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Chapter 6 – Measurement Instruments

6.1 Introduction
6.2 History – Four Generations
6.3 Reasons to Monitor vs. Type of Monitor
6.4 Parameters to be measured
6.5 Monitoring Instruments
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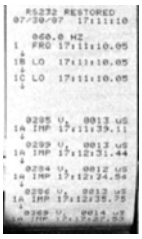
6.7 Safety

6.1 Introduction

- Instruments range from a simple analog voltmeter to a sophisticated multiple-site, permanently installed power quality monitoring system.
- Selection and use of correct type of monitor requires user to understand its capabilities and limitations, responses to power system variations, and specific objectives of the analysis.
- Instrument features required are dependent on the monitoring location and objectives.
- Level of detail required -- rms voltage stripcharts or high-speed waveform captures -- is indicated by type of phenomena likely to be causing problems

6.2 History – 4 Generations

- 1976 : Text-based Events
- 1984 : Graphical Waveform Displays
- 1991 : High Speed Sampling for Transients (1MHz)
- 2003 : Standards Certified -- IEC 61000-4-30 Class A



6.3 Reasons to Monitor vs Type of Monito

- **Portable/handheld monitors**
  - reactive to troubleshoot problems
  - also used for shorter term compliance monitoring.
- **Permanently installed monitors**
  - monitoring longer term system performance and reliability
  - providing data and/or alarms when PQ-related problems occur.
  - includes
    - dedicated PQ monitors,
    - revenue meters with PQ functionality,
    - statistical survey/compliance monitors,
    - system protection relays with some PQ functionality.
    - some mitigation equipment also provides limited PQ information,
- Data can be integrated into customer-owned, enterprise-level process control software to correlate variations in quality of supply as related to quality of the process.

6.4 Parameters to be Measured

- **6.4.1 Primary Measurements**
  - Voltage and Current
  - Peak, average, true RMS
- 6.4.2 AC Current
- 6.4.3 AC Voltage
- 6.4.4 Additional Parameters

6.4.2 Current

- Things to consider
  - Accuracy is a combination of CT and instrument accuracy
  - Phase shift
  - Overcurrent maximum versus the nominal range, in applications where fault currents need to be measured without clipping;
  - Peak value versus the full scale rms value (crest factor capability) for distorted waveforms.
  - Bandwidth

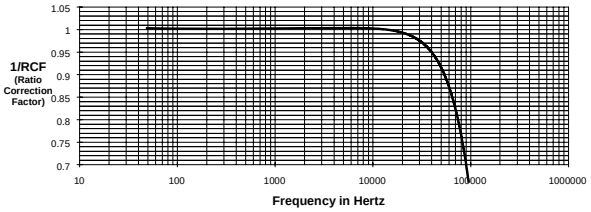


Figure 6-1—Frequency Characteristics of a Typical Current Transformer Used for Monitoring

6.4.3 Voltage

- Things to consider
  - Accuracy is a combination of PT and instrument accuracy
  - Differential versus Single Ended Connections
  - Sampling rate dictates harmonic range
  - Bandwidth for Transient Response

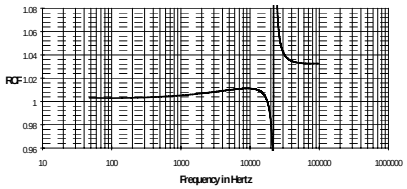


Figure 6-2—Frequency Response of a Standard PT with One Megohm Burden

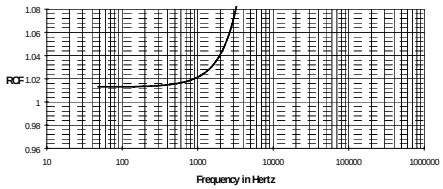


Figure 6-3—Frequency Response of a Standard PT with 100 Ohm Burden

6.4.3 PQ and More

ANSI Transformer Derating Factor	Interharmonic RMS Current	True Power Factor
Arithmetic Sum Power Factor	Interharmonic RMS Voltage	Unsigned Harmonic Power
Arithmetic Sum Displacement PF	IT Product	Vector Sum DF
Arithmetic Sum VA	Negative Sequence Current	Vector Sum PF
Current Crest Factor	Negative Sequence Voltage	Vector Sum VA
Current Total Harmonic Distortion (THD)	Net Current	Voltage Crest Factor
Current THD (rms)	Positive Sequence Current	Voltage THD
Current Total Interharmonic Distortion	Positive Sequence Voltage	Voltage THD (rms)
Current TID (rms)	Residual Current	Voltage TID
Current Imbalance	RMS Current	Voltage TID (rms)
Displacement Power Factor	RMS Current Individual Harmonics	Voltage TIF
Frequency	RMS Harmonic Current (total)	Voltage TIF (rms)
Fund Freq Arithmetic Sum VA	RMS Voltage	Voltage Imbalance
Fund Frequency Vector Sum VA	RMS Voltage Individual Harmonics	Watt Hours
Harmonic Power (sum)	Total Fund Freq Q	Zero Sequence Current
IEEE Std 519-1992 Current Total Demand Distortion	Transformer K Factor	Zero Sequence Voltage

