THE FORTISALBERTA POWER QUALITY SPECIFICATION

Table of Contents

1 Introduction

This document is intended for existing/new Customers with Fluctuating Loads, Distortion Emitting Loads and/or Distortion Sinking Devices (see Section 9 Definition of Terms) that are or will be connected to FortisAlberta's System. As per Section 5.2.4 of FortisAlberta Terms & Conditions, the defined limits, requirements, and responsibilities in this document are intended to ensure Customers do not cause undue interference with any other Facilities' connected physically or electromagnetically to FortisAlberta's Electric Distribution System.

This document will establish the Power Quality limits, requirements and responsibilities for load fluctuations, distortion emission and distortion sinking at the point of common coupling (PCC) and within the FortisAlberta system. It will specifically define the following items:

1. The procedures by which facilities will be added to the FortisAlberta distribution system in order to ensure most distortion and interference problems are avoided.

2. The FortisAlberta Customer Distorting Facility Acceptance Limits and/or FortisAlberta Customer Distortion and Interference Limits which must be adhered to by all Customers to prevent harmful distortion levels on the FortisAlberta Distribution System.

3. The FortisAlberta Customer Interharmonic Limits & Requirements which must be adhered to by all Customers in order to protect the Automated Meter Reading Signals on the FortisAlberta Distribution System.

4. FortisAlberta Distortion Limits which FortisAlberta endeavors to maintain.

5. FortisAlberta Customer Fluctuating Load Limits which must be adhered to by all Customers in order to prevent harmful voltage flicker and rapid voltage change on the FortisAlberta Distribution System.

6. The Responsibilities for Mitigation of FortisAlberta and its Customers when Customer facilities or the FortisAlberta distribution system do not meet the above points 2 through 5.

2 New/Upgraded Service Power Quality Evaluation

2.1 Introduction to the Process

This section outlines the procedure for the majority of Customer distorting load additions. FortisAlberta will be involved with the Customer from facility inception throughout its lifecycle. FortisAlberta will not be responsible for any Customer design engineering. FortisAlberta's involvement with respect to distortion/interference will be to ensure the Customer's facility does not exceed distortion acceptance limits or distortion and interference limits as described in Section 3 and Section 4 of this document respectively.

FortisAlberta will not evaluate the Customer's facility with regards to their interharmonics or voltage fluctuation during this New/Upgraded Service process. It shall under all circumstances remain the Customer's responsibility to adhere to the limits and requirements of Section 4, Section 5 and Section 7 at all times during the facilities' operation; see Section 8 for FortisAlberta and Customer responsibilities.

2.2 Facility Identification

Customers shall identify if they are or will be a distorting Customer by either:

1. Completing the online "*New/Upgrade Service Form",* found by going to www.fortisalberta.com / Customer Service / appropriate customer type (i.e. Oil and Gas) / New/Upgraded Service / Online New/Upgraded Service Form or Offline Excel New/Upgraded Service Form.

2. Calling FortisAlberta at 310-WIRE to set up an Open Item # for the facility. A few business days after calling 310-WIRE, a FortisAlberta New Connects Agent will call the Customer to discuss the facility in more detail.

2.3 Multi-Grounded Neutral Requirement

FortisAlberta will install a Multi-Grounded Neutral (MGN) on overhead lines feeding exclusively the Customer's load at Customer cost if that load includes 150KW or greater distorting load. This measure will provide some harmonic mitigation and reduce equipment damage by reducing temporary over voltages during line-ground faults. The Customer is responsible for notifying FortisAlberta of any 150KW or greater distorting load.

Notes: See Appendix B – [1]

2.4 Simple Evaluation: Facility Distorting Load Identification

If FortisAlberta has determined the Total Facility Load is significant, the facility will undergo at minimum a Simple Evaluation. In order to perform this, FortisAlberta will send the Customer a Quotation Package which includes:

- Proposal Letter,
- *Distorting Load Information Sheet*
- This document, titled *The FortisAlberta Power Quality Specification.*

After receiving the Quotation Package from FortisAlberta, the Customer will confirm if the Facility plan will move forward by signing the proposal letter. If the Customer will use distorting loads the "*Distorting Load Information Sheet*" must be filled out in full and returned to FortisAlberta with the proposal letter. If there is no distorting load, the Customer will indicate this by answering only the first question in the "*Distorting Load Information" Sheet* and return it with the proposal letter. It is solely the Customer's responsibility to notify FortisAlberta of distorting loads at the site.

The questions asked in the *Distorting Load Information Sheet* are required for FortisAlberta to do the Distorting Load Size and Capacitor Resonance Limits Evaluation (see Section 2.5).

2.5 Simple Evaluation: Distorting Load Size and Capacitor Resonance

If the Customer's facility uses distorting load then the FortisAlberta Customer Distorting Load Acceptance Limits (Section 3) must be met for the facility to be accepted without adhering to the FortisAlberta Customer Distortion and Interference Limits (Section 4).

