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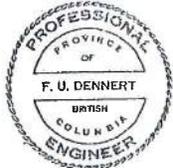
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REVISIONS: UPDATED LEGAL ACKNOWLEDGEMENT FORM. FD MAR '16

DESIGNED	RECOMMENDED	ACCEPTED	ENGINEER OF RECORD	<p><b>NOTICE FROM THE EXECUTIVE VICE PRESIDENT TRANSMISSION AND DISTRIBUTION AND CUSTOMER SERVICE</b></p>	
J. AGNOLIN	F. DENNERT	G. REIMER			
<p><b>DISTRIBUTION STANDARDS</b></p> 		<p>ISSUED: MAR 2016 REPLACES: MAY 2004 ORIGINALLY ISSUED: NOV 1980</p>		<p>PAGE 1 OF 2</p>	<p>ES43/53/54/55/65 A1-01.01 <sup>R</sup> 4</p>

**Scope**

This manual is one of a series containing standards for construction of the BC Hydro electrical distribution plant within the service area of BC Hydro. A new distribution plant shall be designed, constructed, owned, operated, maintained and repaired to these standards.

**Purpose of Standards**

BC Hydro objectives require standardization to:

- a) Ensure uniform safety requirements comply with BC statutes and regulations.
- b) Provide uniform system reliability.
- c) Provide uniform operating practices.
- d) Permit economic bulk purchasing of materials.
- e) Achieve optimum life cycle cost of plant construction.
- f) Effect efficient quality assurance.

**Responsibility**

The Distribution Standards Department prepares these standards and verifies that specified plant and procedures will perform adequately under all normally expected conditions encountered throughout the province of British Columbia. These standards are approved by Professional Engineers. It is the responsibility of BC Hydro Managers to ensure that the standards are followed unless abnormal conditions are encountered that require variations. These variations should be kept to a minimum and their performance shall be the responsibility of the Professional of Record in charge of the project, who will record and seal the variation based on satisfactory qualifications and experience to do so. As per the latest revision of the BC Hydro Distribution Owner's Engineer Guide, these variations must be accepted by BC Hydro's Owner's Engineer.

**Use of Stock Materials**

The electrical distribution plant covered by these standards is built using stock materials approved by a Professional Engineer as required by law. The use of non-stock materials for special and unusual situations must be approved by Distribution Standards or the BC Hydro Engineer responsible for the project.

**Revisions to Manual**

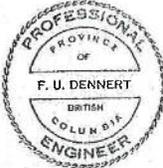
These standards are revised from time to time to improve the safety, performance, workability, cost effectiveness or appearance of the plant. The existing plant built to previous standards need not be updated unless so specifically advised by BC Hydro. When maintenance or other work, such as voltage conversion or conductor change is being done, updating plant to current standards is encouraged.

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Suggestions for changes in the manual, or required changes of address may be made on the pre-addressed comment sheet included in the Manual and with each issue of revision.

REVISIONS: UPDATED LEGAL ACKNOWLEDGEMENT FORM. FD MAR '16

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<b>DISTRIBUTION STANDARDS</b> 	ISSUED: MAR 2016 REPLACES: MAY 2004 ORIGINALLY ISSUED: NOV 1980		PAGE 2 OF 2	ES43/53/54/55/65 A1-01.02	R	4

# ES55 Design Standards

## Q1-02 – Electromagnetic Compatibility

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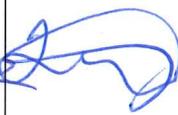
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### Revision History

Rev. No.	Revision Content	Date	POR
0	First issue	Jan 9, 2015	Scott Mercer

 <p>DESIGNED R. S. MERCER #39029 2015, 2019 S. MERCER</p>	<p>RECOMMENDED</p>  <p>K. MIDDLETON</p>	<p>ACCEPTED</p>  <p>F. DENNERT</p>	<p><b>ELECTROMAGNETIC COMPATIBILITY</b></p>		
	<p>DISTRIBUTION STANDARDS</p> 	<p>Revised: Jan 9, 2015 Replaces: N/A Originally Issued: Jan 9, 2015</p>	<p>ENGINEERING STANDARD</p>	<p>Page 1 of 12</p>	<p>ES55 Q1-02</p>

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## Scope

This section discusses general topics relating to electromagnetic compatibility which address:

- the source of, and rationale for, BC Hydro's operational planning limits;
- determining appropriate points of evaluation for assessing compliance with network planning limits, and
- uncontrolled electrical events.

