Distributed Generation Technical Interconnection Requirements

Addendum

Distribution Voltage Performance Criteria and Requirements

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Presentation Overview

1. Introduction
2. Experience with Long Feeders
3. Purpose of Addendum
4. An Important Existing Technical Interconnection Requirement (TIR) on Voltage
5. Proposed Modification
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Introduction

- Based on experience with the connection of Distributed Generators (DGs) on long feeders, Hydro One became aware of numerous voltage performance issues
- Substantiated by field measurements
- Traditional limits (400A rule) proved insufficient
- New requirements identified and proposed in this addendum are distance from PCC to the station bus, feeder X/R ratio, supply station strength and power output

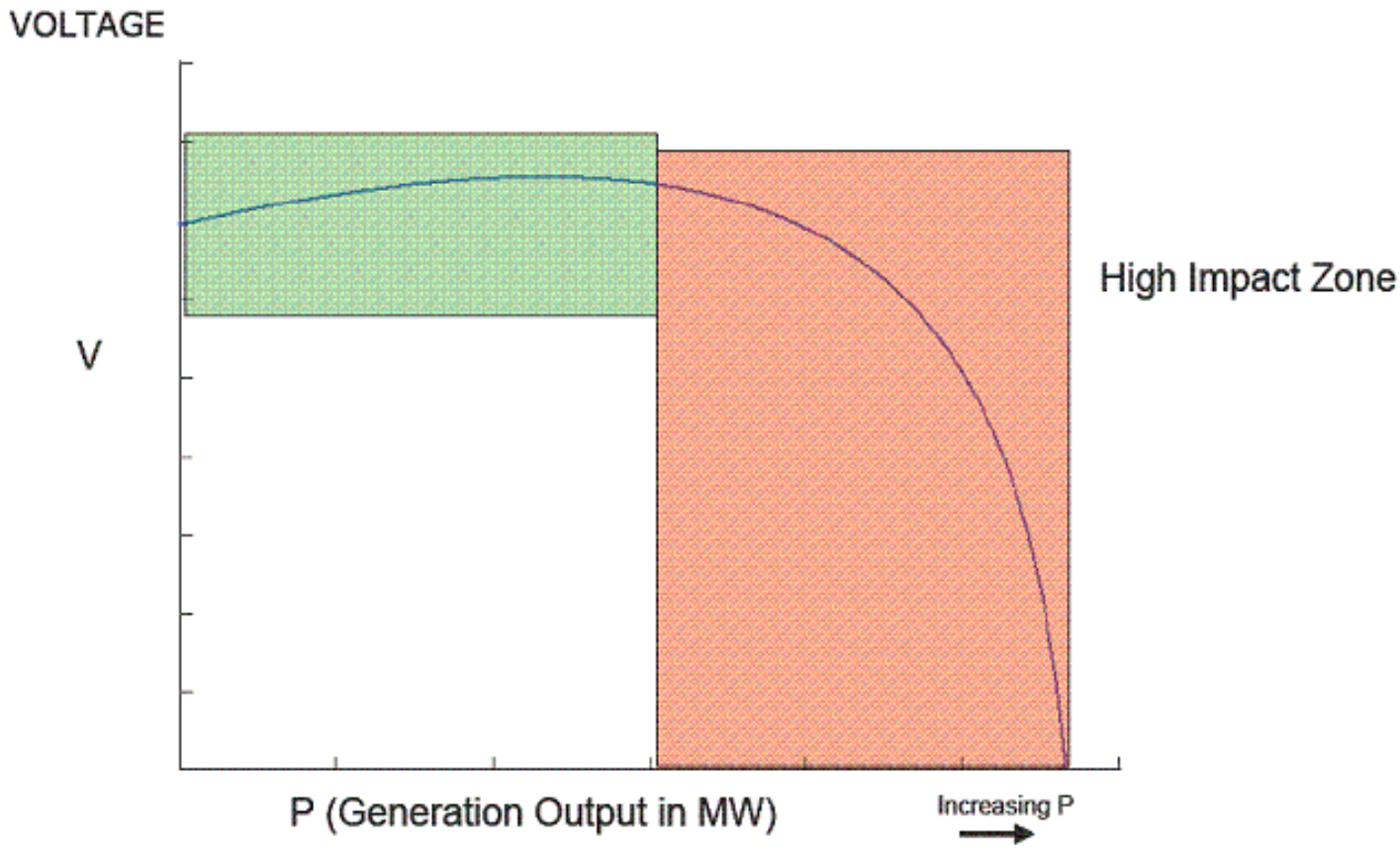
Experience with Long Feeders

- A system with long, rural feeders, such as Hydro One's distribution system, is much more susceptible to voltage swings that result from variable power injection from generators
- As the distance of the connection point from the station increases, voltage becomes more sensitive to changes in injected power
- Large generators far from the station have a significant impact on voltage levels in the vicinity of the connection as their power injection fluctuates