Note: See Appendix B – [1]

2.6 Information Exchange for Detailed Design

If the facility was not accepted in Section 2.5, the Customer must complete a detailed distortion evaluation to ensure the facility adheres to the FortisAlberta Customer Distortion and Interference Limits (Section 4). A FortisAlberta Planner will provide the following information to enable this evaluation:

- This document, *The FortisAlberta Power Quality Specification,* which outlines FortisAlberta's:
  - Distorted Current Limit (Section 4.1)
  - Residual I*T Limit (Section 4.2)
  - Balanced I*T Limit (Section 4.2)
- FortisAlberta Short Circuit Apparent Power (S_{FSC}) at the PCC.
- At Fundamental (60Hz)
  - Customer Load Servicing Transformer information such as X/R and winding configuration
  - Positive, Negative and Zero sequence Impedances at the 25KV bus of the substation and at the Customers PCC.
- A Frequency Scan at the PCC up to the 50th harmonic.
- Additional information required by the Customer regarding the FortisAlberta distribution system

2.7 Customer Compliance Report

The Customer will assess the facility design according to FortisAlberta Customer Distortion and Interference Limits (Section 4) and make any changes as needed.

The Customer must provide a compliance report to FortisAlberta that includes:

- facility identification
- final results summarized and compared to the FortisAlberta Customer Distortion and Interference Limits (Section 4)
- final single line diagram of installation
- transformer (customer owned) ratings and impedance
- cable impedance that should be included for distortion analysis
- all non-distortion producing loads
- all distortion producing loads and their harmonic spectrums
- power factor correction capacitor and filter information, if applicable
- appendices (background info such as calculations, models, etc.)

All facilities must have a topology whereby if mitigation equipment is needed for the facility to adhere to the FortisAlberta Customer Distortion and Interference Limits (Section 4), then that mitigation equipment must operate when the distorting equipment is operating, and must cease operation when the distorting equipment is not operating.

The final compliance report should then be given to the FortisAlberta Planner for approval. By approving the Customer's compliance report, FortisAlberta is simply acknowledging that the compliance report is complete and the numbers indicated meet limits and design topology requirements. Approval does not mean that FortisAlberta is taking responsibility for report contents.

Note:

1. The facility will not be energized until the compliance report is approved by FortisAlberta.
2. Note: See Appendix B – [2]

2.8 Commissioning

When all FortisAlberta service requirements are met and the facility's compliance report has been approved, FortisAlberta will energize the Customer's service and determine the required facility commissioning process. The requirement for detailed or non-detailed commissioning will be dependent on the characteristics of the Customer Facility and the electrical environment in the area.

2.9 Non-Detailed Commissioning

FortisAlberta will energize the facility and take distortion and interference measurements once normal Customer operation has commenced (see Section 4.3).

If the facility's data show that normal operation is at or below the FortisAlberta Customer Distortion and Interference Limits (Section 4), the facility harmonic acceptance is complete.

If the facility's data show that the normal operation is above the FortisAlberta Customer Distortion and Interference Limits (Section 4), the facility may be de-energized and returned to the Customer Compliance Report Stage (Section 2.7).

Note: See Appendix B – [3], [4].

2.10 Detailed Commissioning

If detailed commissioning is needed before the Customer's facility is energized, FortisAlberta will take background measurements at or near the facility PCC. These measurements may include Voltage Unbalance, Voltage THD or Telephone Probe Wire I*T

These measurements will provide a benchmark of the distribution system, and allow FortisAlberta to identify and fix any pre-existing problems in the area.

FortisAlberta will then energize the facility and take distortion and interference measurements once normal customer operation has commenced (Section 4.3).

If the facility's data show that normal operation is at or below the FortisAlberta Customer Distortion and Interference Limits (Section 4), the facility harmonic acceptance is complete.

If the facility's data show that the normal operation is above the FortisAlberta Customer Distortion and Interference Limits (Section 4), the facility may be de-energized and returned to the Customer Compliance Report Stage (Section 2.7).

Note: See Appendix B – [3], [4].

3 FortisAlberta Customer Distorting Load Acceptance Limits

3.1 Distorting Load Size Limits

The Distorting Load Size calculation methods and limits are based upon the CAN/CSA-C61000-3-6:09 assessment criterion. Additional requirements are added to incorporate a generalized assessment of Telephone Interference.