Section Q1-02 serves as an introduction to, and should be read in conjunction with, the other documents in the Power Quality Standards which describe network planning limits.

## Definitions

These terms are used in this section:

Term	Definition
Power Quality	Characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters.
International Electro-technical Commission (IEC)	The world's leading organization that prepares and publishes international standards for all electrical, electronic and related technologies.
Canadian Standards Association (CSA)	The member-based standards development association serving business, industry, government and consumers in Canada, as well as the global marketplace.
Standards Council of Canada (SCC)	A federal Crown corporation whose mandate is to promote efficient and effective standardization in Canada, and oversee Canada's National Standards System.
Institute of Electrical and Electronics Engineers (IEEE)	The world's largest professional association dedicated to advancing technological innovation and excellence in areas including computing, sustainable energy systems, aerospace, communications, robotics and healthcare.
Electromagnetic Compatibility (EMC)	The ability of an equipment or system to operate satisfactorily in its electromagnetic environment without causing electromagnetic disturbance to

	anything in that environment.
Electromagnetic Disturbance	Any electrical or magnetic characteristic, either conducted or radiated, that affects the normal operation of equipment, or causes unwanted sensory experiences for people.
Compatibility Level	The specified maximum electromagnetic disturbance expected to be impressed on a device, equipment, or system operated in a particular environment under normal conditions.
Immunity Level	The maximum level of a given electromagnetic disturbance incident on a particular device, equipment, or system for which it remains capable of operating at a required degree of performance.
Emission Level	The level of a given electromagnetic disturbance emitted from a particular device, equipment or system.
Low Voltage (LV)	Describes networks with a rated voltage of $0 \text{ V} < U_n \leq 1,000 \text{ V}$ .
Medium Voltage (MV)	Describes networks with a rated voltage of $1,000 \text{ V} < U_n \leq 35,000 \text{ V}$ .
High Voltage (HV)	Describes networks with a rated voltage of $35,000 \text{ V} < U_n \leq 230,000 \text{ V}$ .
Planning Level	Reference level that describes system limits for planning purposes; levels are defined considering IEC compatibility levels.
Point of Interconnection (POI)	The point on BC Hydro's network where a customer is physically connected.
Cumulative Probability (CP[x])	The probability that the measured variable falls within a specified range [x]. For instance, the CP95 value for a set of voltage measurements refers to the voltage quantity that was exceeded during 5% of the recorded values.

## Application

Q1-02 provides general background information on electromagnetic compatibility to supplement all subsequent sections which define network planning levels.

## Uncontrolled Events

The power grid is subject to unpredictable and uncontrollable disturbances caused by events that are beyond the reasonable control of a utility. Such “uncontrolled events” include, but are not limited to:

- extreme “acts of God” such as floods, tsunamis, earthquakes, forest fires, etc.;
- customer equipment operation, mis-operation, or failure;
- utility equipment operation, mis-operation, or failure;
- motor vehicle accidents;
- naturally occurring phenomena such as lightning, heavy winds, snow, ice, etc., and
- high voltage contacts by trees, animals, machinery, debris, etc.

System limits described in this document should in no way be construed as guarantees or obligations on behalf of BC Hydro to meet any specific power quality objectives. BC Hydro does not guarantee to provide regular and uninterrupted supply of electricity, including electricity supply free from electrical disturbances.

## Electromagnetic Compatibility (EMC)

Electromagnetic compatibility is the ability of an equipment or system to operate satisfactorily in its electromagnetic environment without causing electromagnetic disturbance to any equipment or person in that environment.

