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## Market Rule Amendment Proposal

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### PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00359-R00		
Subject:	Generation Facility Requirements		
Title:	Changes to Facilitate Connections		
Nature of Proposal:	<input checked="" type="checkbox"/> Alteration	<input type="checkbox"/> Deletion	<input type="checkbox"/> Addition
Chapter:	4	Appendix:	4.2
Sections:			
Sub-sections proposed for amending:			

### PART 2 – PROPOSAL HISTORY

Version	Reason for Issuing	Version Date
1.0	Draft for Technical Panel Review	November 20, 2009
2.0	Publish for Stakeholder Review and Comment	November 26, 2009
Approved Amendment Publication Date:		
Approved Amendment Effective Date:		

### PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IESO-administered markets* if the amendment is not made.
- Alternative solutions considered.
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IESO-administered markets*.

#### Summary

This amendment proposes changes to simplify and clarify generator technical requirements in order to:

- Facilitate the integration of embedded generation;
- Improve the administrative efficiency of the market entry process;
- Improve the IESO's effectiveness in assessing proposed connections.

#### Background

Refer to amendment submission MR-00359-Q00 for further details.

#### Discussion

##### Facilitating the Integration of Embedded Generation

Under the existing market rules, almost all of the requirements listed in Chapter 4, Appendix 4.2 apply to embedded generation facilities with net output greater than 50 MVA and embedded generation units rated at 10 MVA or higher. It is proposed to simplify the requirements for these facilities by removing all but three requirements.

To make it easier for embedded generators to know their facility requirements under the market rules, it is proposed to move the three remaining applicable provisions to the beginning of Appendix 4.2. These three requirements also represent a subset of the requirements that apply to generation facilities directly connected to the IESO-controlled grid.

The introductory paragraph in Appendix 4.2 indicates that each generation facility must comply with requirements in the appendix (with a few exceptions). As a result of the proposed changes, it's no longer appropriate that the proposed version of Appendix 4.2 apply to existing facilities. Rather, Appendix 4.2 would apply to new installations or to existing generation facilities when equipment is replaced. An existing generator would be required to meet and maintain, as a minimum, the standard that was in effect at the time of registration. If a generator replaces equipment or significantly modifies a piece of equipment, the generator would have to meet the standard in effect at the time of the replacement. That new standard could be higher or lower. An existing generator could take advantage of a lower standard, even if they weren't replacing or modifying equipment, by submitting a new connection assessment (in accordance with Chapter 4, section 6).

##### Improving the Market Entry Process and the IESO's Effectiveness in Assessing Proposed Connections

The proposed changes to generation facility requirements would afford greater clarity through measurable performance requirements and added flexibility to allow emerging technologies to be evaluated on a fair basis. Experience has shown that more clarity is needed in some areas to make the

**PART 3 – EXPLANATION FOR PROPOSED AMENDMENT**

connection assessment process more efficient.

To further simplify Appendix 4.2, it is proposed to re-organize the contents (through an entire re-write). These changes are tracked in the attached Table of Concordance and the existing appendix is attached for reference. The following amendments are proposed to the requirements for generation facilities directly connected to the IESO controlled grid:

- Speed/Frequency Regulation: Extend the requirements to all generation types and add measureable requirements for governor performance.
- Active power: Editorial change for clarification.
- Reactive power: Simplify the requirement by removing the references to leading and lagging power factor. The existing provision requires more capability to withdraw than to provide reactive power to the transmission system whereas a balanced injection and withdrawal reactive requirement is more appropriate. The requirement to provide the entire required range of reactive power for a transmission voltage has been re-expressed in an updated form to match the reactive power range change. The provision regarding continuously available reactive capability is intended to give the IESO latitude to accept less complex and costly connection arrangements that have suitable reliability advantages.
- Voltage regulation: Add a capability requirement for droop systems consistent with present requirement for non-droop systems.
- Excitation System: Remove requirements for distribution connected generation. Clarify voltage response time requirements apply to both positive and negative ceilings. Add performance requirements for high exciter load conditions. The 50.13 reference should be checked to ensure it is still applicable with the latest revision ANSI standard.
- Stabilizer: Add measurable requirements to provide better guidance and specify the type of stabilizer ( $\Delta P\omega$ ) to avoid less stable designs.
- Phase unbalance: Add a measurement location to avoid too onerous a restriction.
- Protection systems and limiters: Make explicit that protection systems and limiters must not unduly restrict equipment capability.
- Performance characteristics: Add a requirement for performance to be consistent with an equivalent synchronous machine with characteristic parameters within typical ranges. Experience has shown generation proponents are being driven towards lower cost options with characteristics that are outside of typical ranges. This new requirement is intended to permit a proper balance between maintaining reliability and removing unnecessary barriers to connection.

**Consequential Amendments**

- Chapter 4, section 3.1.3 specifies that Appendix 4.2 applies to an embedded generation unit rated at 10 MVA or higher or an embedded facility whose net output is greater than 50 MVA. For the sake of consistency and clarity in the language used to describe the thresholds, it is proposed to change the parameter “net output is greater than 50MVA” to “net output 50 MVA or higher” (refer to R01). Revising this threshold would have no impact on the set of

**PART 3 – EXPLANATION FOR PROPOSED AMENDMENT**

requirements that apply to existing facilities under the current and proposed rules.