Capacitor Resonance Limits

If the facility contains power factor correction capacitors, the facility must meet the following limits:

- $|hr - h_{CD}| > 0.35$
- $|hr - h_{ED}| > 0.10$
- $|hr - h_{TD}| > 0.15$

Where:

- hr: The calculated harmonic (h) resonance (r) point of the Customer capacitor bank.
  - $hr = \sqrt{(S_{iSC}/Q_{iC})}$
    - S_{iSC}: Short Circuit (SC) Apparent Power (S) level at the capacitor bank location in the facility (i) in KVA.
    - Q_{iC}: Total installed Reactive Power (Q) generated by the capacitors (C) and cables in the facility (i) in KVAR.
- h_{CD}: The characteristic (C) harmonics (h) of the distorting equipment (D). (i.e. 5, 7, 11, 13, 17….)
- h_{ED}: The even (E) harmonics (h) of the distorting equipment (D). (i.e. 2, 4, 6, 8, 10…..)
- h_{TD}: The triplen (T) harmonics (h) of the distorting equipment (D). (i.e. 3, 9, 15, 21, 27…)

3.2 Distorting Load Information Sheet

The Distorting Load Information Sheet incorporates these calculations and limits and will provide the Customer with a preliminary assessment of their load and resonance. FortisAlberta Planners will provide the final acceptance determination.

4 FortisAlberta Customer Distortion and Interference Limits

4.1 Current Distortion Limits

The Customer's facility PCC shall not have calculated or measured values for current distortion that exceed the limits shown in Table 4.1 if the facility does not meet any of the conditions in Section 3.

In order to properly compare a Customer's calculated total distorted load current emissions with the FortisAlberta Customer Current Distortion and Interference Limits, the Customer's design shall account for unbalance in the voltage supply of 3.0%, where unbalance is defined as,

$$\%unbalance = \frac{Highest\ deviation\ from\ the\ average\ voltage\ of\ the\ 3\ phases}{Average\ voltage\ of\ the\ 3\ phases}$$

Note: See Appendix B – [2]

Table 4.1: Distorted Current (rms) Limits

I_{iSC}/I_{iM}	$\%I_{ID}$ H<11	$\%I_{ID}$ 11≤H<17	$\%I_{ID}$ 17≤H<23	$\%I_{ID}$ 23≤H<35	$\%I_{ID}$ 35≤H	$\%I_{TDD}$
< 20*	4.0	2.0	1.5	0.6	0.3	5.0
20 to <50	7.0	3.5	2.5	1.0	0.5	8.0
50 to <100	10.0	4.5	4.0	1.5	0.7	12.0
100 to <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

*All power generation equipment is limited to these values of current distortion, regardless of actual I_{iSC}/I_{iM}

Notes:

1. Even harmonics are limited to 25% of the harmonic limits above.
2. Current distortions that result in a dc offset (i.e. half-wave converters) are not allowed.

Where:

- I_{ID}: The individual current (I) harmonic distortion (D) values at the PCC of the facility (i) as calculated or measured (see Section 4.3).
- $\%I_{ID}$: I_{ID} expressed as a percentage (%) of the maximum fundamental current component $I_{iM.}$
- $\%I_{THD}$: The root sum square of the magnitudes of individual current harmonic distortion (I_{ID}) at the PCC of the facility. The value is expressed as a percentage (%) of the maximum fundamental current component (I_{iM}).
- I_{iM}: The maximum (m) fundamental demand load current (I) for the facility (i) at the PCC in Amperes. For calculation purposes this value will equal I_i. For measurement purposes it is the maximum 15 minute demand current.
- I_i: The rated current (I) of the Customer's total facility (i) load derived from the agreed upon S_i.
- I_{iSC}: Maximum short circuit (SC) current (I) at the facilities (i) PCC in Amperes.
- H: Harmonic Order (ratio of Odd harmonic frequency to fundamental frequency) excluding non-integer harmonic orders (interharmonics), see Section 5.

4.2 Telephone Interference Limits

The Customer's facility shall not have calculated or measured I*T values that exceed the limits shown in Table 4.2.

Note: See Appendix B – [2]

Table 4.2: I*T Limits

Nominal Bus Voltage	$I*T_B$	$I*T_R$
25 kV or less	1500	100

Where:

- $I*T_B$: The product of the root sum square of $I*T_{iB}$.
- $I*T_R$: The product of the root sum square of $I*T_{iR}$.
- $I*T_{iR}$: The individual residual (R) I*T harmonic injection current from the Customer facilities (i) PCC.
  - $I*T_{iR} = (I_{iDZ} * T)$

- I^*T_{iB}: The individual balanced (B) I*T harmonic injection current from the Customer facilities (i) PCC.
  - $I^*T_{iB} = (I_{iDNP} * T)$
- I_{iDZ}: The individual harmonic current distortion values (I_{ID}) which are zero sequence (Z) from the Customer facilities (i) PCC.
- I_{iDNP}: The individual harmonic current distortion values (I_{ID}) which are negative and positive (NP) sequence from the Customer facilities (i) PCC.
- T: The Single Harmonic Current Weighting Factor (T). (Appendix A)

4.3 FortisAlberta Measurement Assessment Procedure Of Current Emissions

The following list shows how FortisAlberta will compare a Customer's measured total distorted load current emissions with the FortisAlberta Customer Current Distortion and Interference Limits (Section 4).