BC Hydro’s power quality limits and methods for determining customer emission limits are mostly derived from standards published by the Canadian Standards Association (CSA). Where no CSA standard exists to define planning limits, compatibility levels or emission limits, then reference is made to technical reports, guidelines, specifications, or standards published by the International Electrotechnical Commission (IEC) or the Institute of Electrical and Electronics Engineers (IEEE).

**Most IEC 61000 series EMC standards have been adapted for the Canadian electrical environment, published by the CSA, and approved as National Standards by the Standards Council of Canada.**

## Electromagnetic Compatibility Levels

Network power quality limits are designed to be less than or equal to published IEC compatibility levels. IEC compatibility levels are determined

such that coordination exists between expected system disturbance levels and equipment immunity levels.

In order to minimize the occurrence of interference, compatibility levels are assessed using maximum expected disturbance levels, occurring within a certain probability, of a device, equipment or system. The maximum disturbance levels are determined to be that which occurs with 5% probability. Compatibility levels, therefore, give consideration to at least 95% of system disturbance conditions.

Figure 1 below shows the relationships between compatibility, immunity, planning and emission levels.

Figure 1 is not accurately scaled and is not used to represent a true indication of the extent of overlap which may exist between the two normal distribution curves; immunity and disturbance levels vary for each network performance parameter and equipment that is being considered.

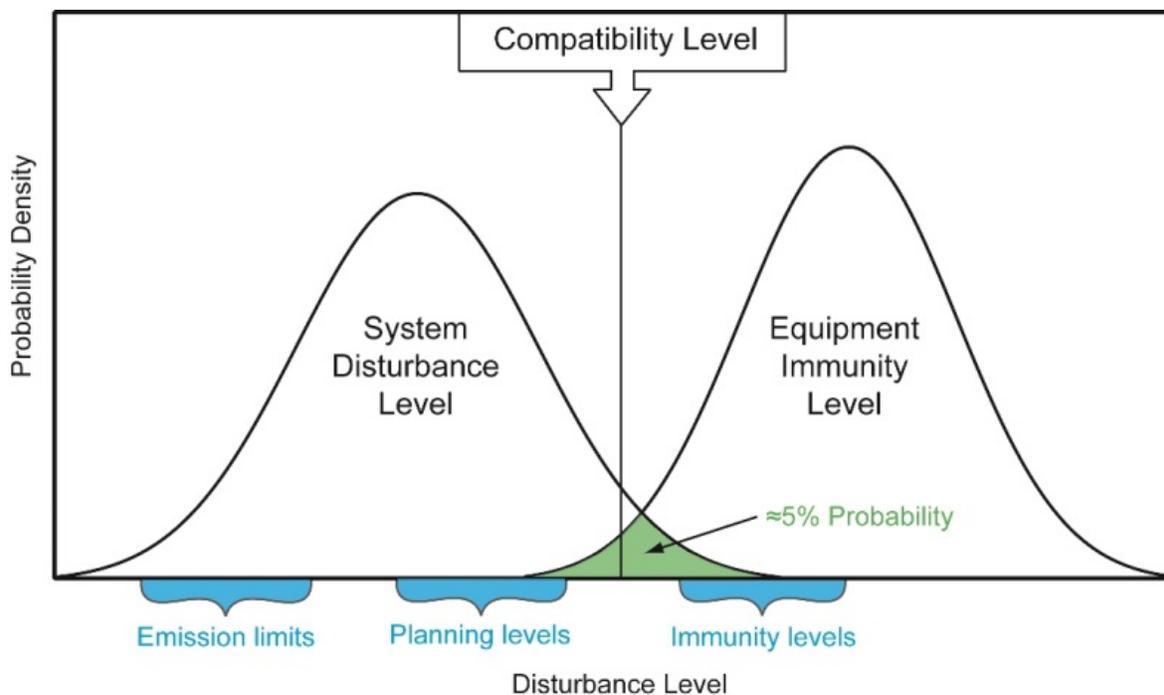


Figure 1- Compatibility, Immunity, Planning and Emission Level Relationships (not to scale)

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## Assessment of Low and Medium Voltage Network Performance

Evaluation of network performance can be done using any combination of electrical measurement data from fixed or portable power quality meters and/or data acquired through network computer simulation.

