HIOKI

HIOKI INDONESIA

Understanding Power Quality Problem & How to Detected

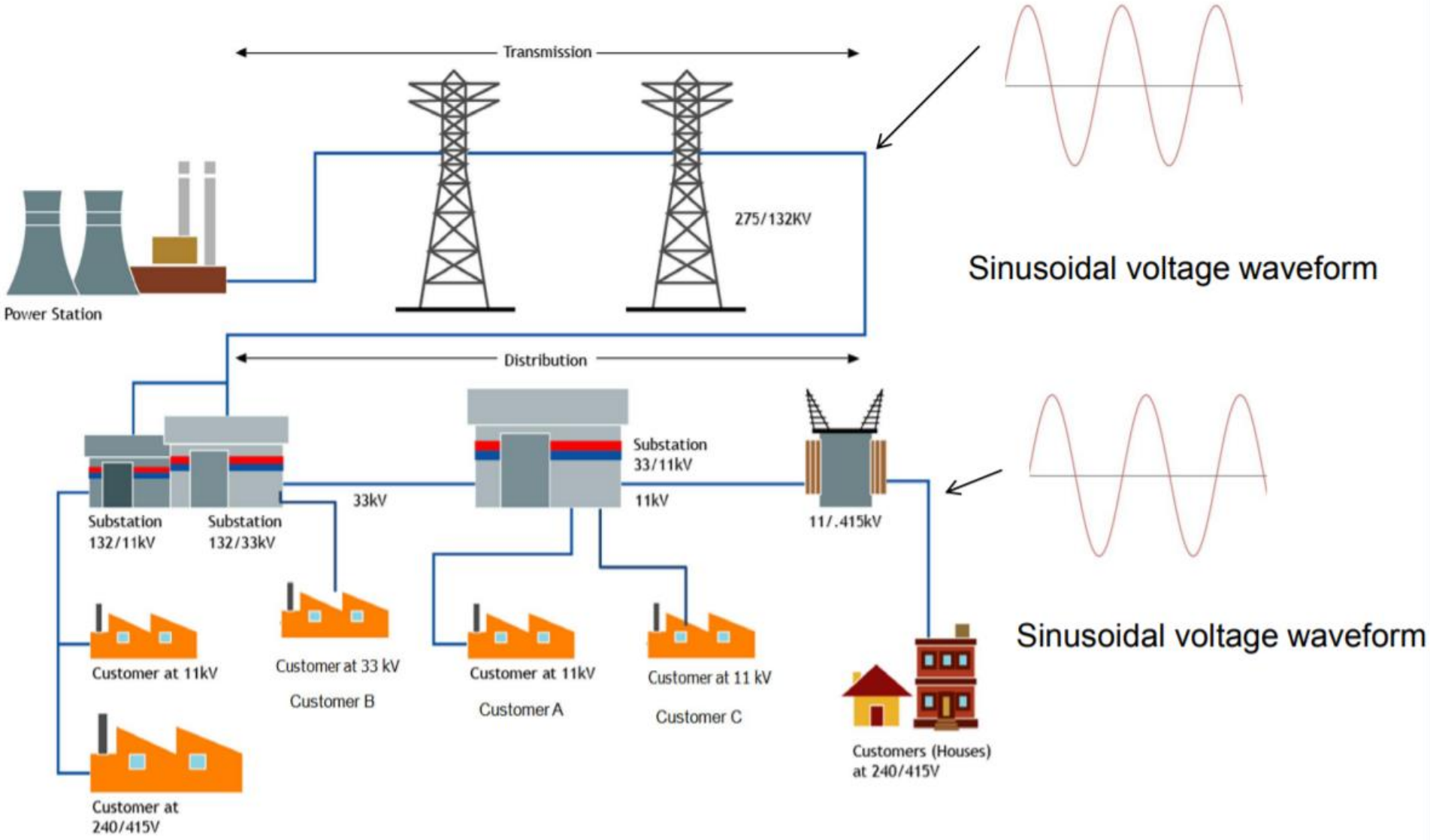
Content

- Understanding Normal Utility Grade Power
- Power Quality Standard
- Power Quality Problem
- PQ3198 + PQ ONE Software

HIOKI

“Electric power quality is the degree to which the voltage, frequency, and waveform of a power supply system conform to established specifications.”

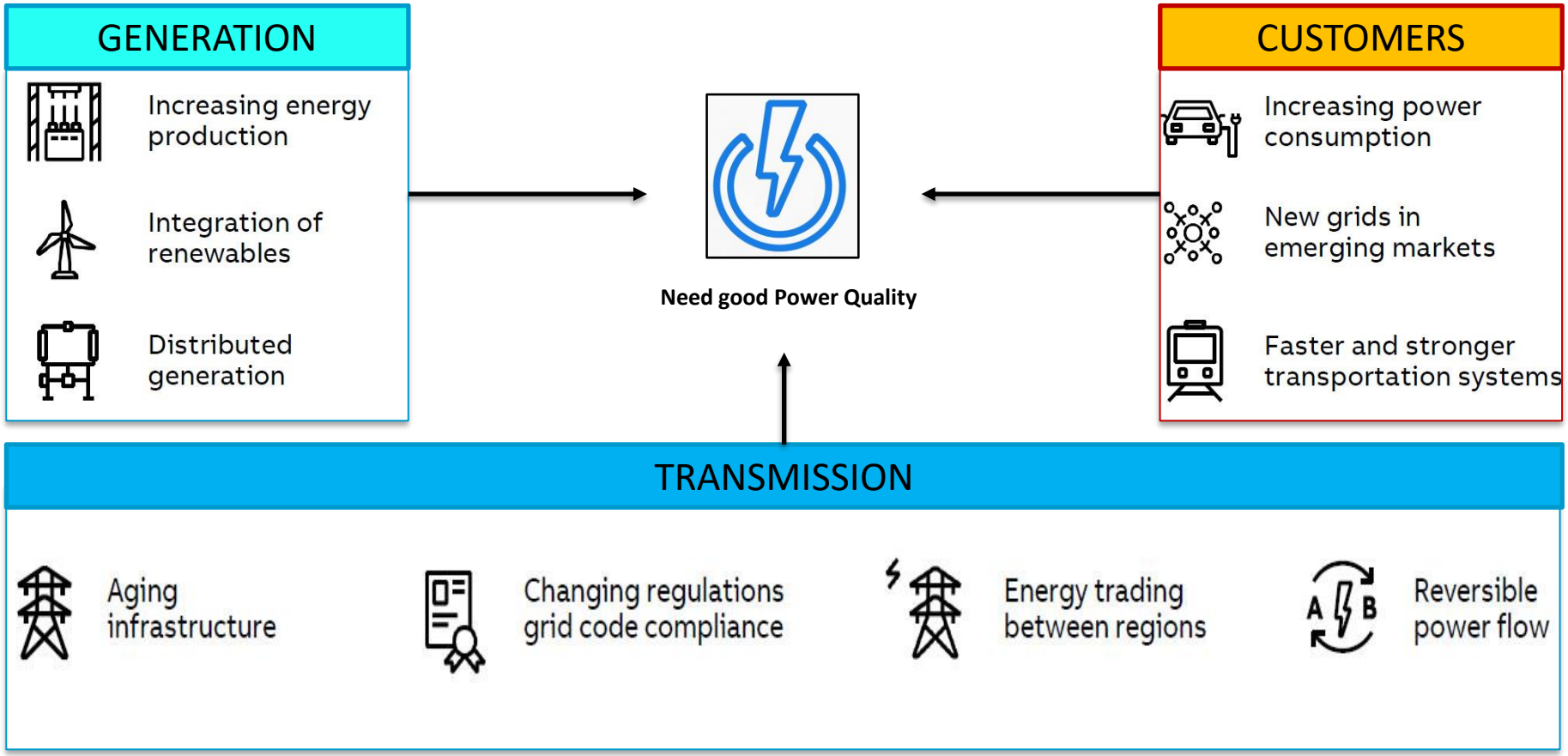
Power utility provides normal utility grade power



HIOKI

Background

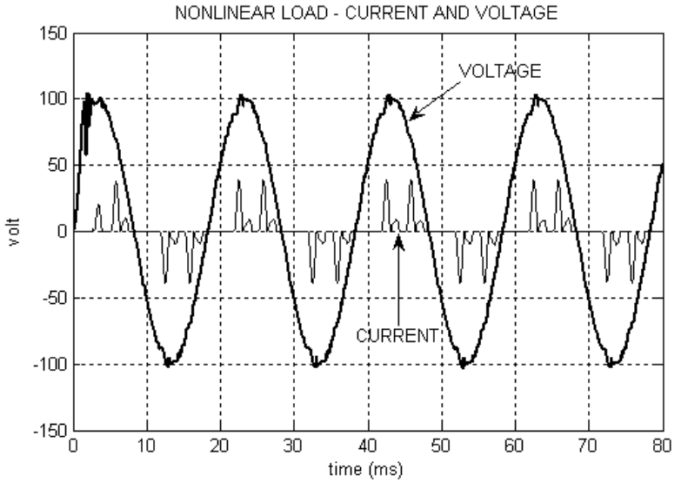
There are many drivers – One Common Need

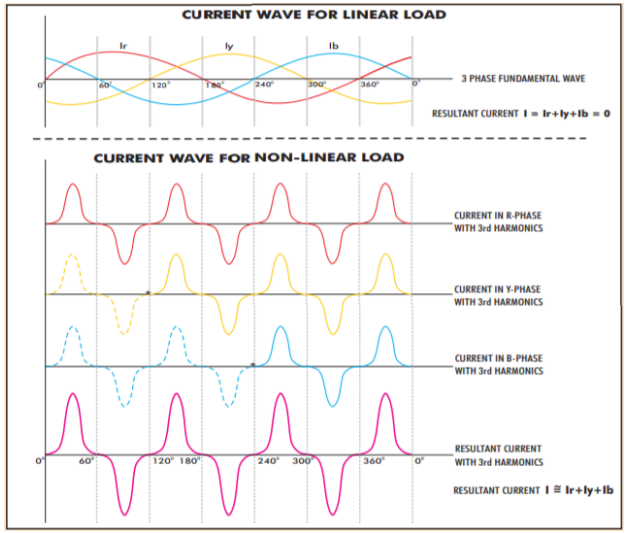


Good power quality is important along the whole energy value chain : Generation, Transmission, Distribution, Industrial Customer and Residential Customers

Electrical Equipment More Diverse

Non-linear Load





Symptoms: Power Outage vs. Power Quality

Symptoms of Power Quality

- Lights blinking
- Sudden Equipment maloperation
- Sudden tripping of circuit breakers
- Premature equipment failure
- Poor performance & unexpected shutdowns
- Lost data in electronics
- Capacitor bank failure
- High ground current
- Others

Symptom of Power Outage
No Electricity for more than 60 s

Power Quality Standards

No	Abbreviation	Standard Name
1	IEEE	Institute of Electrical and Electronics Engineer
2	IEC	International Electrotechnical Communication
3	CENELEC	European Committee for Technical Standardization
4	ANSI	American National Standards Institute
5	NER	Naional Electricity Regulator
6	SEMI	Semiconductor Equipment and Material International
7	UIE	International Union for Electricity

Definitions of Power Quality Problem

- ***Semua permasalahan daya listrik, berupa perubahan nilai tegangan, arus atau frekuensi yang bisa menyebabkan kegagalan atau misoperation peralatan, baik peralatan milik PLN maupun milik konsumen; artinya masalah Power Quality bisa merugikan pelanggan maupun PLN***

Why We Need to Measure Power Quality

■ Troubleshooting

Examine, diagnosis and countermeasure the current poor power supply condition in field that causes trouble the equipment

■ To examine the current power state, For preventive maintenance

Check the condition of before and after the instalment of an electrical facility by monitoring the power quality in long term or periodically

→predict the trouble, and prevent it from happening

■ To check power quality at high risk location

To manage parameters that have management goal

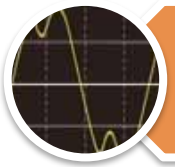
(voltage fluctuation, Voltage flicker, harmonics etc)

■ To investigate Power(load) at new connection

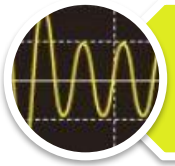
For power saving survey,

checking the trend before adding load to a system.