1. The minimum measurement period should be one week (168 hour period) during typical production load levels. Although one week is preferable, FortisAlberta reserves the right to choose the date/time and duration of the measurements.

2. Only the top 5% of the measured very-short values (r.m.s. values for individual harmonic components, I_{iD} over "very short" 3s periods) during normal operating cycles may exceed the FortisAlberta Customer Current Distortion Limits.

3. The top 1% of measured very-short values (r.m.s. values for individual harmonic components, I_{iD} over "very short" 3s periods) during normal operating cycles shall not exceed 1.5 times the FortisAlberta Customer Current Distortion Limits.

4. The maximum very-short value (r.m.s. values for individual harmonic components, I_{iD} over "very short" 3s periods) during normal operating cycles shall not exceed 2 times the FortisAlberta Customer Current Distortion Limits.

5. The maximum short value (r.m.s. value of individual harmonics components, I_{iD} over "short" 10 min periods) should not exceed the FortisAlberta Customer Current Distortion Limits.

5 FortisAlberta Customer Interharmonic Limits & Requirements

5.1 Emission Limits

The Customer shall normally maintain the normal maximum interharmonic voltage distortion (at the PCC) limits listed in Table 5.1, which are the "worst case" for normal operation.

Table 5.1: Normal Maximum Interharmonic Voltage Distortion Limits at the PCC

Interharmonic	$\%E_{IIHD}$
< 180Hz	0.2
>180Hz to <540Hz	0.2
>540 to <600Hz*	**0.025**
>600Hz to <960Hz	0.2
>960Hz to <1140Hz*	**0.025**
>1140Hz to 2,500Hz	0.5
2,500Hz to <3,000Hz	0.3

* Automated Meter Reading Signal Bandwidths

Where:

- E_{IIHD}: The normal maximum individual interharmonic (IH) voltage (E) distortion (D) values at the PCC of the facility (i) expressed in Volts.
- $\%E_{IIHD}$: The E_{IIHD} expressed as a percentage (%) of the nominal fundamental frequency voltage.

5.2 Sink Requirements

Sinking of all interharmonic frequencies from the FortisAlberta Distribution System is allowed EXCEPT for the signal frequencies used by the FortisAlberta Automated Meter Reading System. Normally sinking of the FortisAlberta Automated Meter Reading Signals will occur when a Customer's capacitive device reacts with the impedance of the FortisAlberta distribution network in such a way as to cause a significant low impedance path at or near the 540Hz-600Hz, and 960Hz-1140Hz frequency bandwidths. Due to the many variables which must be taken into account, it is not appropriate to define limits or capacitive device characteristics that Customers must meet to prevent the Customer's facility from sinking the Automated Meter Reading Signal in a negative way.

If FortisAlberta has determined a Customer facility is sinking the Automated Meter Reading Signal it is the Customers responsibility to disconnect their capacitive device from the service or modify it in such a way as to effectively correct the problem as per Section 8.

6 FortisAlberta Distortion Limits

6.1 System Harmonic Voltage Distortion

FortisAlberta shall normally maintain the normal maximum harmonic voltage distortion (at the PCC) limits listed in Table 6.1, which are the "worst case" for normal operation (conditions lasting longer than one hour). For shorter periods, during start-ups or unusual conditions, the limits may be exceeded by up to 50%.

Table 6.1: Normal Maximum System Harmonic Voltage Distortion at the PCC

Nominal Bus Voltage	$\%E_{ID}$	$\%\ E_{THD}$
25 kV or less	3.0	5.0

Where:

- E_{ID}: The normal maximum individual harmonic voltage (E) distortion (D) values at the PCC of the facility (i) expressed in Volts.
- $\%E_{ID}$: The E_{ID} expressed as a percentage (%) of the nominal fundamental frequency voltage.
- $\%\ E_{THD}$: The total harmonic distortion (THD) voltage (E) at the PCC of the facility, which is the root sum square of the E_{ID} at the PCC of the facility. The value is expressed as a percentage (%) of the nominal fundamental voltage.

7 FortisAlberta Customer Fluctuating Load Requirements

7.1 Introduction

This section outlines the technical requirements for connecting fluctuating loads to the distribution system of FortisAlberta. These requirements are intended to control the phenomena of flicker and rapid voltage changes.

The phenomena of flicker and rapid voltage changes are very similar:

- Flicker is caused by load creating periodic fluctuations in voltage. Flicker quantifies the physiological disturbance caused by fluctuations of light produced by an incandescent lamp powered by a fluctuating voltage. At certain frequencies, fluctuations cause physical and mental fatigue for people exposed to light variations. The phenomenon usually is caused by operation of disturbing loads such as large arc furnaces, welding machines, motors at variable loads, a group of elevators, etc.
- Rapid voltage changes is caused by load creating dynamic fluctuations in voltage. These voltage fluctuations could be over several cycles and could also be in the form of cyclic changes. This phenomenon is usually caused by start-ups, inrush currents or switching operation of equipment.

