The Statistical Behaviour of Voltage at LV Sites

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1. Introduction

Background

Current Australian voltage standard, AS60038
- specifies nominal voltages and ranges
- but not measurement and reporting techniques

Standards Australia and the ENA
- currently developing a PQ type voltage standard
- will specify both limits and measurement techniques

Uncertainty about the effects of
- measurement methods
- data processing techniques
1. Introduction

Voltage Control

The voltage levels at a LV site are dependant on
- Load behaviour
- Supply strength
- Upstream effects (quantised, time-delay)

Voltage dynamic behavior can be decoupled into
- High Frequency Component
  - due to load changes
  - not controllable
- Low Frequency Component
  - due to voltage regulation action, line impedance
  - is controllable
1. Introduction

Measurement and Reporting Chain

**Monitoring**
- Sample rate
- Aggregation interval
- Sag/swell thresholds
- Window widths

**Reporting**

**Reporting Intervals**

**Statistical Analysis**
1. Introduction

Key Monitoring & Reporting Parameters

- **Data Aggregation**

- **Continuous rapid sampling every cycle**
- **Aggregation to primary ‘building blocks’**
- **Aggregation to longer intervals**
- **Final aggregation**

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2. Effect of Data Aggregation Interval

How fast do we need to sample data?

Modern instruments sample data very rapidly
- uncertainty as to how often this data should be captured

IEC61000-4-30 recommends 10 minute intervals
- how much difference does it really make?
- how does equipment respond??

Study
- 14 distinct sites supplying data for 26 weeks
- Sites are fairly typical
- Voltage behaviour over each day examined
2. Effect of Data Aggregation Interval

- Site 1A Day 1 10s Voltage Trend
- Site 1A Day 1 30s Voltage Trend
- Site 1A Day 1 1min Voltage Trend
- Site 1A Day 1 10 min Voltage Trend
- Site 1A Day 1 15 min Voltage Trend

10 s
30 s
1 min
10 min
15 min

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2. Effect of Data Aggregation Interval

Detail is lost as aggregation interval is increased
- High Frequency (HF) components

Proposed that the short term trend is comprised of
- Low Frequency (LF) component which is present in the longer term
- HF component

A method as been developed to separate the components
- Separation of the HF component reveals some interesting behaviour
2. Effect of Data Aggregation Interval

High Frequency Component Behaviour

- No obvious clusters of high frequency variations e.g. due to specific operations
- Random distribution with most variation (approx 90%) being within 1% (of 230V) of the steady state value

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2. Effect of Data Aggregation Interval

High Frequency Component Behaviour

Data Aggregation → Statistical Analysis → Reporting Period

LF component does not vary with HF component
- No correlation between low frequency variation and high frequency variation
- Indicates utility can control voltage levels
3. Variation of Statistical Measures

Study
- Data for 15 weeks from 6 sites sampled at 30 second intervals
- Data also aggregated to 10 min intervals

![Data Aggregation Diagram]

Statistical Analysis

![Statistical Analysis Diagram]

Reporting Period

![Reporting Period Diagram]

Statistical levels (1% - 99%) practically identical
- 5 times as much variation for maximums
- Rationale for fast sampling unclear
3. Variation of Statistical Measures

How much do different Statistical Measures Vary over 1 week?

Statistics calculated from 10 minute data over 1 week
• 22 sites

Significant variation for lower end of range
4. Effect of Reporting Period

Is the Reporting Period Important?

37 sites from the LTNPQS have been studied

- The study focused on methods characterising one year using a 95th percentile value

Methods used

- 95th percentile value across whole year
- Max of monthly 95th percentile values
- Max of weekly 95th percentile
- Max of daily 95th percentiles
4. Effect of Reporting Period

Results

Yearly value calculated monthly will on 10% >
- 19% greater for weekly calculation
- 35% greater for daily calculation

Therefore the reporting period is important
5. Conclusions

Framework for Development of a Measurement Analysis Procedure

Step 1: Choose data Aggregation Interval

- **Proposal:** Use 10 minutes
- Ignore 10 second (or less) values
  - This allows a wider range of instrumentation & ease data handling/processing burden
  - Instantaneous deviations limited to about 1% from 10 minute values

Step 2: Choose Statistical Period

- **Proposal:** 1 day
  - A good day doesn’t compensate for a bad day
5. Conclusions

Step 3: Choose Statistic

- **Proposal:** 1% & 99%
  - Excludes 2 data points at the top and bottom to allow for extreme but rare behaviour

Step 4: Choose Survey Period

- **Proposal:** 1 week
  - Minimum business cycle

Step 5: Choose what to compare with

- **Proposal:** Equipment must be designed to tolerate a range ±1% greater than the utility 10 minute voltage range