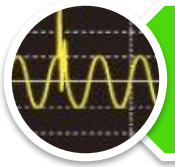
MOST PQ PROBLEMS IN POWER UTILITY



HARMONICS

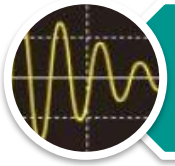


VOLTAGE DIP (SAG)



TRANSIENT OVER VOLTAGE

UNBALANCE



INRUSH CURRENT

LIMIT?

ANSI C84.1 Voltage Limit (Service Voltage)

Service Voltage	Range A	Range B
Maximum	+ 5 %	+ 5.83 %
Minimum	- 5 %	- 8.33 %

SV = Measured at point of common coupling between customer and company

ANSI C84.1 Voltage Limit (Utilization Voltage)

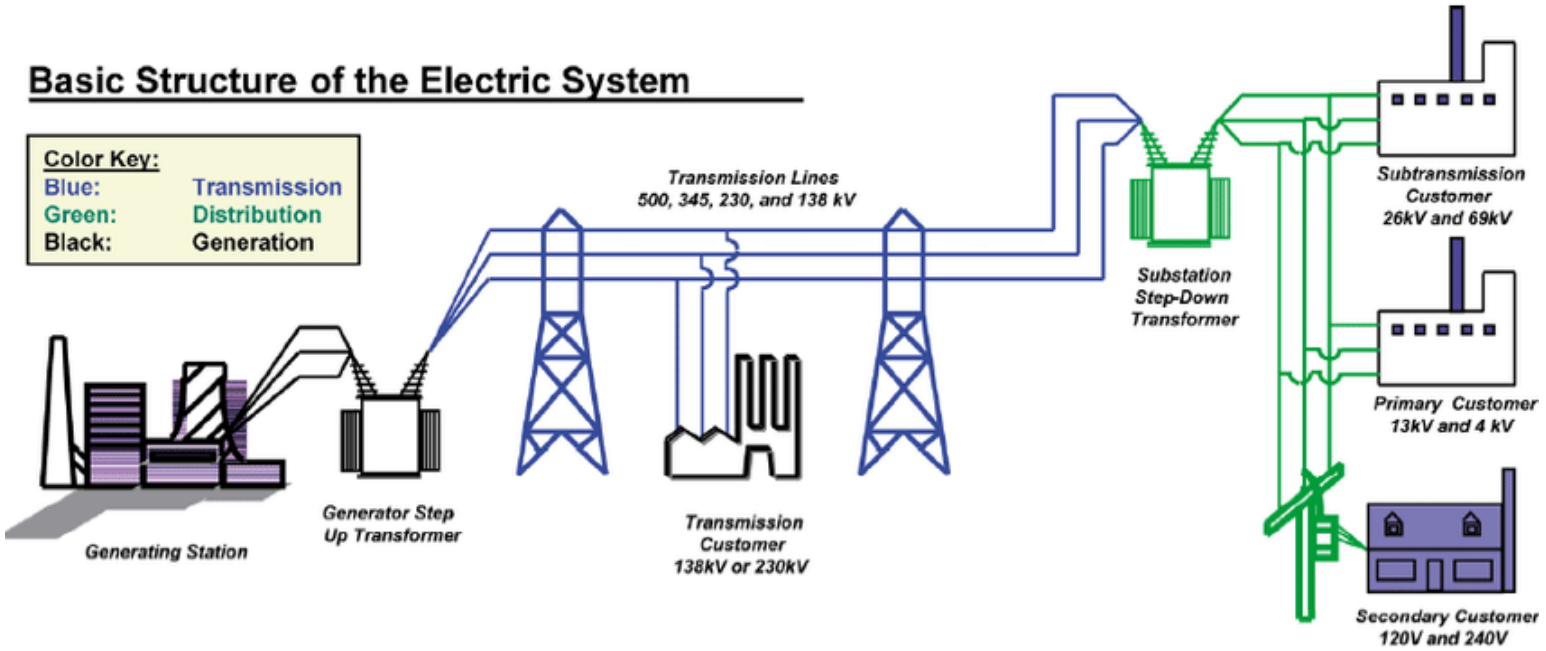
Service Voltage	Range A	Range B
Maximum (equipment > 600V)	+ 5 %	+ 5.83 %
Maximum (equipment < 600V)	+ 4.17 %	- 8.33 %
Minimum	- 8.33 % (- 10 % *)	- 11.67 % (- 13.33 %*)

UV = Measured at the equipment using the electricity
* = for circuit with no lighting equipment

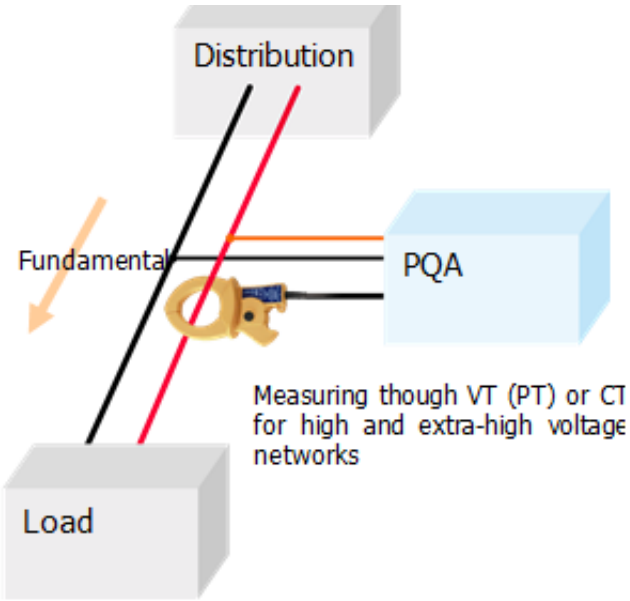
RANGE A = Normal Condition RANGE B = Abnormal Condition

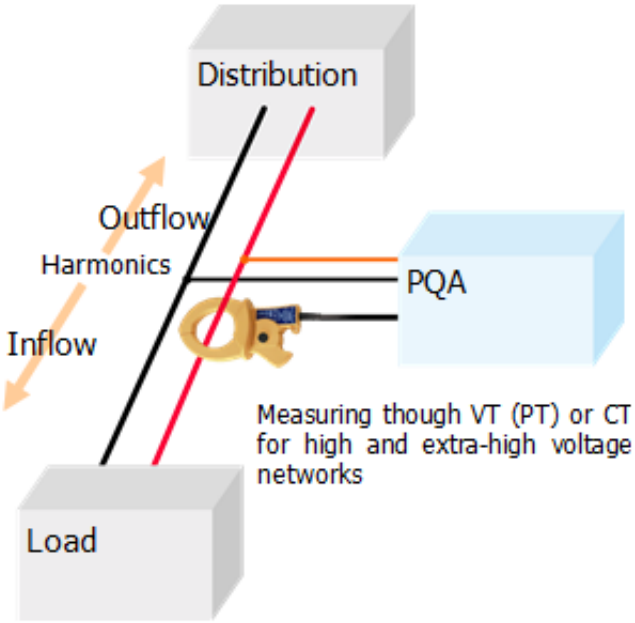
(1) Harmonic Investigation

- Harmonic is one of the most power quality problems in power distribution
- Currently, responsibility for harmonic control is shared between system owners or operators and users.
- Regular harmonic measurement should be conducted for ensure all electrical equipment can work properly
- With PQA, identifying PCC status and harmonic flow will be easier



PQA = Easy to Determine Harmonic Source





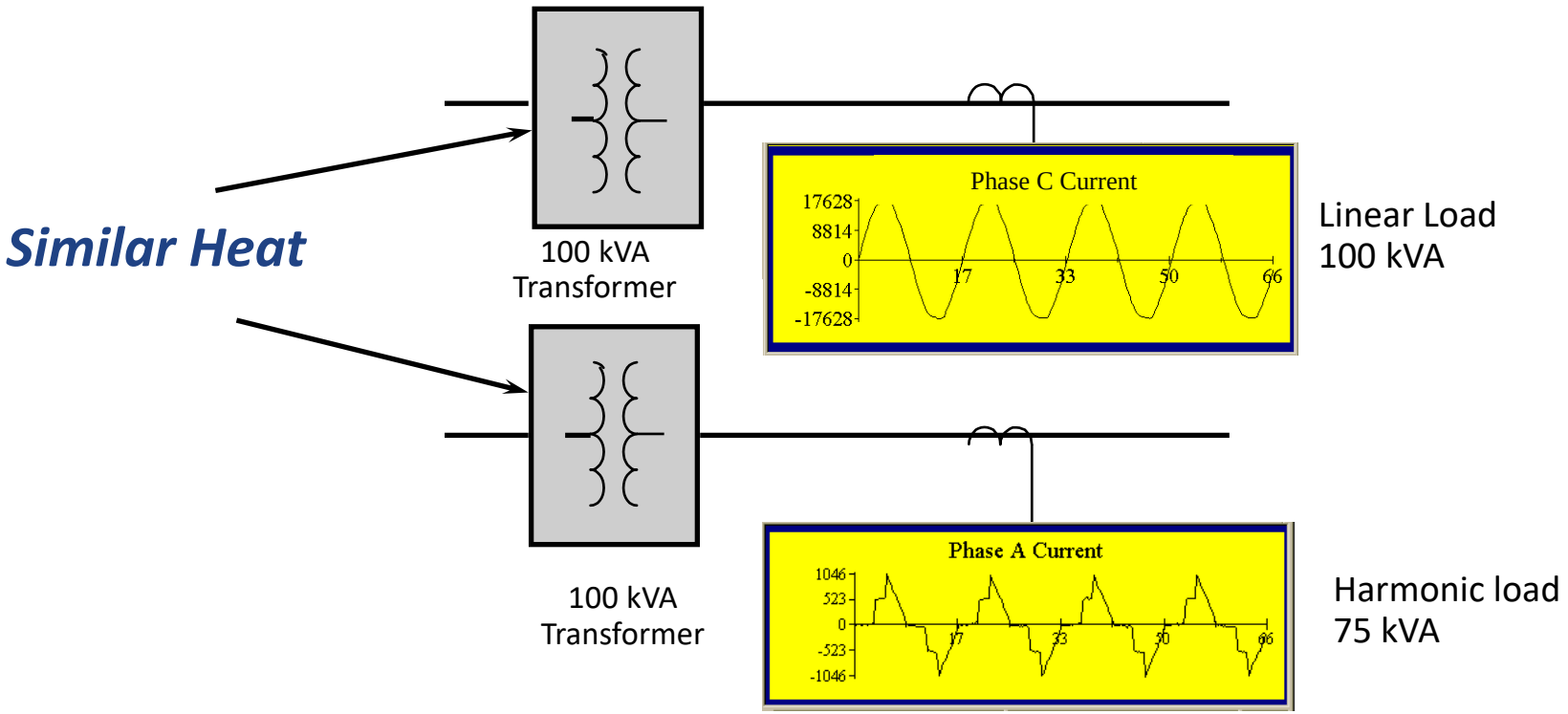
	Condition	Cause
Inflow	The harmonics flow from distribution to load.	**Distribution side** (The harmonics generated by distribution is bigger than the harmonics generated by load.)
Outflow	The harmonics flow from load to distribution.	**Load side** (The harmonics generated by load is bigger than the harmonics generated by distribution.)