It is the Customer's responsibility to ensure its' load does not introduce voltage fluctuations beyond limits specified in this document. FortisAlberta will supply all required system related information in order for the Customer to determine compliance. To request system information, please send an e-mail to power.quality@fortisalberta.com.

7.2 Flicker

7.2.1 The Measure of Flicker Severity

Flicker severity is measured in two quantities: perception of flicker in the short-term (P_{st}) and perception of flicker in the long term (P_{lt}). P_{st} is the standard output of a flickermeter which is measured over 10 minute intervals, and P_{lt} is derived from 12 consecutive values of P_{st} (obtained over 2 hour intervals) using the following formula:

$$P_{lt} = \sqrt[3]{\frac{1}{12} \cdot \sum_{j=1}^{12} P_{st_j}^{3}}$$

P_{lt} shall be calculated every ten minutes using a sliding window where the oldest P_{st} value is replaced by the newest P_{st} value at each 10 minute interval.

7.2.2 Customer Simplified Flicker Evaluation

The connection of small loads, relative to the overall system will not need to go through a detailed evaluation. To determine if a detailed evaluation is needed, the following simple evaluation is used which relates the maximum apparent power of the load to the short circuit power available at the PCC. If variations in the power consumption of the Customer's equipment are relatively low compared to the available short circuit power at the PCC (see Table 7.2.2), it is unnecessary to continue with further flicker analysis.

Table 7.2.2: Limits for Automatic Acceptance

Changes per minute	ΔV%
< 10	0.4 %
10 to 200	0.2 %
> 200	0.1 %

Where:

- $\Delta V\% = S_{max} / S_{sc} \cdot 100$
- S_{max} the maximum apparent power (MVA) of the load new load
  - For induction motors, S_{max} is typically 6X to 8X rated horsepower
  - For induction furnaces, S_{max} is typically 2X to 4X rated MVA.
- S_{sc} the short circuit power (MVA) available at the PCC supplied by FortisAlberta to the Customer upon request.

If the Customer fails this evaluation, the Customer should either 1) re-design their system so that it will pass the automatic acceptance test or 2) perform the flicker emission level evaluation as specified in Section 7.2.3 and *CAN/CSA-C61000-3-7* "Limits - Assessment of Emission Limits for the Connection of Fluctuating Installations to MV, HV and EHV Power Systems".

7.2.3 Customer Detailed Flicker Evaluation

FortisAlberta will supply the Customer with necessary system information upon request such as the short-circuit power (MVA) and line impedance (Z = r+jx pu) at the PCC. This information is only valid at the time of request, and is subject to change due to potential system work.

7.2.3.1 Global Emission Limits

It is assumed that when determining the global emission limits, that there is no flicker on the high voltage grid, and therefore:

- The flicker transfer coefficient of short-term and long-term high voltage to medium voltage network is equal to 0.
- The planning level short-term and long-term flicker for the high voltage grid is equal to 0.

With the above assumptions the planning level short-term (P_{st}) and long-term (P_{lt}) flicker for the FortisAlberta network (medium voltage) is equal to the overall global contribution of flicker in the short-term (G_{Pst}) and long-term (G_{Plt}) for the FortisAlberta (medium voltage) network (see values in Table 7.2.3.1).

Table 7.2.3.1: Flicker Global/Planning Emission Limits

Customer Emission Limits	
P_{st}	0.9
P_{lt}	0.7

It is the customer's responsibility to ensure that their design meets the emission limits and have reasonable margin to accommodate future changes. Post-connection measurements will be taken to check compliance.

7.2.3.2 Calculating Customer Flicker Emission Limits

The calculation of emission limits is to determine the individual portion of the overall contribution (G_{Pst}, G_{Plt}) to be allocated to the Customer.

$$E_{Psti} = G_{Pst} \cdot \sqrt[3]{\frac{S_i}{(S_t - S_{LV})}}$$

$$E_{Plti} = G_{Plt} \cdot \sqrt[3]{\frac{S_i}{(S_t - S_{LV})}}$$

where:

- E_{Psti}, E_{Plti}: the flicker emission limits for the customer's install i directly supplied at FortisAlberta's network.
- G_{Pst}, G_{Plt}: the maximum global contributions to the flicker levels of all the fluctuating installations that can be connected to the considered system.
- S_i : the agreed power the Customer's installation i, or the MVA rating of the considered fluctuating installation (either load or generation)
- S_t : the total supply capacity of the system.
- S_{LV} : the total power of the installations supplied directly at the low voltage level.

7.2.3.3 Calculating Customer Flicker Emission Levels

The Customer must determine the level of flicker emission at the PCC for its main fluctuating loads (present and future). This forecast must be performed for maximum operating conditions (in terms of flicker) during normal operating conditions.

