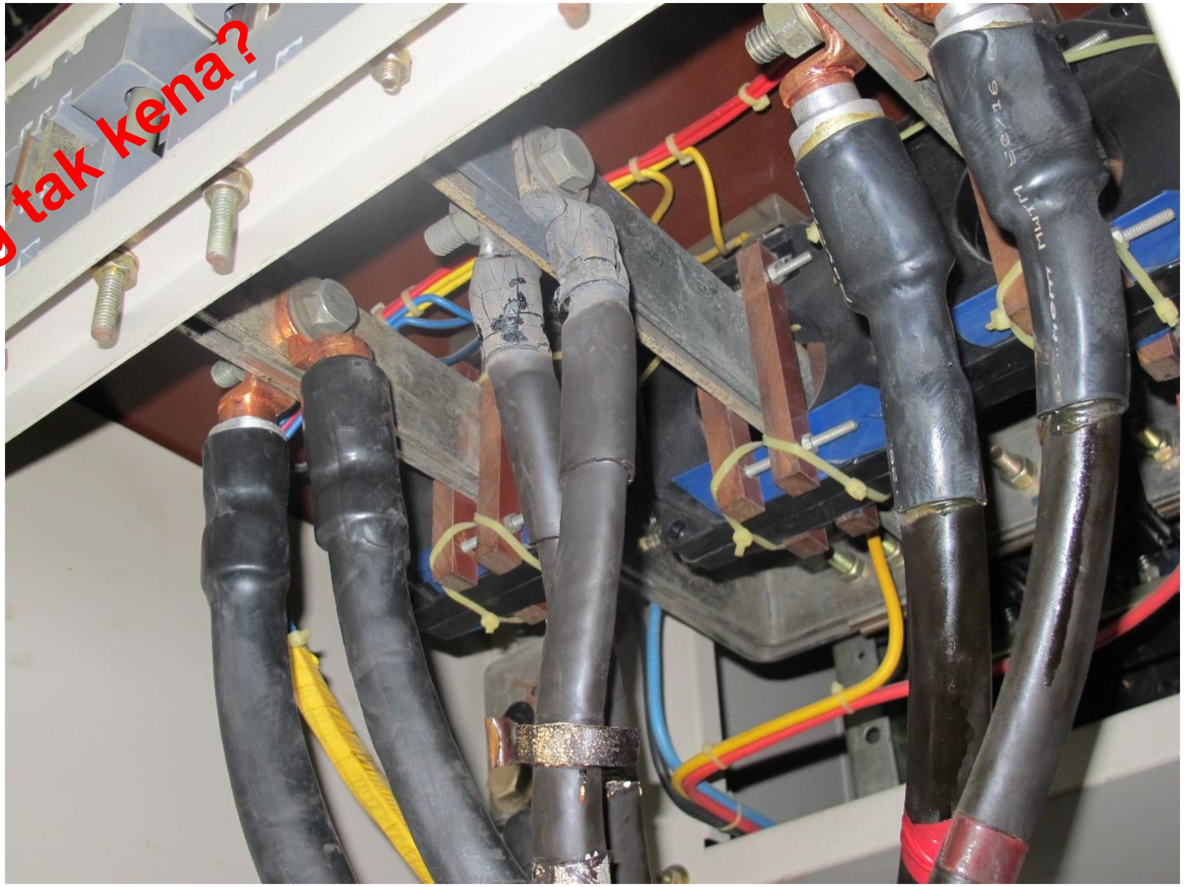
Visual Inspection will Offer Immediate Clues

- A transformer that's much too hot
- Wiring or disconnections discoloured from heat
- Signal wiring running in the same trays as power cables
- Interview affected personnel. This is most important for problems that are intermittent

Step 3: Site Survey

Visual Inspection will Offer Immediate Clues

Apa yang tak kena?



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Step 3: Site Survey

Information to be Obtained

- Nature of the problem (data loss, nuisance trips, component failures, control system malfunction etc.)
- Characteristic of sensitive equipment experiencing problems (equipment design information or at least application guide information)
- Time of disturbance
- Possible sources of power quality variation within the facility (motor switching or capacitor switching)
- Existing power conditioning being used.
- Electrical system data (single-line diagram, transformer data, load information, capacitor information, data cable etc.)

