

STANDARDS AUSTRALIA

Amendment No. 1
to
AS 61000.3.100—2011
Electromagnetic compatibility (EMC)
Part 3.100: Limits—Steady state voltage limits in public electricity systems

REVISED TEXT

The 2011 edition of AS 61000.3.100 is amended as follows; the amendments should be inserted in the appropriate places.

SUMMARY: This Amendment applies to Clause 8 and Appendix D.

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No. 1
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2016

Clause 8

Add new Clause 8 as follows:

8 ASSESSMENT OF NETWORK WIDE COMPLIANCE

A method for assessing customer steady state voltage compliance across an entire electricity distribution network is provided in Appendix D.

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Appendix D

Add new Appendix D as follows:

APPENDIX D

**ASSESSMENT OF POWER QUALITY FUNCTIONAL COMPLIANCE IN
ELECTRICITY DISTRIBUTION NETWORKS**

(Informative)

D1 INTRODUCTION

With distribution companies often having hundreds of thousands of electricity customer connections spread over a large geographic area, achieving 100% compliance for all customers at all times is not economically nor practically possible. While distributors have a responsibility to respond to individual customer complaints of non-compliant power quality, many instances of localized and brief power quality non-compliance with standards, codes and regulations go unnoticed.

This Appendix sets out a method for assessing the global level of power quality disturbances at low voltage, recognizing that many customers are unaware of non-compliance and the adverse impacts that non-compliance may have on their electrical equipment and their operations. This method allows the development of standards that require a network-wide minimum compliance level for each of the power quality disturbance types. The concept of standards specifying compatibility levels in terms of 95% of space and time has long been established. Guidance on principles for determining these requirements is given in TR IEC 61000.3.6, *Electromagnetic compatibility (EMC), Part 3.6: Limits—Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems*, and TR IEC 61000.3.7, *Electromagnetic compatibility (EMC), Part 3.7: Limits—Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems*. The procedures detailed in this Appendix are an extension of these principles.

Because it is uneconomic to take accurate power quality measurements at all customer network connections points, a sampling method has been developed that uses a branch of statistics called ‘order statistics’. This method provides the establishment of minimum sample sizes to assess the level of power quality compliance across a whole network to a given level of confidence.

D2 METHOD

This Appendix provides a method for assessing network wide compliance for a power quality parameter. The method is based on the following procedures:

- (a) Establishing power quality compliance levels for individual sites from existing standards.
- (b) Determining from this Standard, the percentage of individual sites required to achieve compliance for the network to be assessed as being functionally compliant.
- (c) Taking sample power quality measurements from customer network connection points from within the network that meet conditions that provide for random selection from available sites, cater for seasonal variations and satisfy minimum survey periods.
- (d) Analysing the sampled power quality survey data for each power quality measure using a specified non-parametric (non-curve fitting) statistical technique to estimate the spread of customer site power quality levels across a network.
- (e) Using specified non-parametric statistical techniques to assess the error around the calculated power quality levels.
- (f) Assess for power quality compliance by determining if the assessed value and the associated error band meets the required compliance level.

The selection of sample size is a very important aspect in the process of demonstrating network wide functional compliance and requires careful consideration in the early stages of the design of the power quality surveying.

D3 STATISTICAL TERMS AND DEFINITIONS

Symbol	Definition
Error	Range of uncertainty around a measure to a nominated confidence level.
N	Integer number of sampled power quality measurements—where each surveyed site contributes one measurement to the sample, it is also the number of surveyed sites.
p	Quantile of the population where $0 \leq p \leq 1$, e.g. a $p = 0.95$ represents the 95th percentile.
Q_{limit}	Limit specified in the applicable standard, code, regulation or national electricity rules for an individual power quality parameter at any class of site.
R	Rank of the sample measures where $1 \leq R \leq N$.
R_p	Rank of the sample at a quantile of p .
$R_{p \text{ lower}}$	Rank of the sample at the lower end of the confidence interval.
$R_{p \text{ upper}}$	Rank of the sample at the upper end of the confidence interval.
X	Power quality measure, e.g. $V_{1\%}$, $V_{50\%}$ or $V_{99\%}$
X_p	Power quality assessment at the quantile p .
$X_{p \text{ lower}}$	Power quality assessment at the lower end of the confidence interval.
$X_{p \text{ upper}}$	Power quality assessment at the upper end of the confidence interval.
z_c	Number of standard deviations associated with the required confidence level.