For details on how to perform an emission level evaluation, please follow *CAN/CSA-C61000-3-7* "Limits - Assessment of Emission Limits for the Connection of Fluctuating Installations to MV, HV and EHV Power Systems".

7.2.4 Flicker Measurements

FortisAlberta, at its discretion, may perform a post installation flicker measurement to ensure compliance with flicker emission limits.

The minimum measurement period is 1 week (a total of 1008 P_{st} values) and Customer equipment shall be in normal operating conditions without extended periods of stoppage. Voltage change due to transient events such as lightning strike or faults shall be excluded from the data.

For short-term (P_{st}) and long-term (P_{lt}) flicker values measured at the PCC over a week, 95% of those values must not exceed the emission limits calculated in section

7.2.3.2. However, 99% of the weeks short-term (P_{st}) must not exceed the emission limit by a factor greater than 1.5.

7.3 Rapid Voltage Change

Rapid Voltage Change is defined as dynamic voltage fluctuations, which is caused by equipment in non-steady state operation such as the starting and stopping of motors, energization of transformers, etc.

7.3.1 Rapid Voltage Change Limits

The Customer must assess the extent and rate of repetition of the rapid voltage changes produced at the PCC. The formula in Section 7.2.2 or any other more precise formula can be used in order to calculate equipment compliance with the rapid voltage change limits in Table 7.3.1.

Table 7.3.1: Allowable Rapid Voltage Change Limits

Maximum Number of Changes	Voltage Change (%)
≤ 4 per day	5%
> 4 per day to ≤ 2 per hour	4%
> 2 per hour	3%

7.3.2 Rapid Voltage Change Measurements

FortisAlberta, at its discretion, may perform a post installation rapid voltage change measurement to ensure compliance with rapid voltage change limits.

The minimum testing period is one week of normal business activity and should include the period of expected maximum rapid voltage change levels. Transients will be removed from the data and the worst case of rapid voltage changes is considered when assessing the emission level (no percentile compliance). The maximum rapid voltage change shall be calculated by subtracting the minimum RMS voltage from the steady-state pre-voltage:

$$\%\text{voltage change} = \frac{U_1 - U_2}{U_1} \times 100\%$$

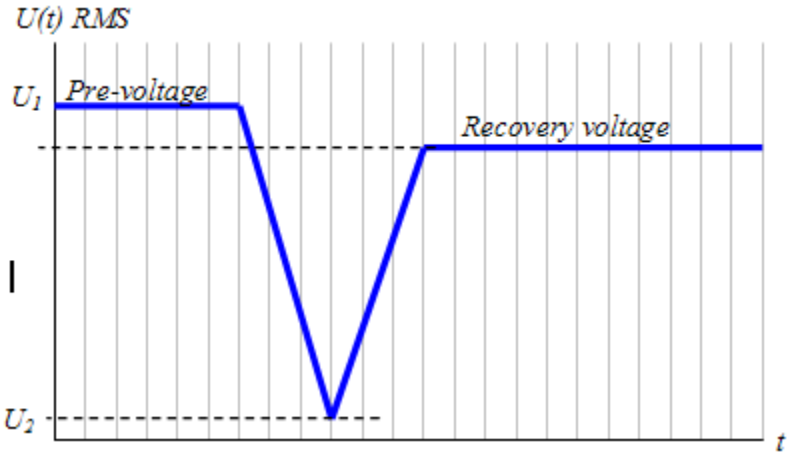

Figure 7.3.2: RMS voltage profile of a dynamic voltage fluctuation.

8 Responsibilities for Mitigation

8.1 Customer Responsibility

1. Obligation to Help in the Investigation

If FortisAlberta determines the Customer's equipment may be the source of unacceptable Power Quality on FortisAlberta's distribution system, the Customer must provide FortisAlberta within 48hrs:

- Required up-to-date facility information which includes:
  - final single line diagram of the facility
  - transformer ratings and impedance
  - cable impedance that should be included for distortion analysis
  - all non-distortion producing loads
  - all distortion producing loads and their harmonic spectrums
  - power factor correction capacitor and filter information, if applicable
- Necessary access for monitoring equipment.

2. Timely Correction of Deficiencies

If undesirable Power Quality on the FortisAlberta distribution system is being caused by the Customer's facility not adhering to the requirements in Section 3 or Section 4, Section 5 and Section 7, the Customer will be required to cease operation of the offending equipment until satisfactory corrective action has been taken by the Customer at the Customer's cost. If the Customer does not take such action within a time frame considered reasonable by FortisAlberta, FortisAlberta may disconnect the supply of energy to the Customer or purchase and install mitigation equipment at Customer cost.

Note: Once FortisAlberta has determined the Customer is not adhering to the requirements in Section 5 and causing a negative impact on the Automated Meter Reading Signal a Notification of Disconnection will be immediately issued to the Customer giving the Customer 48hrs to correct the problem.