BC Hydro network performance must be assessed using measurement data from an appropriate Point of Evaluation (POE).

### Points of Evaluation, Interconnection and Common Coupling

To assess BC Hydro's compliance with system planning limits, and/or a customer's compliance with prescribed emission limits, consideration must be given to an appropriate point on the network where evaluation should be performed, known as the "point of evaluation" (POE).

Determining the POE requires an understanding of the differences between a customer's point of interconnection (or POI, also known as the point of delivery or POD), and their point of common coupling (PCC).

Although the term PCC is often used interchangeably with the term POI, this is not always accurate:

- The **point of interconnection (POI)** is the point on the network where a customer is physically connected to the public supply network. For a residential customer the POI is the revenue meter base. For a MV customer the POI might be an overhead load break switch or a primary disconnect in their electrical vault.
- The **point of common coupling (PCC)** is the nearest point on the public utility network where the customer's electrical equipment operation has potential to impact other customers. Although this may be the same as the POI in some cases, it is not always so.

The figure below illustrates the difference between the POI and PCC.

Customer being evaluated

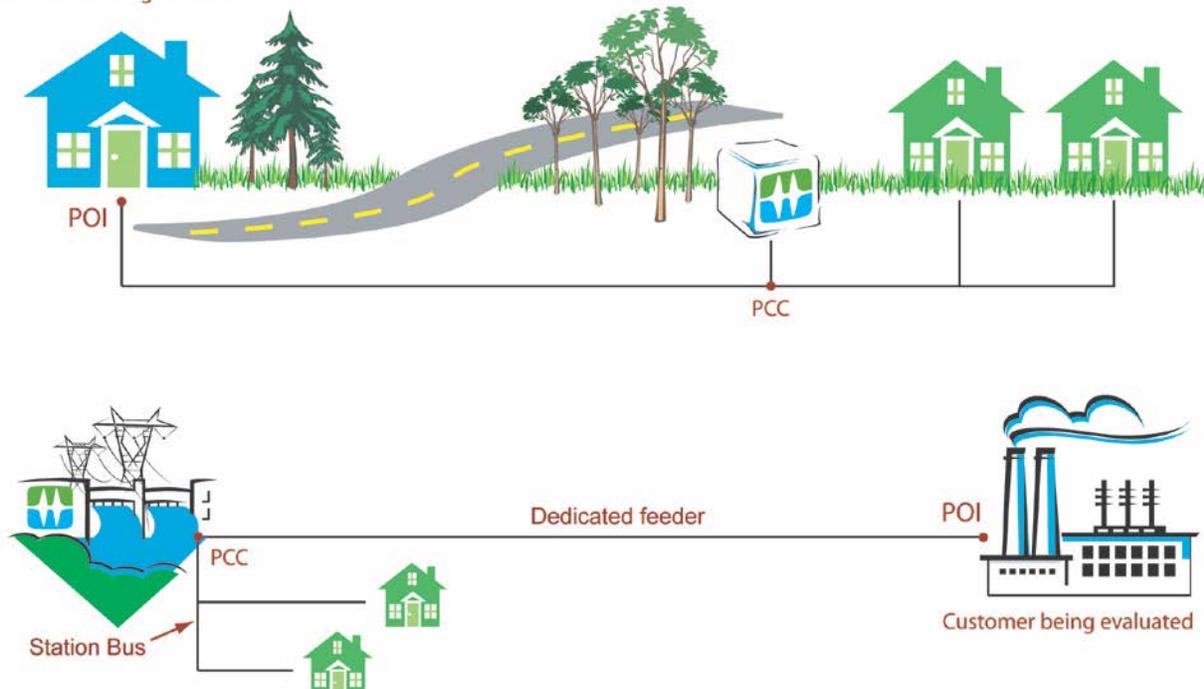


Figure 2 - Point of Interconnection vs. Point of Common Coupling

## Rules for Selecting a Point of Evaluation

The following rules shall be used to select a POE:

- For assessment of BC Hydro's network performance with respect to a particular customer's location, the POE shall be that customer's POI.
- For assessment of a particular customer's compliance with prescribed emission limits, the POE shall be that customer's PCC.