Harmonic Effect

Transformer	• Increase Eddy Current Loss • Derating (K factor increase)
Power Cable	• Increase I2R losses • Additional heat • Cable Derating
Power Factor	• PF < DPF • Meter reading error *
Motor & Generator	• Vibration and Counter Torque • Iron losses such as eddy current and hysteresis losses • Generator derating
Electronic Equipment	• Equipment mis operation. • Incorrect Meter Reading • Malfunctioning medical instruments • Voltage Notching

Harmonic in Transformer

- The primary effect of power system harmonics on **transformers** is the additional heat generated
- The additional heating caused by harmonics requires **load capability derating** to remain **within the temperature rating of the transformer.**



Harmonic Voltage Limits

Low Voltage (<1kV) & Percentiles

- **IEEE STD 519-2014**

At the PCC, system owners or operators should limit line-to-neutral voltage harmonics as follows:

Table 1—Voltage distortion limits

Bus voltage V at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \leq 1.0$ kV	5.0	8.0
1 kV < $V \leq 69$ kV	3.0	5.0
69 kV < $V \leq 161$ kV	1.5	2.5
161 kV < V	1.0	1.5[a]

IEEE STD 519-1992 version for Utility

Bus Voltage at PCC	Individual Voltage distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV through 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5

HIOKI

Current Distortion Limits (120V to <69kV)

IEEE STD 519-2014

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)[a, b]						
I_{SC}/I_L	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	TDD
< 20[c]	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

[a]Even harmonics are limited to 25% of the odd harmonic limits above.

[b]Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

[c]All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L.

where

I_{sc} = maximum short-circuit current at PCC

I_L = maximum demand load current (fundamental frequency component) at the PCC under normal load operating conditions

HIOKI

Harmonic Recording
Base on IEEE STD 519-2014

1. Very short time harmonic measurements

- Will assessed over a **3-second interval based**.
- Measurement duration: **24 hours (1 day)**
- The **99th percentile value** should be calculated for each 24-hour period for comparison with the recommend limits
- For voltage harmonics, daily 99th percentile very short time (3 s) values should be **less than 1.5 times** the values given in Table 1.
- For current harmonic limits, daily 99th percentile very short time (3 s) harmonic currents **should be less than 2.0 times** the values given in the Tables.

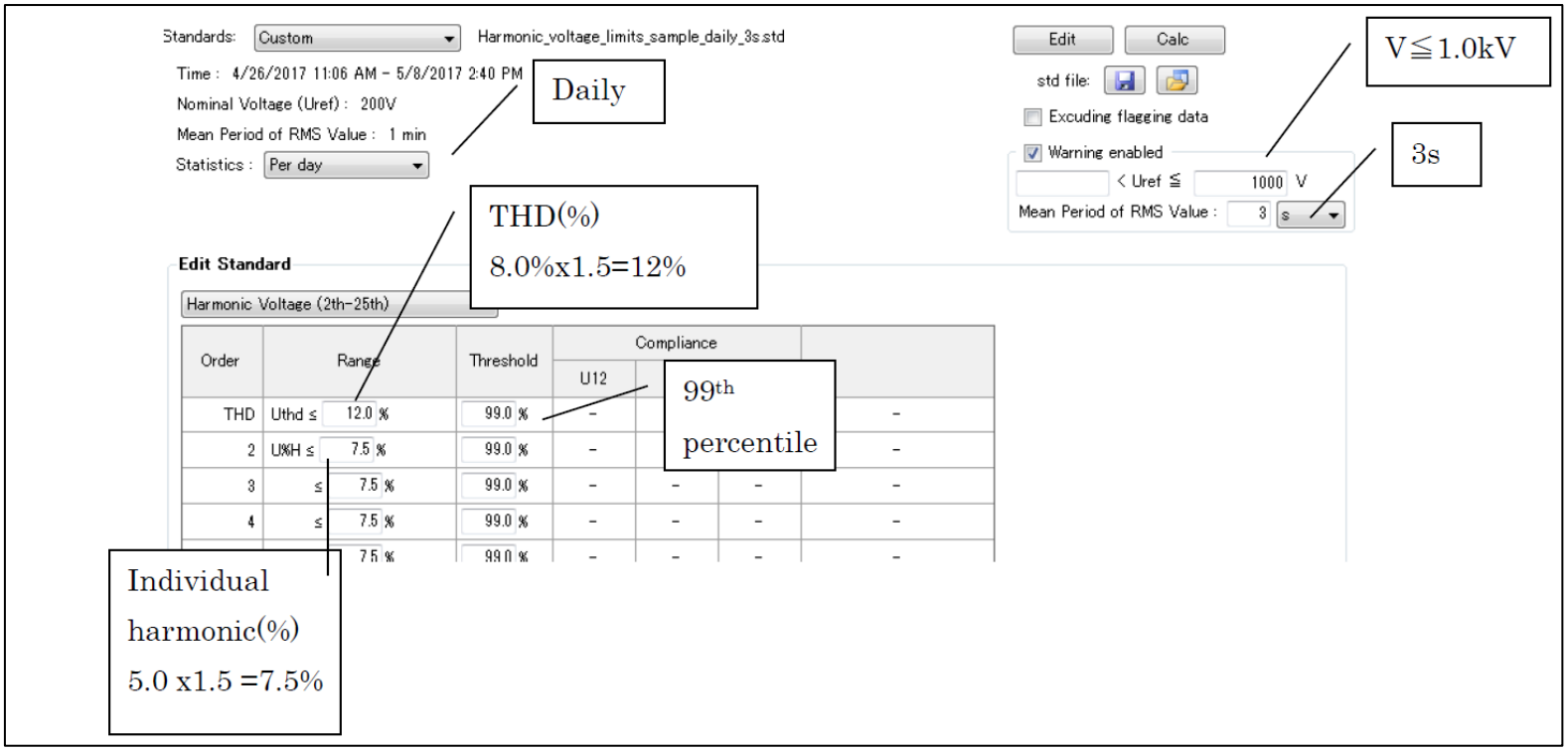
Harmonic Recording
Base on IEEE STD 519-2014

2. Short time harmonic measurements

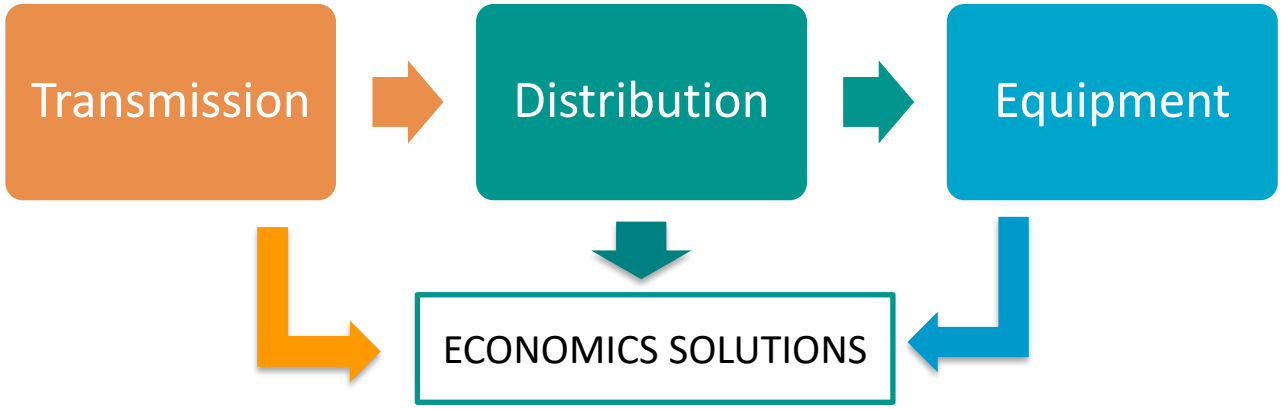
- Short time harmonic values are assessed over a **10-minute interval based**
- Measurement duration: **7-day period (1 week)**
- **95th and 99th percentile values** should be calculated for each 7-day period for comparison with the recommended limits
- For voltage harmonics, Weekly 95th percentile short time (10 min) values should be **less than the values given in Table 1**.
- For current harmonic limits, Weekly 99th percentile short time (10 min) harmonic currents should be **less than 1.5 times** the values given in Tables. And Weekly 95th percentile short time (10 min) harmonic currents **should be less than the values given in Tables.**

PQ One for Harmonic Analysis

- With PQ one software, its easy to analyse harmonic condition base on IEEE STD 519-2014.
- We can create custom standard value for very short and short harmonic measurement with PQ check function



(2) Estimating Voltage DIP (SAG) Performance with Power Quality Analyzer



- Determine the number and characteristics of voltage dips that result **from transmission** system faults.
- Determine the number and characteristics of voltage dips that result **from distribution** system faults.
- Determine the **equipment sensitivity** to voltage dips.
- Evaluate the **economics of different solutions** that could improve the performance.