D4 REQUIREMENTS FOR POWER QUALITY NETWORK FUNCTIONAL COMPLIANCE

A network is functionally compliant for each power quality measure when the required percentage of sites satisfies the power quality individual site limit specified in Table D1.

TABLE D1
POWER QUALITY NETWORK PERFORMANCE
REQUIREMENTS FOR FUNCTIONAL COMPLIANCE AT LOW VOLTAGE

Power quality measure	Units	Minimum network compliance requirement		Required confidence level		Individual site power quality limit	
		Percentile of sites % of N	Quantile of sites p	Percentile	z_c	Limit value Q_{limit}	Limit type
$V_{99\%}$	Volts	95%	0.95	90%	1.282	253*	Upper
$V_{50\% \text{ upper}}$	Volts	95%	0.95	90%	1.282	244†	Upper
$V_{50\% \text{ lower}}$	Volts	95%	0.05	90%	1.282	225†	Lower
$V_{1\% \text{ lower}}$	Volts	95%	0.05	90%	1.282	216*	Lower
V_{spread}	Volts	95%	0.95	90%	1.282	37*	Upper

* Limits from Table 2.

† Preferred performance from Table 3.

D5 STATISTICAL ANALYSIS OF POWER QUALITY SAMPLE MEASUREMENTS

In statistics, the k_{th} order statistic of a statistical sample is equal to its k_{th} smallest value^[1]. Order statistics provides tools for estimating the 50th percentile ($p = 0.5$), 95th percentile ($p = 0.95$), 99th percentile ($p = 0.99$), 1st percentile ($p = 0.01$) or any other percentile of a population from a random set of power quality measurements. In addition, order statistics provides tools to assess the error associated with such an estimate based on a certain level of confidence.

The objective of this power quality statistical analysis is to determine the error associated with sampling a population to determining the p_{th} quantile value ($0 \leq p \leq 1$) from N samples. The sample size (N) is of critical importance because it is a major determinant of both the cost of the required power quality surveying and the level of sampling error.

D6 CALCULATING THE QUANTILE OF THE SAMPLE

For N power quality samples, the rank R_p associated with the p_{th} quantile of the population is given by Equation D1^[2].

$$R_p = pN + 0.5 \quad \dots D1$$

Where R_p is an integer, it represents the R_{pth} sample when all samples are sorted from lowest to highest. Where R_p is a non-integer, it represents a value between two sampled points.

The power quality measure X at the p_{th} quantile of the sample is the value associated with the rank R_p . For the case where R_p is an integer, Equation D2 applies and the value of X_p is the sample measurement.

$$X_p = X(R_p) \quad \dots D2$$

If R_p is a non-integer it can be considered as an integer part plus a fraction part as shown in Equation D3. To determine the value of X_p , interpolation between the two sampled points is used. Applying linear interpolation to Equation D2 gives Equation D4.

$$R_p = \text{integer}(R_p) + \text{fraction}(R_p) \quad \dots D3$$

$$X_p = X(\text{integer}(R_p)) + \text{fraction}(R_p) \times (X(\text{integer}(R_p) + 1) - X(\text{integer}(R_p))) \quad \dots D4$$

Where $\text{integer}(R_p)$ is the function that rounds down to the nearest integer and $\text{fraction}(R_p)$ is the function that gives the fractional part of a number.

D7 ASSESSING SAMPLING ERRORS

When considering the entire population of power quality measures X , a confidence interval needs to be established around X_p . The rank confidence^[2] interval as defined by the upper and lower limits around R_p is given by:

$$R_{p_lower} = R_p - z_c \sqrt{(Np + 0.5)(1 - p)} \quad \dots D5$$

$$R_{p_upper} = R_p + z_c \sqrt{(Np + 0.5)(1 - p)} \quad \dots D6$$

Where z_c is the number of standard deviations associated with the required confidence level. Table D2 provides commonly used values of z_c .