[Section Q2, Planning Limits for Low and Medium Voltage Networks](#), considers network performance limits. For information on assessing customer emission limits, see [Section Q3, Customer Emission Limits for Connection to the Low Voltage Network](#) and [Section Q4, Customer Emission Limits for Connection to the Medium Voltage Network](#).

Depending on the distribution of loads on a feeder, potential points of evaluation for network performance assessment may vary considerably. The following are possible load distribution topologies:

- **Distributed:** loads may be distributed along the whole feeder from the substation to the very last pole. In such a case, any point along the feeder is a potential point of evaluation.

- **Dedicated:** the feeder may be dedicated to one large customer, so the only potential point of evaluation is that customer’s point of interconnection.
- **Express:** the feeder may have a section which acts purely as an express conduit to a clustered load centre, such as a small town or industrial park. In this case, the potential points of evaluation will not comprise the whole feeder, but only the sections where loads exist.

The figure below illustrates these three topologies:

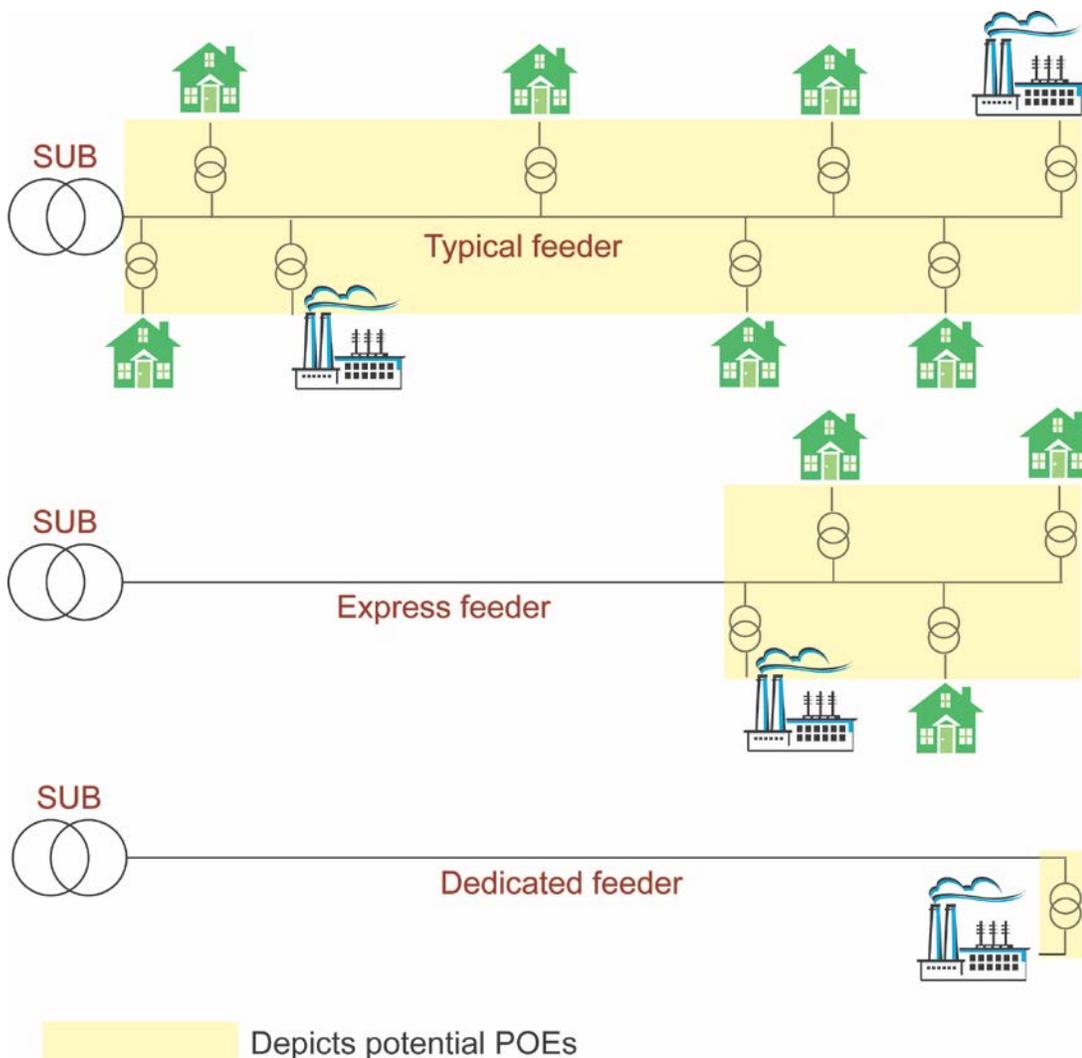


Figure 3 - Potential POEs for Assessment of Network Performance

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## Performance Criteria

Generally, assessment of steady-state voltage phenomena requires continuous voltage monitoring over some period of time with data stored at defined intervals, followed by statistical evaluation of the recorded data.

The length of recording, length of intervals, sampling frequencies, sensor accuracies and calculation algorithms are all subject to user settings and variability between manufacturers. Each one of these parameters may significantly impact the results of a compliance study.