PQ Standard for Variation Voltage

And by using Hioki PQ One you were able to analyze your measurement with PQ Check

Standards: EN50160 (Us≤1kV)

Time : 30/7/2020 4:00 pm - 6/8/2020 12:53 pm

Nominal Voltage (Uref) : !30V

Mean Period of RMS Value : 10 min

Statistics : Per week

Supply Voltage Variations

Range	Threshold	Compliance			
		U1	U2	U3	
230V +10.0% / -10.0%	95.0%	100.0%	N/A	N/A	passed
230V +10.0% / -15.0%	100.0%	100.0%	N/A	N/A	passed

Flicker

Range	Threshold	Compliance			
		U1	U2	U3	
Plt ≤ 1.0	95.0%	100.0%	N/A	N/A	passed

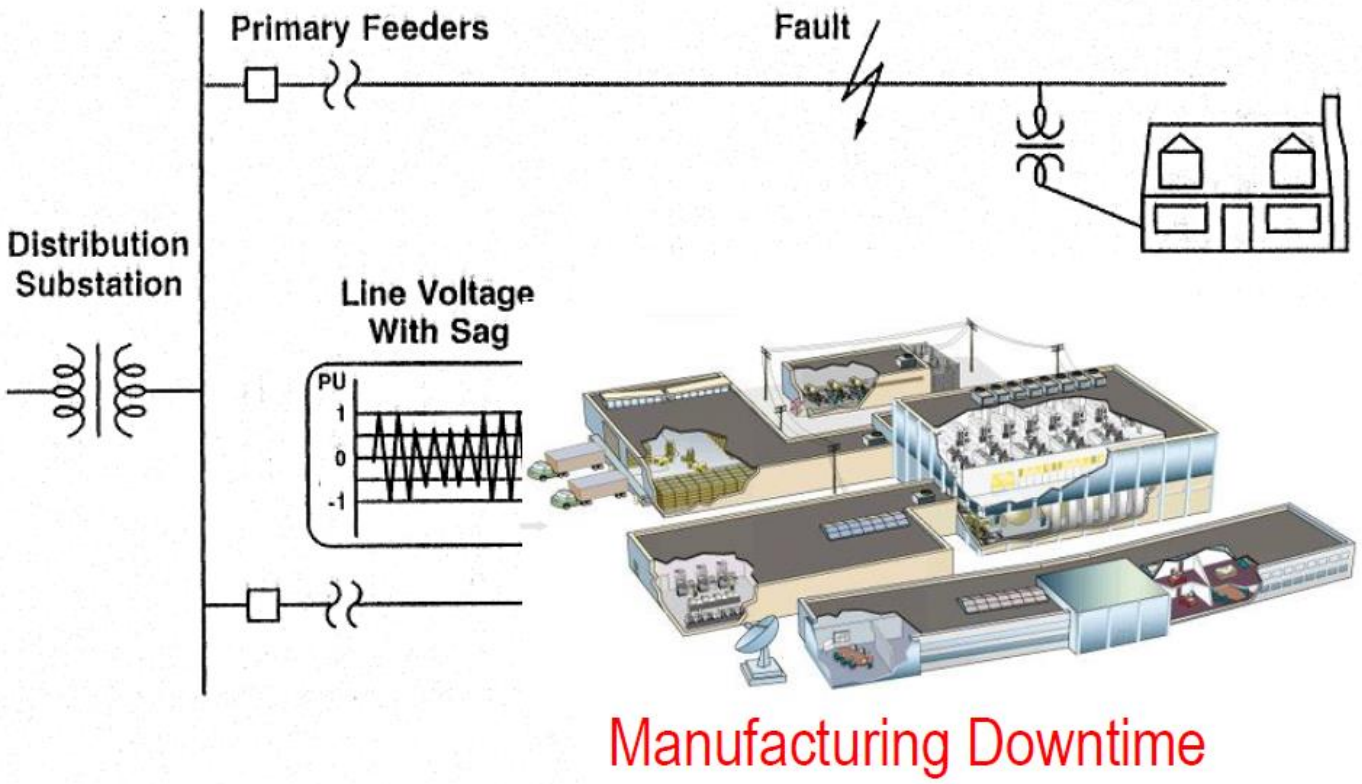
EN50160 is the standard which defines the main characteristics of the voltage at a network user's supply terminals in public low voltage and medium voltage electricity distribution systems under normal operating conditions.

HIOKI

Why We Serious About DIP?

DOE Study:

- $377,000 per year / large industrial customer because of Voltage SAG
- $132, 000 per year / large industrial customer due to voltage intteruption



Why We Serious About DIP?

Conferences > 2019 2nd International Confer...

Risk Cost Analysis and Impact of Dip Voltage, Case Study of The Food and Beverage Industry in East Java

Publisher: IEEE | Cite This | PDF

Bustani Hadi Wijaya ; Nanang Hariyanto All Authors

101 Full Text Views

View References

Abstract

Document Sections

I. Introduction

II. Theory

III. Dip and Evaluation Event

IV. Preventive Action

V. Conclusion

Authors

Figures

References

Keywords

Metrics

Abstract:

Power quality and voltage stability are the main indicators of customer satisfaction because it influences business operations. Based on the results of the 2016 customer satisfaction survey by Markplus.inc, some industrial customers complain of voltage stability, especially related to dip voltage. Industrial customers complained about this dip voltage due to the loss of the company's operational tools. Dip voltage is a problem that must be resolved by industrial customers and electric utility companies. For electric utility companies, dip voltage greatly affects the sale of electricity that is not optimal because the dip voltage has an impact on the operation failure in industrial machinery. In addition, the dip voltage also has a negative effect on the service image of the electric utility company on the priority customer side. For this reason, the voltage dip needs to be handled seriously. According to IEEE 1159-1995, Dip voltage of 20 kV is a decrease in AC voltage of 2 kV up to 18 kV for 0.01 seconds until 60 seconds (for a frequency of 50 Hz). This dip voltage is caused by lightning, network interference, the effect of switching, motor operation, and sudden load changes. Dip voltage causes a huge financial impact on industrial consumers. In this paper, a dip voltage case study will be evaluated at The Food and Beverage Industry in East Java. The financial loss of industrial customers reaches 328,000 USD or 4.7 billion Rupiah in one dip voltage event. This is because customers have suffered a production failure so they have to restart their production process. They also have to dispose of large quantities of raw materials due to product failure due to the dip voltage. For this reason, it is necessary to formulate a proposed management model in solving this dip voltage problem. This paper also offers proposed steps that can be taken by electric utility companies in suppressing the amount of dip voltage so that the electricity supply becomes more qualified. In accordance with the evaluation of priority and risk management matrices, the results show that the steps are appropriate and can be implemented in reducing the number of dip voltages.

(Show Less)

More Like This

Power plant optimization in a regulated environment electricity supply industry: A least cost generation approach

2008 IEEE 2nd International Power and Energy Conference

Published: 2008

Electricity market models in restructured electricity supply industry

2008 IEEE 2nd International Power and Energy Conference

Published: 2008

Show More

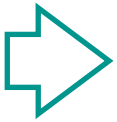
Source: https://ieeexplore.ieee.org/document/9011037

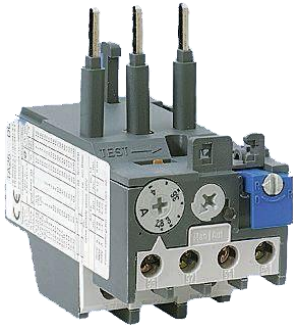
HIOKI

a. Malfunction of Relay and Contactor

- All manufacture process control by PLC (Programable Logic Control)
- To control the actuator, PLC have to connect with Relay, Contactor and Motor starter

PLC





What happens during a voltage sag down to 50% of nominal for 5 cycles ?

- Main Contactor 2 cycle, 43%
- EMO Relay 1 cycle, 52%
- EMO Relay 0.5 cycle, 61%
- Contactor 2 cycle, 49%
- Next Gen EMO Relay 0.5 cycle , 78%

b. The Trends : Changing Load Characteristic

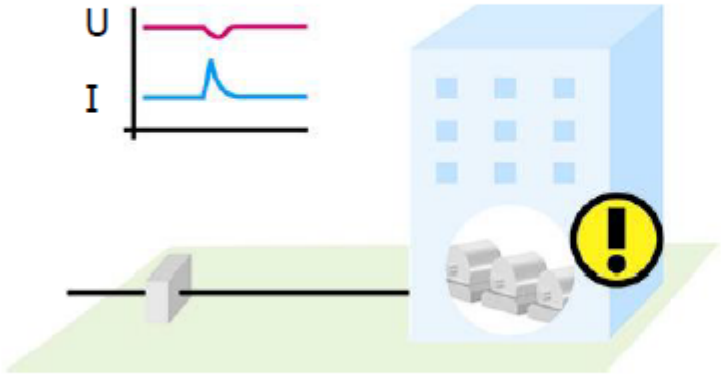
- Newer generation load equipment, with microprocessor based controls and power electronic devices, is **more sensitive to power quality variations**.
- The increasing emphasis on power efficiency has resulted in continued growth in the application of devices such as **adjustable-speed motor** drives creating more **pollutant in powerline**

Modern Load Characteristic

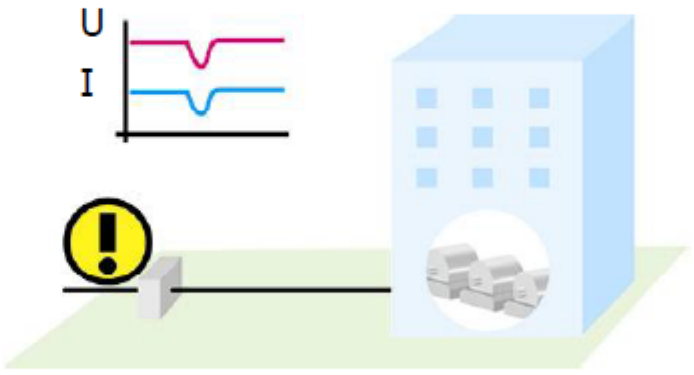
- More Sensitive
- Creating harmonic => THDi 40-80%
- High Power factor =>0.98
- High efficiency

Tips for Identifying the Cause of Power Quality Problems

If the voltage drops during the increase of current consumption in a building, the cause is considered to come from inside the building. On the other hand, if both the voltage and current drop, the cause is attributed to equipment or anomaly outside the building. It is important to determine where to measure as well as to measure the current itself.

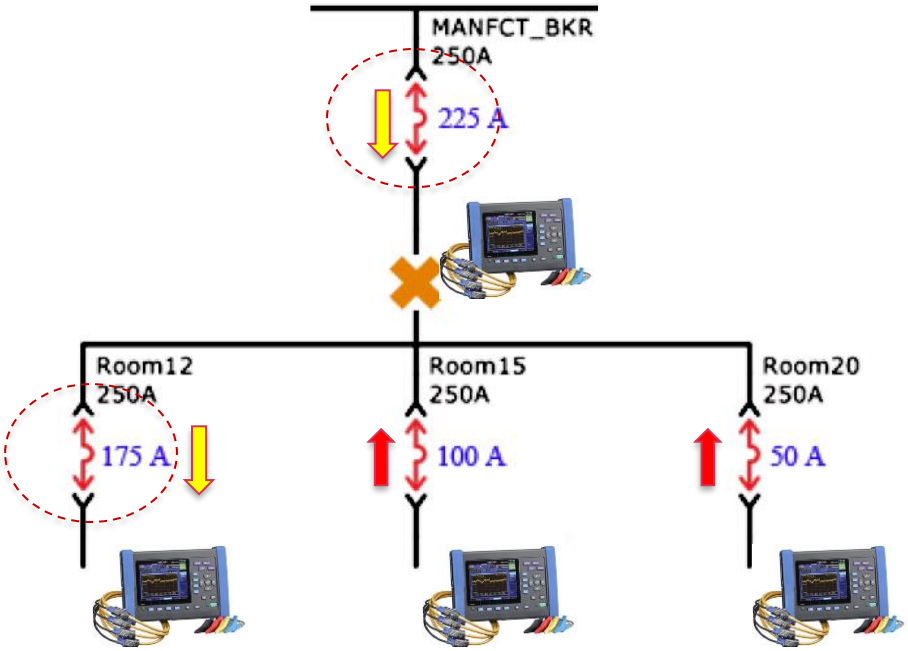


The current consumption inside the building increases due to a short-circuit or inrush current. This causes a voltage drop due to insufficient power supply capacity.