Experience with Long Feeders *(cont'd)*

- Experience has shown that changes in voltage (both voltage rise and voltage fall) can occur and impact customers
- This is further aggravated when the connected generation is large, the output is variable and the electrical system strength is weak

Experience with Long Feeders Voltage-Power Profile



Purpose of Addendum

- Add to and supplement §2.2.2.1 of the existing TIR including additional requirements for:
  - Acceptable voltage levels at the Point of Common Coupling (PCC)
  - Acceptable voltage variation anywhere on the feeder or at the supply station low-voltage bus
  - Acceptable voltages on the Hydro One distribution and transmission system, immediately after sudden tripping of DGs

Existing TIR Requirement Criterion 1

- DGs shall not actively regulate their Point of Common Coupling (PCC) voltages. (Clause 2.2.2.1, iii, Page 66 of existing TIR)
- DG active voltage regulation means the DG will continuously monitor the feeder voltage and respond to it by automatically adjusting its reactive power to control the feeder voltage within a desired range.

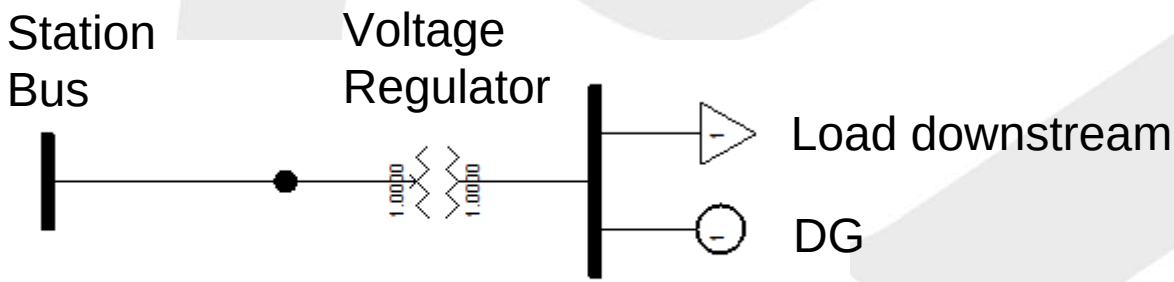
Existing TIR Requirement Criterion 1 *(cont'd)*

Technical Basis

- DG active voltage control interferes with existing voltage regulating facilities, causing unacceptable post-contingency voltage if DGs trip. (Scenario 1)
- DG active voltage control of one location may aggravate voltage fluctuation at other locations. (Scenario 2)

Existing TIR Requirement Criterion 1 *(cont'd)*

Scenario 1 - DG voltage control interferes with VR



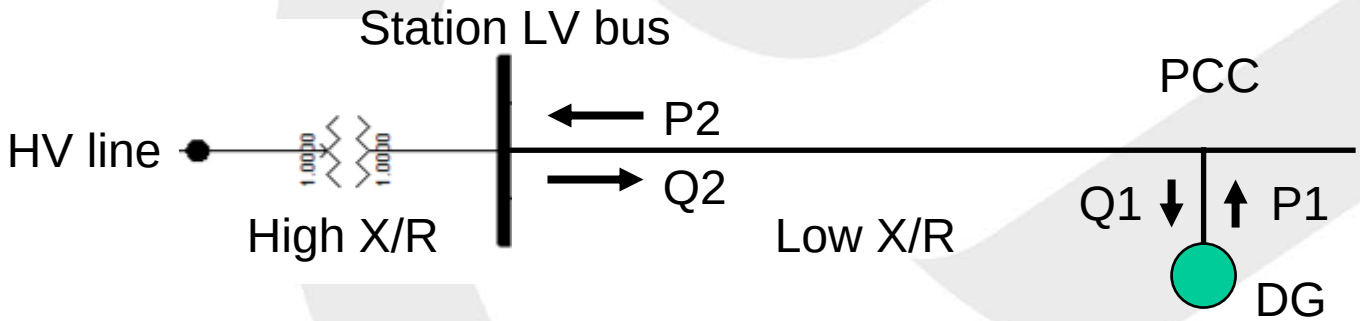
Load voltage controlled by the DG.