CSA 61000-4-30 defines specifications for power quality measurement and classification for meters as Class A, B, or S.

## Measurement Aggregation

Electrical data recorded over extended periods of time requires aggregation (or collection) into intervals which are practical for the user to evaluate, but which are still representative of network performance. For example, a 10-minute average voltage is sufficient for assessment of steady-state voltage performance, but is not sufficient for assessment of rapid voltage fluctuations.

CSA 61000-4-30 defines four possible aggregation intervals which may be applied to evaluate recorded data:

- 200 milliseconds (12 cycles at 60 Hz);
- 3 seconds;
- 10 minutes, and
- 2 hours.

## Statistical Evaluation

Once aggregated, measurement data is subject to statistical evaluation which is intended to define a reasonable amount of event activity that can be expected for that particular phenomenon, while omitting outlying events from the analysis, such as electrical faults.

For the statistical evaluation of measurement data, the 'cumulative probability' values are used, or 'CP[x]', where [x] can be any number between 0 and 100. The cumulative probability of a measured quantity is the probability that it falls within a specified range. For example, the CP95 value of a voltage recording refers to the measured voltage quantity that was exceeded 5% of the time. Likewise, the CP01 value is the value that was exceeded 99% of the time.

The cumulative probability distribution is presented in a histogram chart. The example below shows an A-phase voltage trend recorded over a

period of one week with its cumulative probability chart. The vertical dashed lines represent the CP95 and CP99 voltage values corresponding to the recorded data set:

- The CP95 value is 1.050 pu – the voltage was recorded above 1.050 pu during 5% of the recording period.
- The CP99 value is 1.051 pu – the voltage was recorded above 1.051 pu during 1% of the recording period.