Step 3: Site Survey

Data Forms

Supply Transformer Data:

Manufacturer: ____________
Connection: ____________
kVA Rating: ____________
Primary Voltage: ____________
Secondary Voltage: ____________
Taps: ____________
Tap Position: ____________

Test Data:

Primary Voltages:		Primary Currents:	
A-B	______	A	______
B-C	______	B	______
C-A	______	C	______
A-N	______	Neutral	______
B-N	______	Ground	______
C-N	______		

Secondary Voltages:		Secondary Currents:	
A-B	______	A	______
B-C	______	B	______
C-A	______	C	______
A-N	______	Neutral	______
B-N	______	Ground	______
C-N	______		

N-G Bond? ______

Panel Identification: ____________
Location: ____________

Voltages:		Feeder Currents:	
A-B	______	A	______
B-C	______	B	______
C-A	______	C	______
A-N	______	Neutral	______
B-N	______	Ground	______
C-N	______		
		Feeder Wire Sizes:	
N-G Bond?	______	Phase	______
		Neutral	______
		Ground	______

Comments: ____________

- Data forms can be used for this initial verification of the power distribution system.
- They can be used to organize the power quality monitoring results from throughout the facility.

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Step 4: Equipment Documentation

- Equipment's wiring requirements, specifications, and O&M manuals.
- Comparing the site survey notes with the equipment documentation may provide clues to resolve a power quality problem.

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Step 5: Installation of Power Quality Monitoring Instruments

- A number of different instruments may be used, depending on the phenomena being investigated.
- Basic categories of instruments that may be applicable include:
    - Wiring and earthing test devices
    - Multimeter
    - Oscilloscopes
    - Disturbance analyzers
    - Harmonic analyzers and spectrum analyzers
    - Combination disturbance and harmonic analyzers
    - Flicker meters
    - Energy monitors

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Step 5: Installation of Power Quality Monitoring Instruments

- The Fluke 1750 power recorder and the Fluke power analyse software are used to conduct the power quality study, assessment and audit.
- Other instrument that can be used to help solve power quality problems by measuring ambient conditions; i.e. infrared meter or thermographic camera can be very valuable in detecting loose connections and overheating conductors.

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Step 5: Installation of Power Quality Monitoring Instruments

A number of important factors that should be considered when selecting the instrument:

- Number of channels (voltage and/or current)
- Temperature specifications of the instrument
- Ruggedness of the instrument
- Input voltage range (e.g., 0 to 600 V)
- Power requirements
- Ability to measure three-phase voltages
- Input isolation (isolation between input channels and from each input to ground)
- Ability to measure currents (wide current range up to 5000A)
- Housing of the instrument (portable, rack-mount, etc.)
- User friendly (user interface, graphics capability, etc.)
- Communication capability (network interface – RJ45, USB)
- Data storage, Hard disk or static RAM
- Analysis software

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Step 5: Installation of Power Quality Monitoring Instruments

- Proper measuring techniques are required to safely obtain useful and accurate data

SYSTEMATIC PQ MONITORING

Step 6: Analysis of Power Quality data

Monitoring Standards

- IEEE 1159, 1996 : Recommended Practice on Monitoring Electric Power Quality
- ER (Engineering Recommendation), E5/4 (UK), for Harmonic limit criteria
- ER (Engineering Recommendation), P29 (UK), for Flicker limit criteria
- IEEE 519, 1992 : Recommended Practice for Harmonic Control in Electric Power System
- IEC 61000-4-x : Monitoring standard

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Step 6: Analysis of Power Quality data

- Fluke power analyse software is used to conduct the power quality study which enables users to analyse the behaviour of power quality in time domain.
- It specially designed to study the six important indicators of power quality:
  - frequency deviation,
  - voltage variations,
  - voltage and current harmonics,
  - unbalance,
  - flicker and
  - events.