The voltage regulator does not respond to load correctly.

Load voltage uncontrolled immediately after the DG trips.

Existing TIR Requirement Criterion 1 *(cont'd)*

Scenario 2 – DG voltage control aggravates fluctuation



DG aggressively varies Q1 to control PCC voltage as P1 fluctuating.

As result, Q2 fluctuation at station LV bus is aggravated.

Station LV bus voltage is sensitive to Q2 fluctuation.

Proposed Modification Criterion 2

- PCC voltage shall be maintained within 0.94 ~1.06 p.u. and shall not be lower than pre-connection voltage
- Existing TIR does not define a PCC voltage constraint with respect to pre-connection voltage.
- The proposed modification is to ensure the feeder voltages are within the CSA requirement of 0.94 to 1.06 p.u. over the full range of DG operation.

Proposed Modification Criterion 2 *(cont'd)*

Technical basis

- Hydro One primary feeders supply step-down transformers that may not have under-load tap changers.
- Even if primary feeder voltages are well above 0.94 p.u., voltages of feeder circuits supplied by those step-down transformers may well be approaching 0.94 p.u.

Proposed Modification Criterion 3

- At the feeder level, the DG shall not contribute to short-term voltage fluctuation anywhere on the feeder by more than 1%
- This addresses customer complaints due to short-term voltage fluctuation and prevents frequent operations of voltage regulating tap changers
- Also enables Hydro One to accommodate higher level of DG connection to a station

Proposed Modification Criterion 3 *(cont'd)*

Technical basis

- Short term voltage fluctuation due to load variation is well below 1%. Hydro One has received complaints of short-term voltage fluctuation due to DGs.
- The dead-band of existing Hydro One voltage regulating facilities is about 2%. We choose half of the dead-band intended to mitigate the risk of frequent operation of voltage regulating facilities.

Proposed Modification Criterion 3 *(cont'd)*

Technical basis

- DGs that violate the criterion typically absorb more reactive power per MW as compared to the DGs that comply with the criterion.
- However, reactive power consumption attributed to DGs is limited by the post-contingency voltage performance requirement (see Criterion 5).
- Therefore, if DGs conform to the proposed criterion, a station can accommodate more DGs.

Proposed Modification Criterion 4

- At the station level, all DGs connected to the TS/DS shall not collectively contribute to short term voltage fluctuation at the station LV bus by more than 1%
- The rationale for the criterion is similar to those for Criterion 3 – to address customer complaints due to short-term voltage fluctuation and to prevent frequent operations of station under load tap changers.

Proposed Modification Criterion 5

- Tripping of all DGs connected to the station shall not cause abrupt voltage change to result in a voltage above 110% of nominal bus voltage, or less than 90% of nominal bus voltage, after a single contingency and before the station Under Load Tap Changer (ULTC)/feeder Voltage Regulator (VR) operates
- This is a post-contingency voltage performance criterion.

Proposed Modification Criterion 5 *(cont'd)*

Technical basis

- Post-contingency voltage limit is consistent with the existing TIR
- The voltage limit takes into account IEC standard, the IESO SIA criteria and is also consistent with the Information Technology Industry Council (ITIC) curve for supply to sensitive equipment
- DGs ride-through capability has not been required

Proposed Modification Criterion 5 *(cont'd)*

Technical Implication

- Net change in reactive power consumption from the system due to DG tripping should be minimized to prevent excessive voltage change before regulating facilities can react

Follow up Webinar

- Hydro One will hold a second webinar on this topic
- Topics for next webinar will include:
  - Brief review of long feeder issues
  - Review of Hydro One TIR addendum on voltage criteria

Questions?

We will answer questions only on today's Webinar - Distribution Voltage Performance Criteria and Requirements

For questions outside of the scope of the Webinar, please contact your local Hydro One Account Executive or email your question to DGConnectionReq@HydroOne.com

Feedback Process

- Additional questions and/or feedback regarding the addendum will be accepted for a period of one week
- Please use the following e-mail address to communicate your comments

DGConnectionReq@HydroOne.com