6.5 Monitoring Instruments

6.5.1 Event Indicators

6.5.2 Oscilloscopes

– Don’t "floating the scope"

6.5.3 PQ Disturbance Monitors

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6.5.3.1 Overview PQ Monitors
6.5.3.2 Data Acquisition
6.5.3.3 Communication
6.5.3.4 Visualization
6.5.3.5 Advanced Analysis

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6.5.3.1 Overview PQ Monitors

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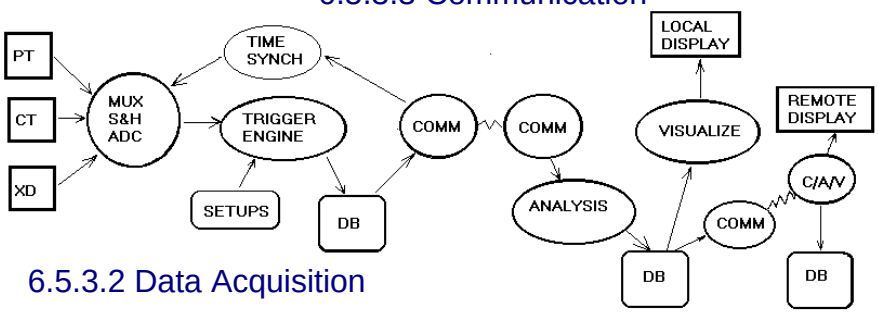
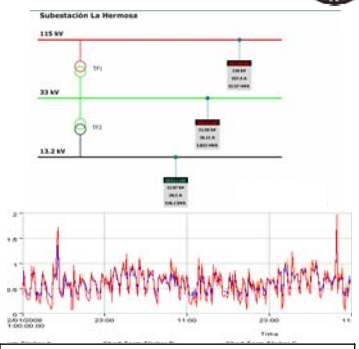


6.5.3.2 Data Acquisition

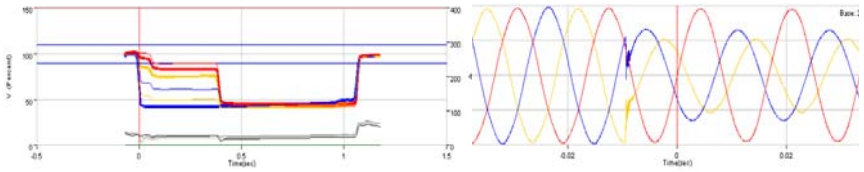
6.5.3.5 Advanced Analysis

Pro-active PQ Monitoring System

Info courtesy of
Mr. Carlos Alberto Quiroz G.
Jefe División Operación
CHEC, Manizales,Colombia



01/03/2008 21:58:58.768	xxxx30100	Momentary Sag	Rms Voltage B	Mag = 8,043.5 V (0.44pu), Mag(Aggregated) = 7,490.8 V (0.41pu), Dur = 1.08 s, Category = 5, **Downstream Sag**
01/03/2008 21:58:58.396	xxxx23100	Momentary Sag	Rms Voltage B	Mag = 3,329.9 V (0.44pu), Mag(Aggregated) = 3,103.9 V (0.41pu), Dur = 1.08 s, Category = 5, **Upstream Sag**



6.6 Pitfalls / Cautions

6.6.1 Instrument Power Supply and Monitoring Compatibility --- *Minimize the impact on measurements from measurement probes and power supply of the instrument.*

- What is level of instrument power supply generated noise?
- Does power supply or measurement burden influence measurements, such as containing transient protective devices
- Immunity of the instrument to what it is measuring
  - Recording data properly during PQ disturbance
  - Adequate EMI/RFI immunity of instrument and probes especially with long leads and/or power cords.
- Have "ground loops" been introduced into the measurement setup?

6.6 Pitfalls / Cautions

6.6.2 DC Power

- If using external power, are the power cables properly sized?
- Is instrument properly grounded?
- Does dc power come from a battery pack whose capacity is unknown or possibly degraded?
- If an external charger is used and connected to an ac outlet, what is the charger's isolation?
- What effect does the charger have on the power system?
- Is the charger capable of charging and conditioning the battery quickly and adequately without damage?

6.7 Safety

Personal, equipment, and system safety

- Equipment should pass such safety standards as appropriate for jurisdiction where used.
- Good grounding practices should be observed
  - Touch potential of the enclosure should be within safe limits
  - No ground loops are created.
- Placement/mounting with properly rated NEMA-type enclosure for the environment
- Should not interfere with normal facility operations, especially safety-related measures such as light curtains.
- Improper connection of communication equipment can affect not only those media, but the measurements themselves.


Thank you