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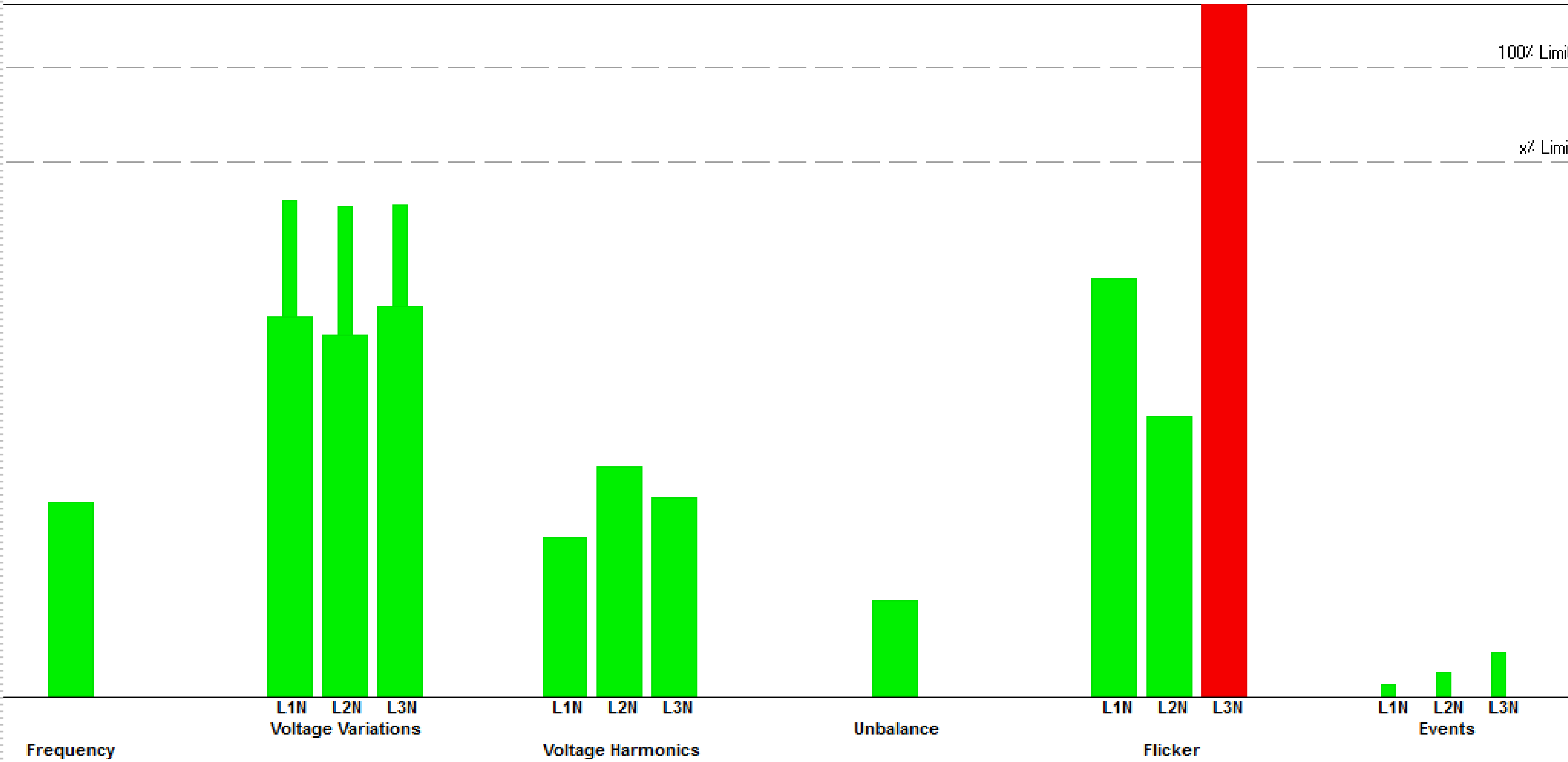
Step 6: Analysis of Power Quality data



SYSTEMATIC PQ MONITORING

Step 7: Report Writing

- Acknowledgements
- Title pages
- Executive summary
- Contents page
- Terms of reference
- Introduction/ background
- Methodology/ procedures
- Finding and analysis
- Conclusions
- Recommendations
- Appendices
- References/ Bibliography
- Glossary of terms and abbreviations

SYSTEMATIC PQ MONITORING

Step 7: Report Writing

- Easily produce well formatted, easy-to-read reports for management, customers, and clients.
- Sorts and analyzes a large volume of data.
- Reports on one, several, or all aspects of power.
- Combines text and graphics.
- Isolates the report to a specific time period.
- Suggests solutions to power quality problems.

CONCLUSION

- Before any major electrical changes or purchase of power conditioning devices is made, a systematic approach to PQ investigation is required for proper identification of causes and sources to PQ problems so that the proper solution can be developed.

Thank You

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