Note: FortisAlberta Inc. will enforce all disconnections as per part (b) of section 10.3.2 of the "FortisAlberta Inc. Customer Terms and Conditions of Distribution Access Service"

Note: See Appendix B – [3], [4].

3. Dynamic Mitigation Strategies

Due to the dynamic nature of the FortisAlberta distribution system, the system impedance envelope may change in a negative way such that the Customers service connection or distribution access service begin to be in violation of the requirements listed in this document, "*The FortisAlberta Inc. Power Quality Specification*". In such a case, the Customer will be responsible for resolving the new Power Quality issues at the PCC.

The Customer is encouraged to develop mitigation strategies independent of system changes to avoid this risk.

4. Maintaining Facility Distortion Mitigation

All facilities must maintain a facility configuration whereby if mitigation equipment is needed for the facility to meet the requirements stipulated in this document, then that mitigation equipment must be in working order and operating at all times while the offending equipment is operating. It must also cease operation when the offending equipment is not operating. If the Customer's facility configuration changes it is the responsibility of the Customer to provide documentation of this change to FortisAlberta.

8.2 FortisAlberta Responsibility

1. Diagnostic Investigations

FortisAlberta will conduct diagnostic investigations in reaction to complaints. The investigations will seek to determine the source of the Power Quality problem.

2. Limiting Distortion Levels on the FortisAlberta Distribution System

For new connections, FortisAlberta will be involved in the facility from its inception to ensure that it will meet the FortisAlberta Customer Distorting Facility Acceptance Limits (Section 3) or FortisAlberta Customer Distortion and Interference Limits (Section 4). FortisAlberta will also monitor after energization to make sure the FortisAlberta Customer Interharmonic Limits & Requirements (Section 5) and the FortisAlberta Customer Fluctuating Load

Limits (Section 7). If any of these limits or requirements are not met, FortisAlberta has the right to deny electricity service.

When all Customers have met all limits and requirements but Power Quality problems still remain on FortisAlberta's distribution system, FortisAlberta is responsible for the Power Quality problems.

9 Definition of Terms

Balanced I*T: An I*T value of the positive and negative sequence currents per phase. (See Telephone Interference for a definition of I*T)

Distortion Emitting Loads: Loads which produce harmonics and/or interharmonics. These include power electronic equipment (drives, inverters, rectifiers, computers, etc); and arcing devices (fluorescent lighting, welders, arc furnaces, etc).

Distortion Sinking Devices: includes capacitive devices (filters and capacitors)

Flicker (or light flicker): refers to the phenomenon of variable light production from lamps as a result of voltage fluctuation, which can be a nuisance to observers. Its severity depends on several factors including the magnitude, rate, and shape of voltage fluctuation, the type of lamp, and the human response to flickering light.

Fluctuating Loads: includes arc furnaces and welders; installations with frequent motor starts (air conditioner units, fans, elevators); motor drives with cyclic operation (mine hoists, rolling mills); equipment with excessive motor speed changes(wood chippers, car shredders); motors that use motor jogging and jamming or have variable loads

Fundamental Component: The current or voltage value with a frequency of 60Hz.

Line I*T: A measurement method for I*T levels. Harmonic currents are measured directly off the power line and through a series of calculations I*T levels can be determined. This is the normal measurement method for I*T levels at the PCC.

Point of Common Coupling (PCC)*:* The PCC is defined as the FortisAlberta point closest to the Customer that is also common to other FortisAlberta Customers. Normally, the primary terminals of the Customer supply transformer would be the PCC; however, this may be subject to change depending on the situation. In all situations, FortisAlberta shall identify the PCC.

Probe-Wire I*T: A measurement method for I*T levels. A wire, grounded on both ends, is placed on the ground under and parallel to an overhead power line. This wire is used to get measurements of the induced voltage from the magnetic field produced by harmonic currents flowing in the above overhead power line. From the

induced harmonic voltage on the probe wire, the harmonic currents in the power line can be determined. This is the normal method for measuring I*T levels for primary distribution power lines.

Residual I*T: An I*T value of the zero sequence or neutral (ground return) current.

Telephone Interference (I*T): The I*T is the product of the root sum square of the rms current (I) and the Telephone Influence Weighting Factor of the current waveform (T), see Appendix A.

Total Harmonic Distortion (THD): The total harmonic distortion of a waveform is the root sum square of the magnitudes of each individual harmonic/interharmonic distortion, divided by the magnitude of the fundamental frequency. The value of THD is usually expressed in both voltage and current as a percentage of the fundamental component.

$$\textbf{THD (voltage)} = \frac{\sqrt{(V_2^2 + V_3^2 + \ldots + V_n^2)}}{V_1} \text{ , } \textbf{THD (current)} = \frac{\sqrt{(I_2^2 + I_3^2 + \ldots + I_n^2)}}{I_1}$$

10 Reference Documents

1. IEEE 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control*.

2. CAN/CSA-C61000-3-6:09, *Electromagnetic Compatibility (EMC) Part 3-6: Limits – Assessment of Emission Limits for the Connection of Distorting Installations to MV, HV and EHV Power Systems.*

3. CAN/CSA-C22.3 No.3-98 Reaffirmed 2007, *Electrical Coordination*

4. IEEE 776-1992, *IEEE Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines.*

5. ATCO Electric: June 13, 2005, *System Standard for the Installation of New Loads.*

6. Manitoba Hydro: January 2005*, Power Quality Specification for Interconnection to Manitoba Hydro's Electrical System*

7. TransAlta Utilities, May 1998, *Understanding and Solving Audible Telephone Noise Problems Induced by Power Line Harmonic Currents*.