The supply voltage and current drop at the same time.

PQA = Easy to Determine Source of Fault



3. Transient Overvoltage

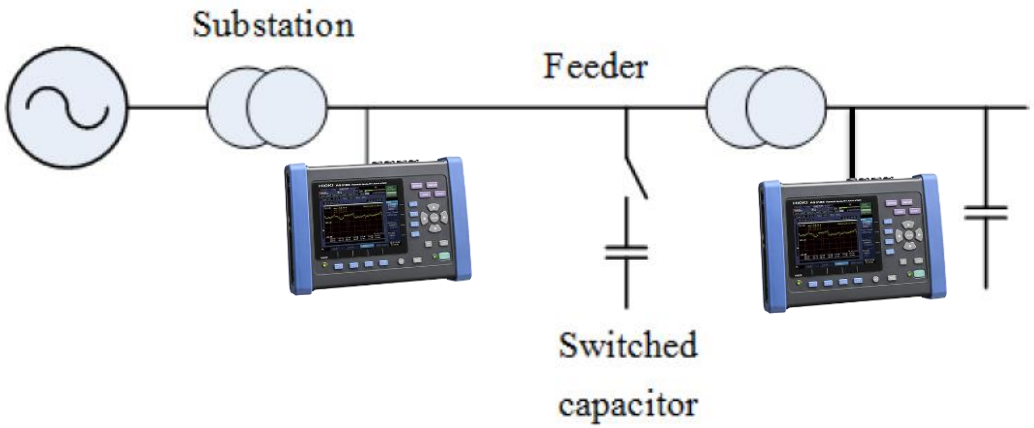
A. Lightning Strikes

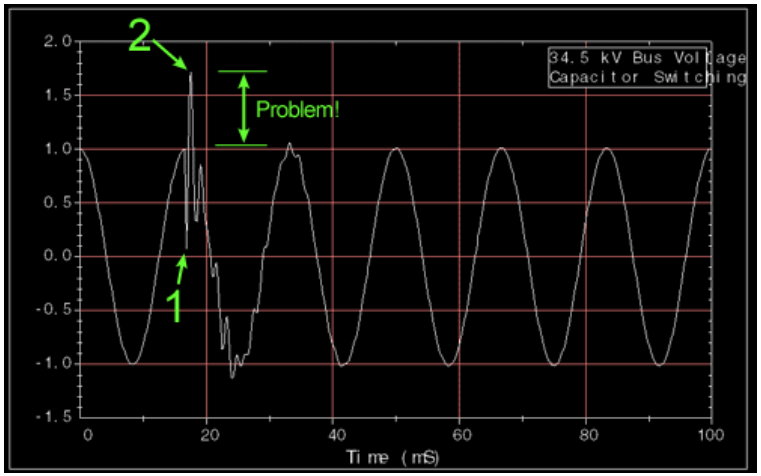
B. Load Switching Activity

- Opening and closing of disconnects on energized lines
- Capacitor bank switching
- Reclosing operations
- Tap changing on transformers

C. Loose connections on distribution system

D. Accidents, human error, animals and bad weather conditions





Why We Should Aware With Transient

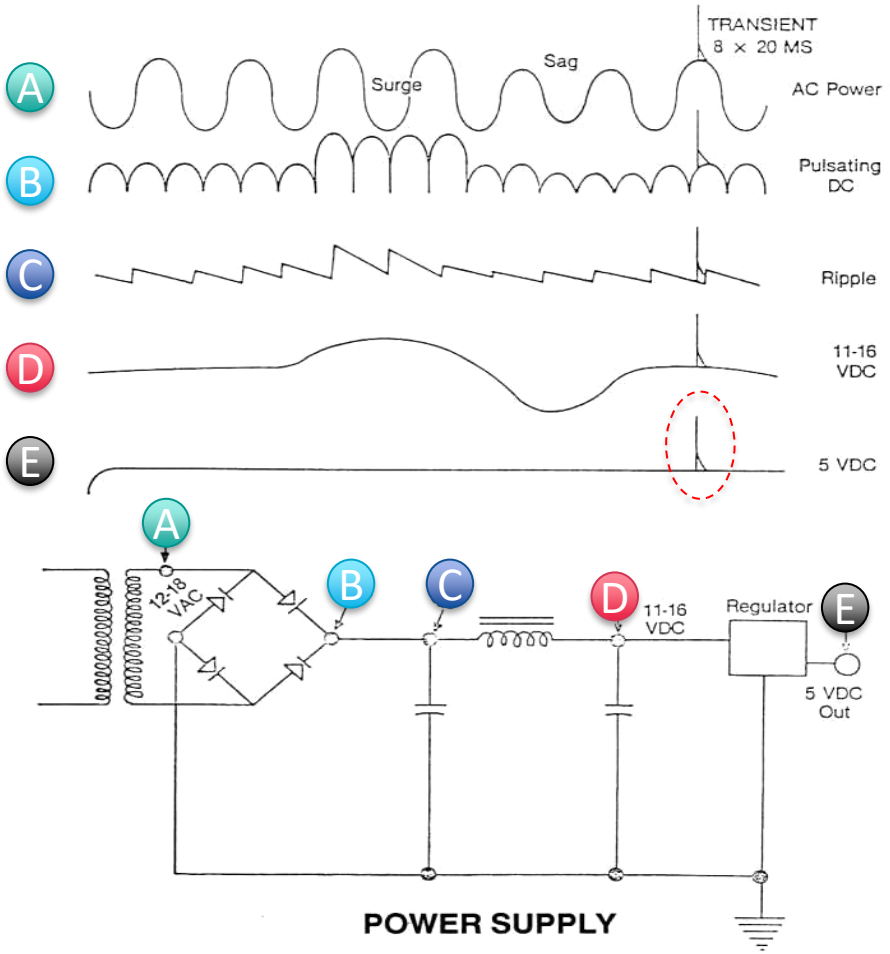
Power Utility

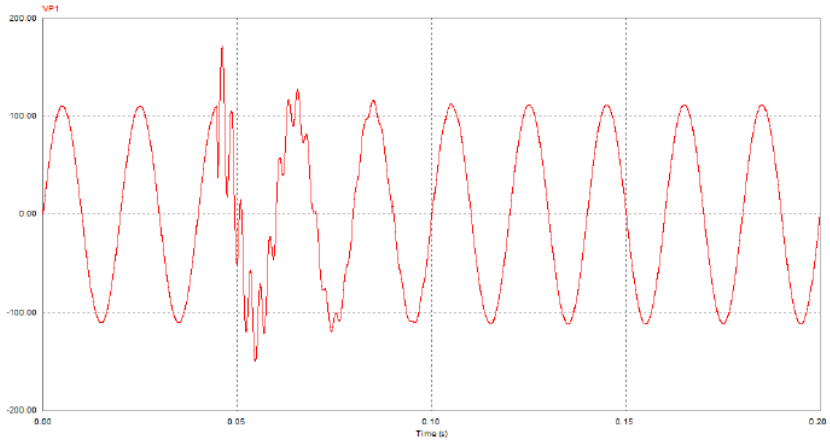
- Transients degrade the contacting surfaces of circuit breakers and switches (electrical equipment)
- Reduce transformer efficiency because of increased hysteresis losses (electrical equipment)

Customers

- Equipment will malfunction and produces corrupted results
- Improper specification and installation of TVSS can aggravate the failures
- Efficiency of electronic devices will be reduced

Transient Characteristic





HIOKI

Transient Detection

The most importance thing when we do transient analysis :

1. ***Know the peak of voltage***
   - Ensure the correct mitigation devices (level protection)

2. ***Know the time duration***
   - Ensure the correct mitigation devices (fast response)
   - Predicted source of the disturbance.
     - Nanosecond transient, 5 ns rise time with less than 50 ns (near the source)
     - Microsecond impulsive transient *, rises in 1μs and has a duration of 50 ns to 1 ms.
     - Millisecond impulsive transient**, rises in 0.1 ms and lasts more than 1 ms

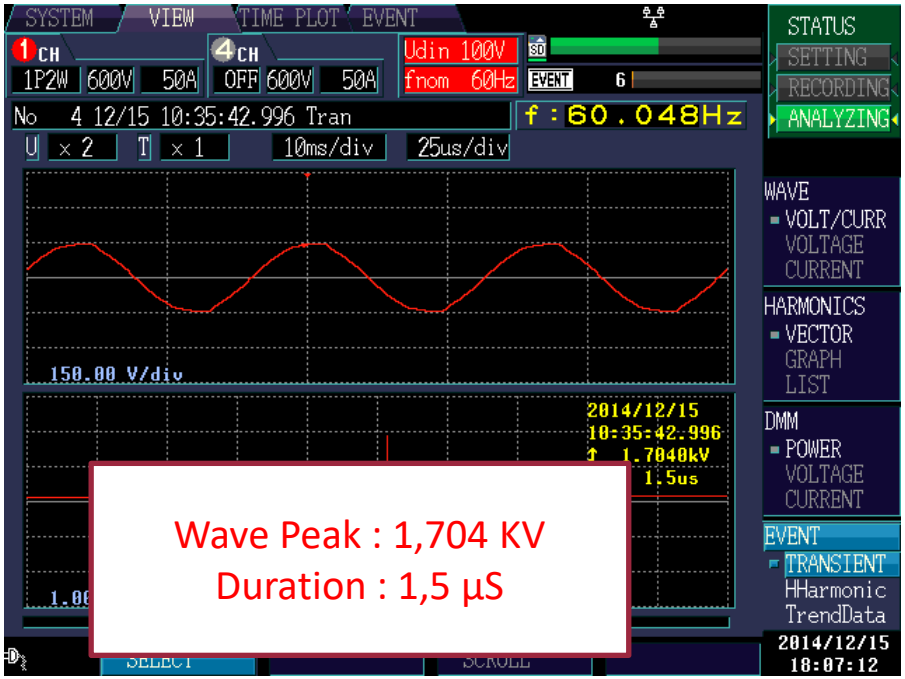
Transient Sampling Speed on PQA will be crucial