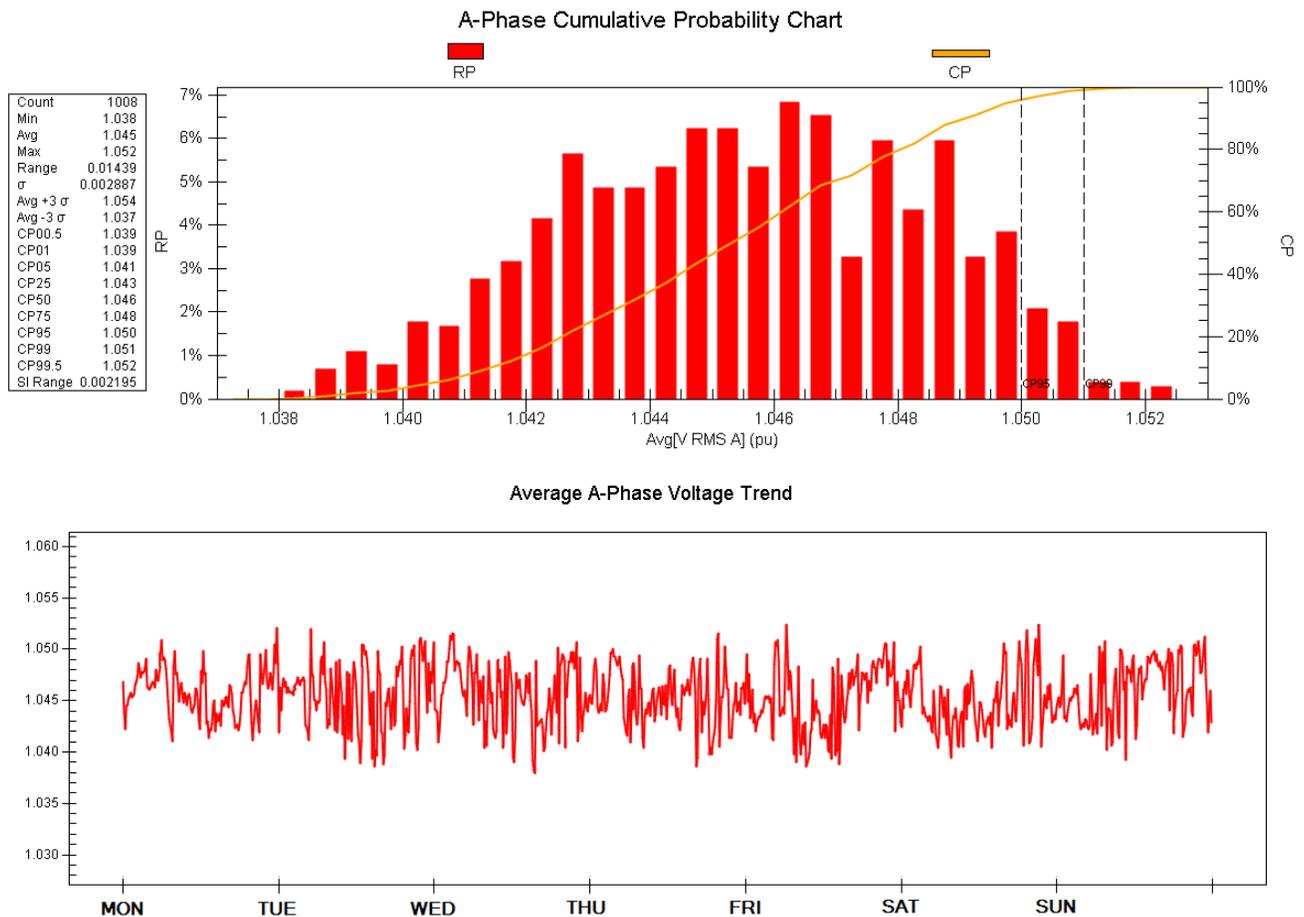


Figure 4 - Cumulative Probability and Trend Charts for Voltage Measurements

The commonly used cumulative probability values throughout Q1 are:

- CP05 and CP95;
- CP01 and CP99; and
- CP0.1 and CP99.9.

When there are limits prescribed for both lower and upper bound performance, then the statistical analysis for that parameter will include consideration for both. For instance, if voltage must fall between 110 V and 125 V 95% of the time, then the CP05 value must be  $> 110$  V, and the CP95 value must be  $\leq 125$  V.

## BC Hydro Response

When power quality problems are determined to be caused by BC Hydro feeders operating outside of the requirements set forth in [Q2-01 through Q2-12](#), then mitigation must occur within a reasonable amount of time. The [Power Quality Risk-Based Response Prioritization Matrix \(Q1-03\)](#) is used to determine an appropriate target date for completion of remedial action.

## References

- [Q1-03 Power Quality Risk-Based Response Prioritization](#)

## Sources

- Neilson, J.B., Buchholz, Vern L. BC Hydro Power Quality Guide. (2005).
- CAN/CSA-C61000-2-1-97 - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems.
- CAN/CSA-C22.2 NO. 61010-2-030-12 - Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 2-030: Particular requirements for testing and measuring circuits.