8. CAN/CSA C61000-3-7: 09, *Electromagnetic Compatibility (EMC) Part 3-7: Limits - Assessment of emission limits for fluctuating loads in MV and HV Power Systems – Basic EMC publication*

9. IEC 61000-4-15: 2003, *Electromagnetic Compatibility (EMC) Part 4-15: Testing and Measurement Techniques – Flickermeter – Functional and design specifications*

10. IEEE Std 1453-2004, *IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems*

11. CAN/CSA-C61000-3-7: 2008, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 7: Assessment of emission limits for fluctuating loads in MV and HV Power Systems – Basic EMC publication*

APPENDIX A

Single Harmonic Weighting Factors

Harmonic	Frequency	Weighing	Sequence	Harmonic	Frequency	Weighing	Sequence	Harmonic	Frequency	Weighing	Sequence
1	60	0.5	POS	23	1380	6370	NEG	45	2700	10480	ZERO
2	120	10	NEG	24	1440	6650	ZERO	46	2760	10350	POS
3	180	30	ZERO	25	1500	6680	POS	47	2820	10210	NEG
4	240	105	POS	26	1560	6790	NEG	48	2880	9960	ZERO
5	300	225	NEG	27	1620	6970	ZERO	49	2940	9820	POS
6	360	400	ZERO	28	1680	7060	POS	50	3000	9670	NEG
7	420	650	POS	29	1740	7320	NEG	51	3060	9230	ZERO
8	480	950	NEG	30	1800	7570	ZERO	52	3120	8880	POS
9	540	1320	ZERO	31	1860	7820	POS	53	3180	8740	NEG
10	600	1790	POS	32	1920	8070	NEG	54	3240	8410	ZERO
11	660	2260	NEG	33	1980	8330	ZERO	55	3300	8090	POS
12	720	2760	ZERO	34	2040	8580	POS	56	3360	7680	NEG
13	780	3360	POS	35	2100	8830	NEG	57	3420	7470	ZERO
14	840	3830	NEG	36	2160	9080	ZERO	58	3480	7080	POS
15	900	4350	ZERO	37	2220	9330	POS	59	3540	6730	NEG
16	960	4690	POS	38	2280	9590	NEG	60	3600	6460	ZERO
17	1020	5100	NEG	39	2340	9840	ZERO	61	3660	6130	POS
18	1080	5400	ZERO	40	2400	10090	POS	62	3720	5620	NEG
19	1140	5630	POS	41	2460	10340	NEG	63	3780	5080	ZERO
20	1200	5860	NEG	42	2520	10480	ZERO	64	3840	4610	POS
21	1260	6050	ZERO	43	2580	10600	POS	65	3900	4400	NEG
22	1320	6230	POS	44	2640	10610	NEG	66	3960	3960	ZERO

Referenced from the **IEEE 519-1992 and the** Canadian Electrical Association**.**

Note: If the non-linear three phase equipment has no neutral connection, the harmonics (3rd, 9th, 15th, etc.) shown to be zero sequence in the above table, are then assumed to be positive or negative sequence only. For non-linear phase to neutral connected equipment the harmonics (3rd, 9th, 15th, etc.) are correctly labeled as zero sequence in the above table.

APPENDIX B

Notes

[1] Due to the fact that harmonic emissions from distorting Customers have the potential to adversely affect other facilities parallel to the supply power lines, FortisAlberta will attempt to gain needed third party stakeholder approval for the service. If this approval is not obtained, further evaluation and/or mitigation may be required.

[2] FortisAlberta will measure harmonic current to the 63rd harmonic during commissioning.

[3] Under special circumstances, a Customer may be allowed to temporarily emit disturbances beyond the FortisAlberta Current Distortion Limits, if the power and telephone systems are capable of absorbing the harmonics without an adverse result. This will be determined through the conditions described below.

a. Where the measurements on telephone lines parallel to the feeder that serves the Customer's facility are below the maximum acceptable level to the telephone provider.

b. Where the measured voltage distortion at the Customer facility PCC meets the limits in Section 6.0.

c. Where the Automated Meter Reading Signal is unaffected by the disturbance.

[4] If note [3] conditions are met the Customer will be given a Notice of Temporary Energization.