* *Unusual but they have much higher amplitudes*

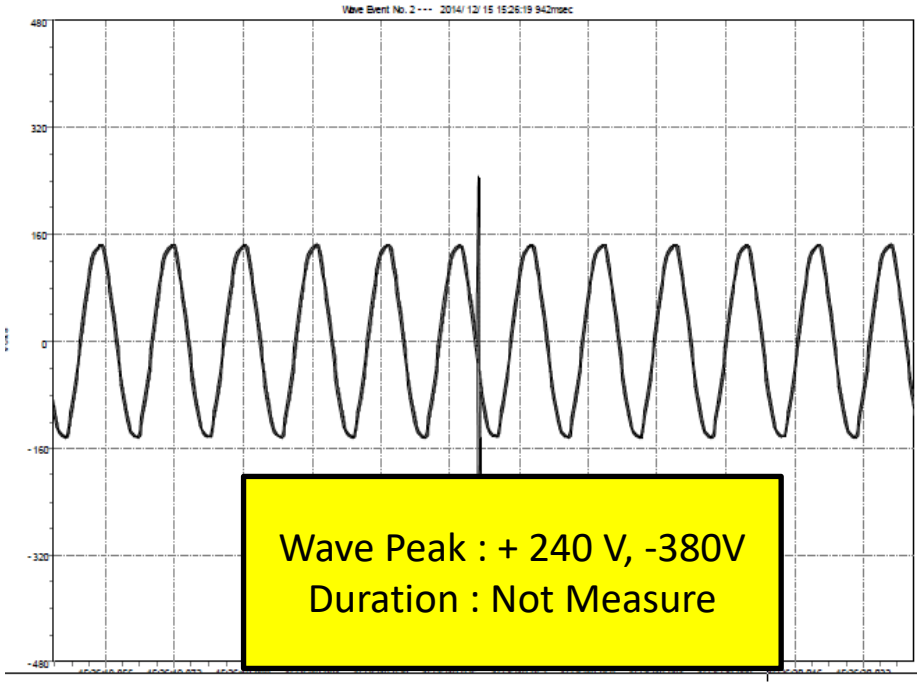
* * *The most common to occur in a power system*

2 MHz VS 200 kHz Sampling

Signal Test :
1,8 KV transient injected on 100 V AC 60 Hz



PQ 3198



Other PQA

13 Masalah Pada Motor

Power quality

1. Transient Voltage
2. Voltage Imbalance
3. Harmonic Distortion

Variable frequency drives

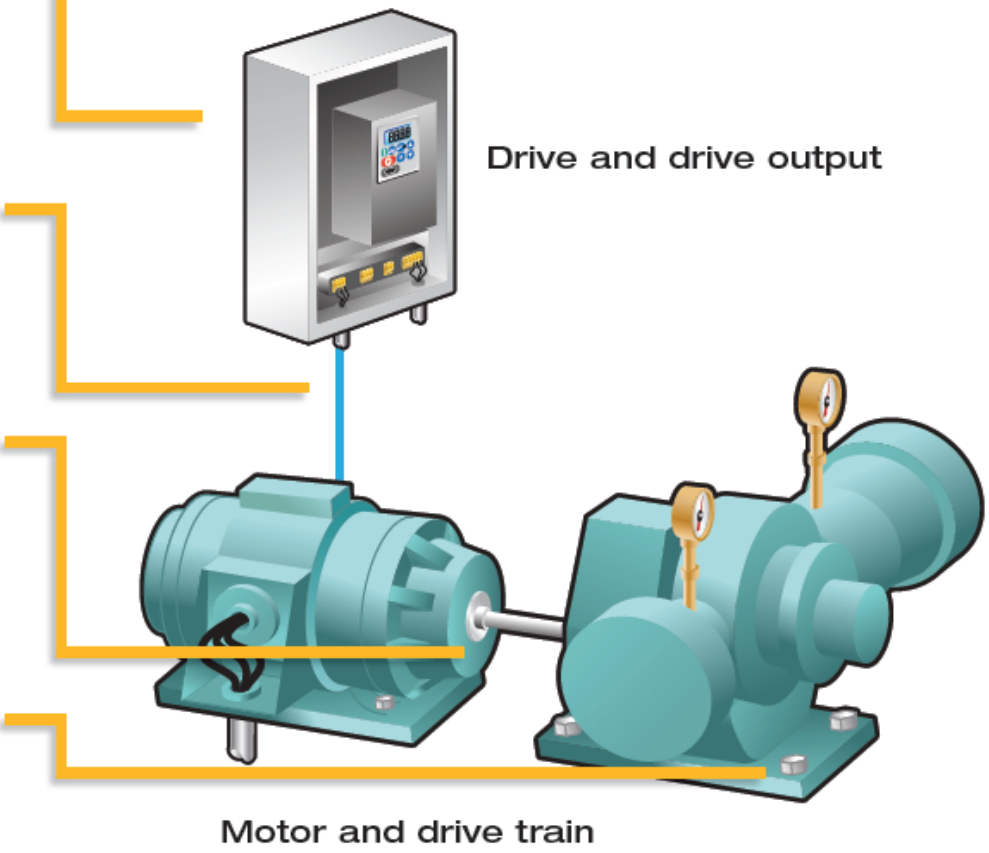
4. Reflections on drive output PWM signals
5. Sigma current
6. Operational overloads

Mechanical

7. Misalignment
8. Shaft imbalance
9. Shaft looseness
10. Bearing wear

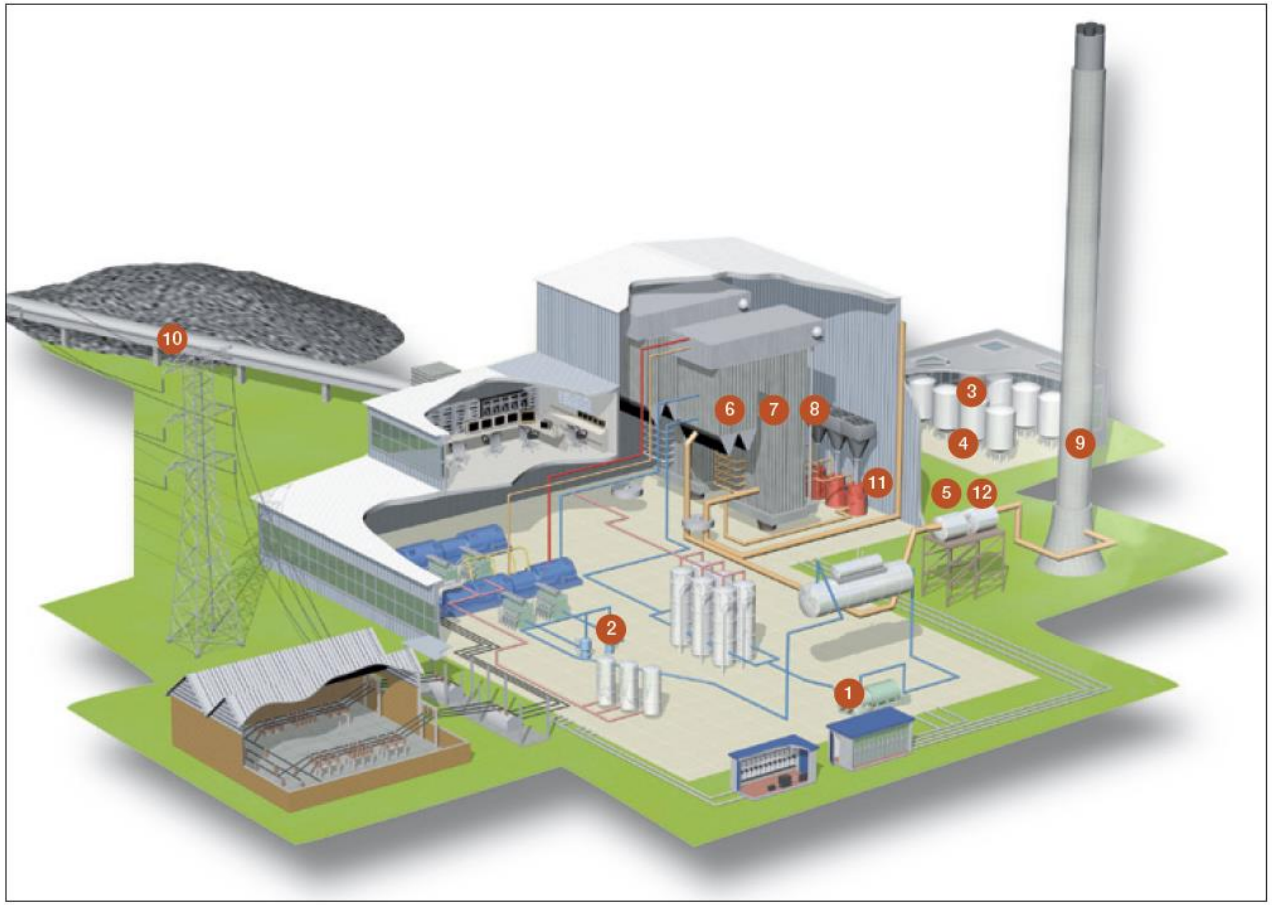
Improper installation factors

11. Soft foot
12. Pipe strain
13. Shaft voltage



Motor Monitoring at Coal Power Plants

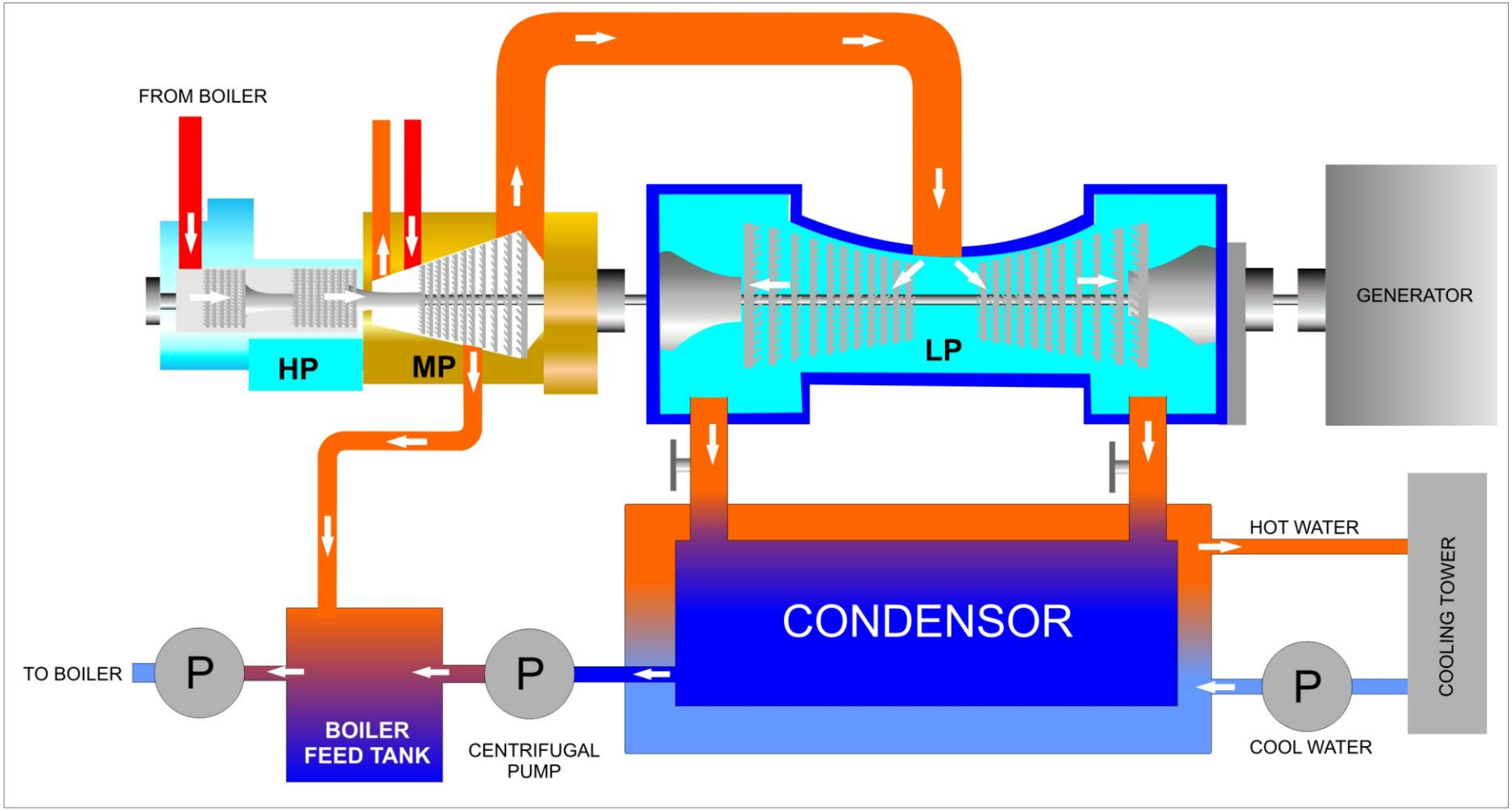
Most location of Motor & Pumps at Coal Powerplant



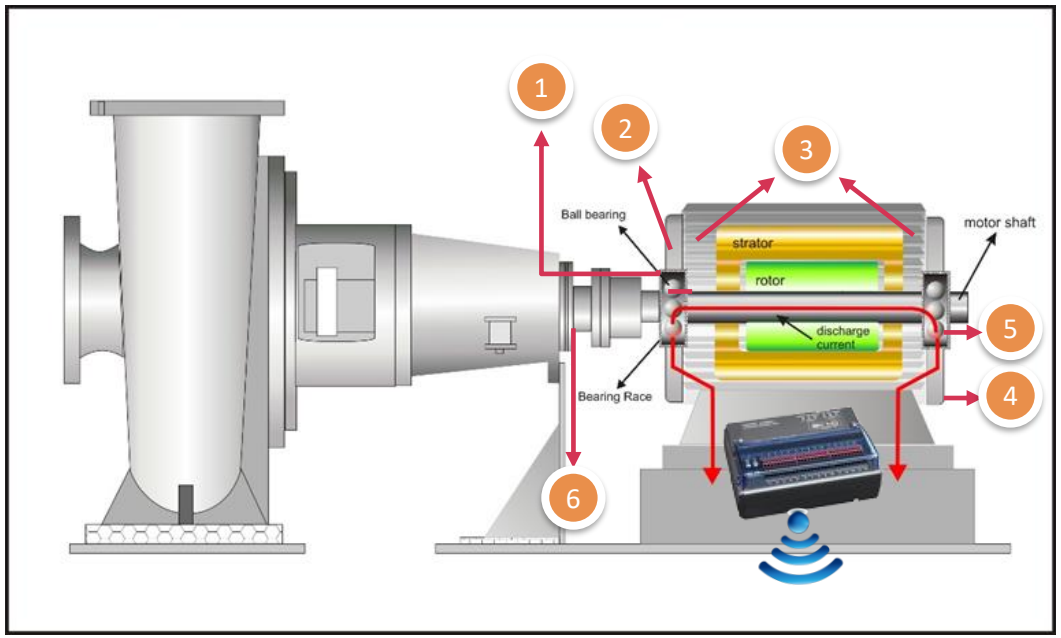
1. Boiler feed water pumps
2. Condensate extraction pumps
3. Cooling water district heating & C-generation pumps
4. Condenser & Cooling tower pumps
5. FGD slurry & absorber pumps

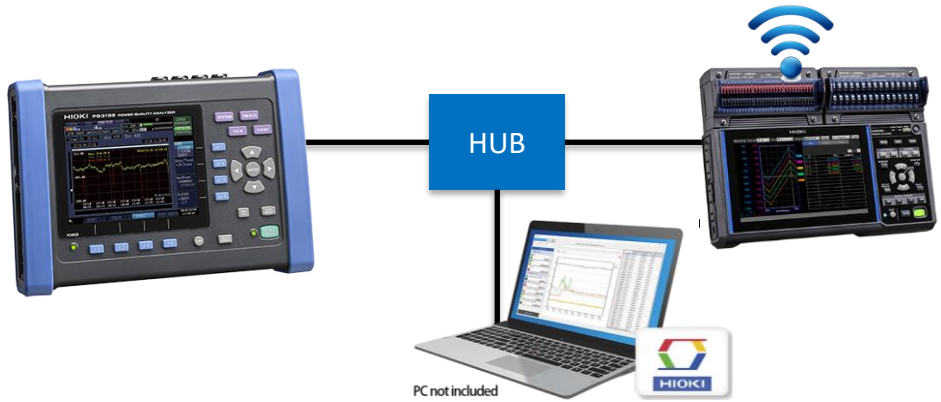
HIOKI

Coal Power plant



Pump Motor Monitoring at Coal Powerplant





Mechanical Side

Measure Temp & RPM

1. Temp. Cover bearing shaft Inner
2. Temp. Cover Winding Inner
3. Temp. Cover surface A and B
4. Temp. Cover winding Outer
5. Temp. Cover bearing shaft outer
6. RPM
7. Vibration

Electrical Side

Measure Voltage, Current & Frequency

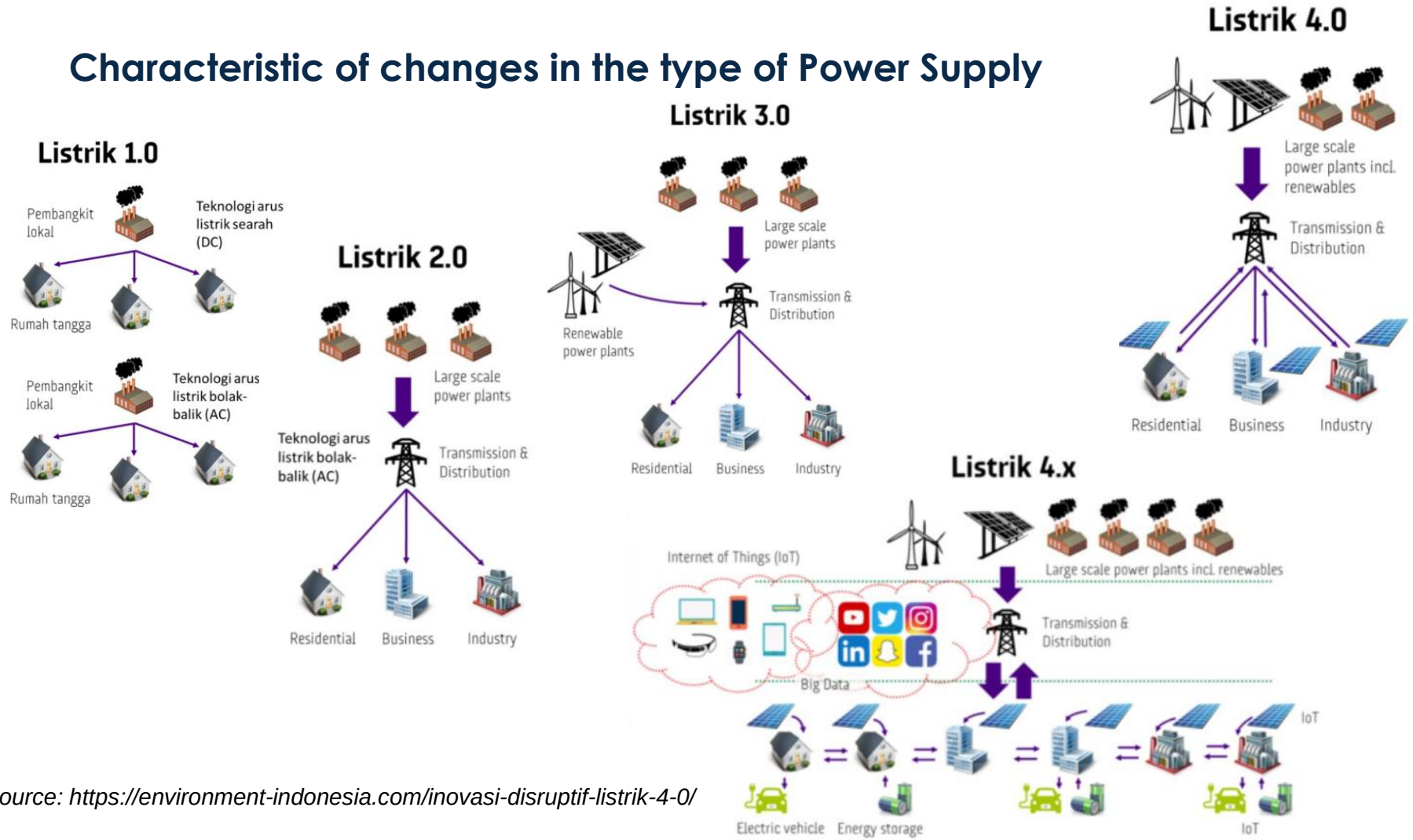
1. Monitor Unballance Voltage RST
2. Monitor Unballance Current RST
3. Monitor Voltage and Current Grounding
4. Monitor Inrush Current
5. Monitor Harmonic

Others

1. Checking Shaft Voltage
2. Efficiency

Our Power Environment Update

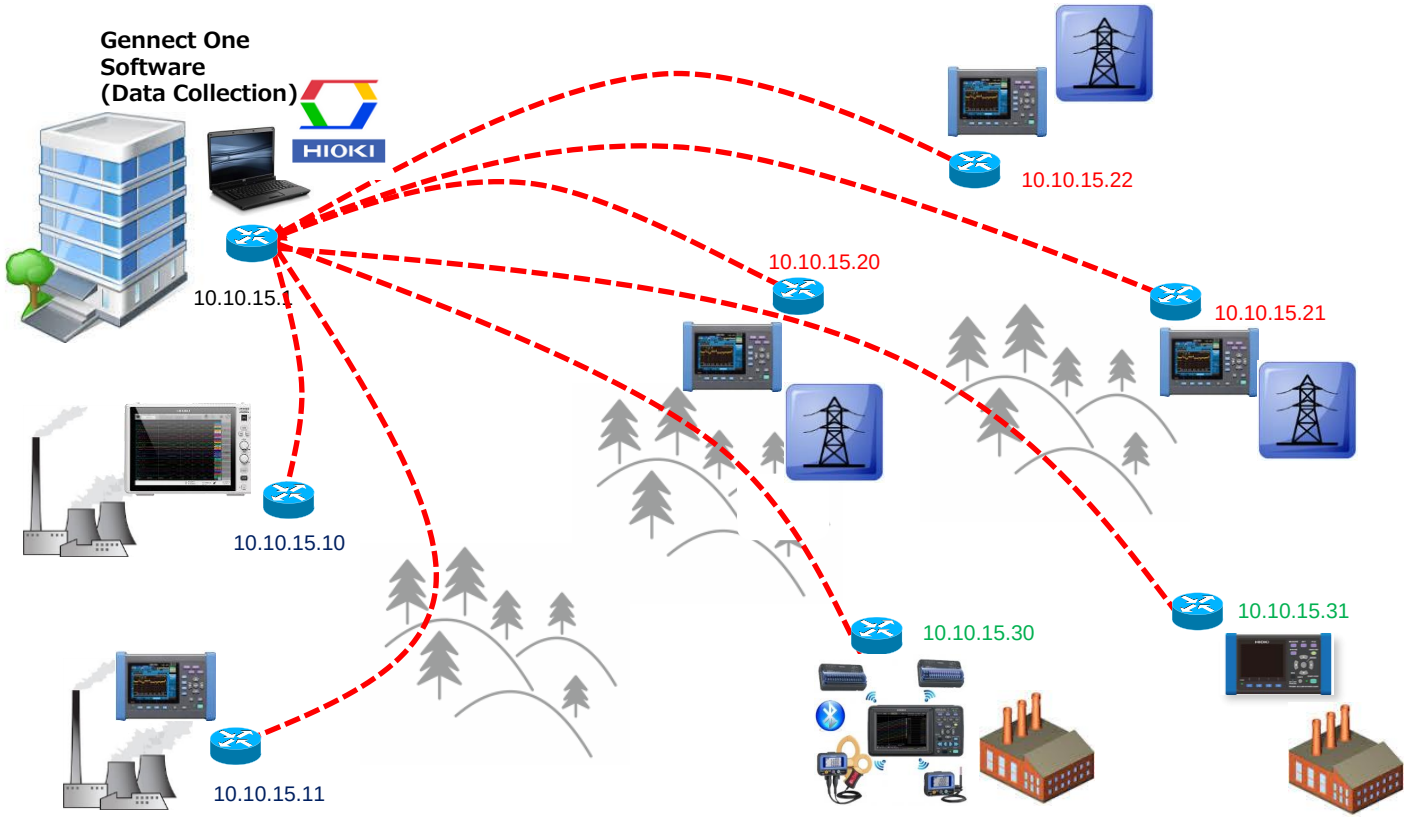
Characteristic of changes in the type of Power Supply



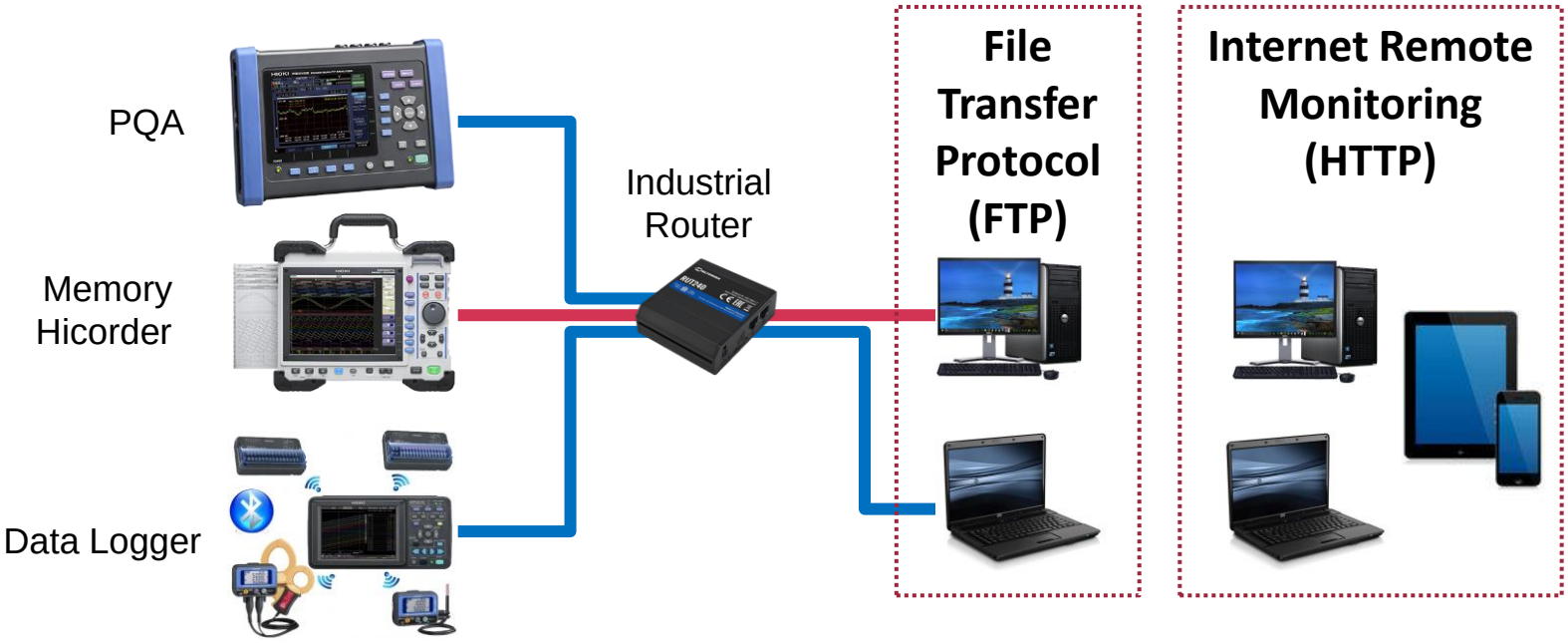
Source: https://environment-indonesia.com/inovasi-disruptif-listrik-4-0/

HIOKI

Multiple Logging with Static IP Addresses



Hioki's Product with IoT



Power Quality Analyzer PQ3198

HIOKI

Features in PQ3198

- **Highly accurate・broadband**

  IEC61000-4-30 Class A

- **2 line measurement**

  example：3PAC+DC

- **400Hz measurement**

- **PC software(PQ ONE) bundled**

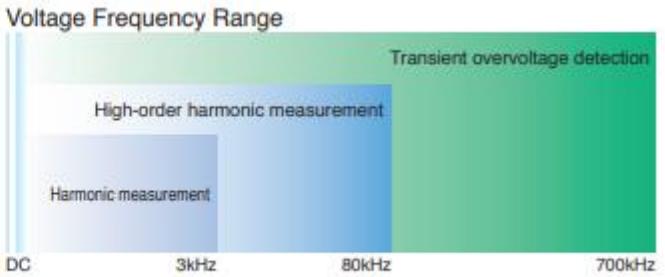
HIOKI

PQ3198 Highly accurate , broadband, wide dynamic range

- **Highly accurate**
  V RMS accuracy (200ms)：±0.1% of commercial voltage
  IEC61000-4-30 Class A
- **Simple measurement of inverter**（**Not specified in PW3198**）
  Fundamental freq: 40~70Hz, Carrier freq:~20kHz
- **Transient Voltage measurement**
  6000Vpeak, 2MS/s, measurement bandwidth 700kHz
- **High-order harmonics measurement**
  measurement bandwidth 2kHz~80kHz

As inverter equipment become popular nowadays, malfunction and trouble factor can be found in this measurement range.

Both low and high voltages can be measured in a single range.



Wide range from DC voltage to 700 kHz

PQ3198 two-lineMeasurement

■ Voltage for Channels [1,2,3] isolated from Channel 4

Pic: PQ3198

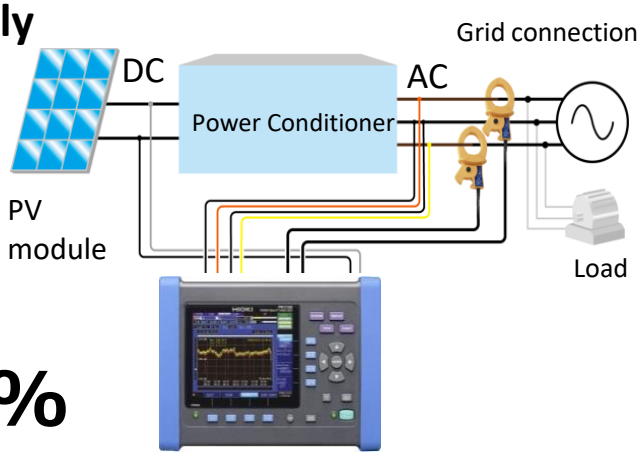
isolated

CH123 ⟷ CH4

→In addition to the main measurement system such as three-phase AC, it is possible to simultaneously measure another line in CH4.
In addition, in PQ3198, power measurement is performed with CH4, efficiency calculation of CH123 and CH4 is also possible.

■ Application example

- Simultaneous measurement of input and output of AC-DC converter of EV quick charger
- Measure input and output of a DC-AC converter for PV system simultaneously
- Measure UPS primary and secondary side simultaneously
- Two-line voltage analysis
- Measure three-phase line and grounding wire
- Measure neutral line to detect short circuit
- Leakage current measurement



$$\eta = \%$$

HIOKI

PC Application software (PQ ONE)

■ PC application software, PQ ONE is bundled

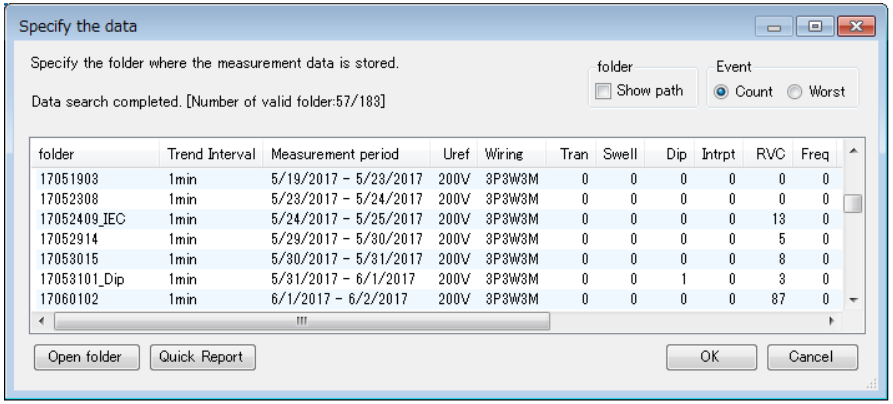
Bundled software for PQ3198, PQ ONE ver.4 starts supporting data from PW3198 (Hioki old version PQA)

→PQ ONE will be bundled with PQ3198

■ PQ ONEの popular features（details on P36 onwards)

- Event Statistics(Show event statistics by By date・By hours)
- Specify the data screen(Event count・Worst value, data selection)
- PQ Check function

  (Able to determine PASS/FAIL without opening the data)
- Statistics(5/50/95% statistics)



Thank You

HIOKI