**PART 4 – PROPOSED AMENDMENT**

## Appendix 4.2 – Generation Facility Requirements ~~(Embedded and Non Embedded)~~

~~Each generation facility shall comply with the following requirements, provided that a generation facility that was in service or that existed and was licensed on the date of coming into force of this Chapter 4 shall preserve original excitation system design capabilities and shall not be required to comply with the requirements set forth in rows 12 to 15 of this Appendix until its exciter is replaced. Such generation facility shall, until that time, be required to operate in accordance with the design capabilities applicable in respect of each of the items referred to in rows 12 to 15 of this Appendix. The performance requirements set out below shall apply to generation facilities subject to a connection assessment finalized after March 5, 2010. To determine whether a performance requirement in this section is satisfied, performance of alternative technologies will be compared at the point of connection to the IESO-controlled grid with the performance of a conforming conventional synchronous generation unit with an equal apparent power rating.~~

~~Each generation facility that was authorized to connect to the IESO-controlled grid prior to March 5, 2010 shall remain subject to the performance requirements in effect at the time of its authorization to connect to the IESO-controlled grid was granted until the main elements of an associated system (e.g. governor control mechanism, main exciter) are replaced or substantially modified.~~

Generation facility directly connected to the IESO-controlled grid, or generation facility greater than 50MW, or generation unit greater than 10MW

<u>1. Off-Nominal Frequency</u>	<del>Each generation facility shall be able to operate continuously between 59.4Hz and 60.6Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0s, 57.0Hz), (3.3s, 57.0Hz), (300s, 59.0Hz), and (740s, 59.4Hz). Active power reductions in proportion to frequency drops are permissible.</del>
<u>2. Speed/Frequency Regulation</u>	<del>Each generation facility shall be able to regulate speed with a droop adjustable between 3% and 7%. Any intentional deadband shall not be wider than ±36mHz. The governor shall control speed in a stable fashion in both interconnected and island operation and provide immediate, appropriate, and sustained response to abnormal frequency excursions. The governor shall have the capability to effect a 10% change of rated active power after 10s in response to a constant rate of change of speed of 0.1%/s. Due consideration will be given to inherent limitations such as mill points and gate limits when evaluating active power changes. Non -AGC control systems that inhibit governor response shall be automatically disabled when grid</del>

	<u>frequency is less than 59.9Hz or greater than 60.1Hz.</u>
<u>3. Low Voltage Ride Through</u>	<u>Each <i>generation facility</i> shall be able to ride through design criteria contingencies assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times unless disconnected by configuration.</u>
<u><i>Generation facility</i> directly connected to the <i>IESO-controlled grid</i></u>	
<u>4. Active Power</u>	<u>Each <i>generation facility</i> shall be able to continuously supply all levels of active power output for 5% deviations in terminal voltage. Rated active power is the smaller output at either rated ambient conditions (e.g. temperature, head, wind speed, solar radiation) or 90% of rated apparent power. To satisfy steady state reactive power requirements, active power reductions to rated active power are permitted.</u>
<u>5. Reactive Power</u>	<u>Each <i>generation facility</i> shall be able to continuously (i.e. dynamically) inject or withdraw at its highest voltage terminal reactive power up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the <i>IESO</i>. A conventional synchronous unit with a 0.90 lag and 0.95 lead capabilities and main output transformer impedance not greater than 13% based on generator rated apparent power is acceptable. Each <i>generation facility</i> shall be able to continuously supply its entire range of reactive power over a 2% range of <i>connection point</i> voltage.</u>
<u>6. Automatic Voltage Regulator (AVR)</u>	<u>Each <i>generation facility</i> shall be able to automatically regulate voltage at a point whose impedance is not more than 13% within their <i>facility</i> from the highest voltage terminal based on the <i>facility's</i> rated apparent power and rated voltage. Voltage shall be able to be regulated within <math>\pm 0.5\%</math> of any set point within <math>\pm 5\%</math> of rated voltage. The slope <math>\Delta V / \Delta Q_{max}</math> in droop systems shall be adjustable to 0.5%. When multiple <i>generation units</i> are connected to a common bus, each unit's AVR reference compensation shall be adjustable to within 10% of the unsaturated direct axis reactance on the unit side from this common bus.</u>
<u>7. Excitation System</u>	<u>Each <i>generation facility</i> shall have the following excitation system capabilities: (a) Positive and negative ceilings not less than 200% and 140% of rated field voltage at rated terminal voltage and rated field current, (b) A positive ceiling not less than 170% of rated load field voltage at rated terminal voltage and 160% of rated field current, (c) A voltage response time to either ceiling not more than 50ms for a 5% step change from rated voltage under open-circuit conditions, (d) A linear response between ceilings, and (e) A small signal frequency response (<math>\Delta E / \Delta V_t</math>) magnitude and angle change not more than 3dB and <math>32^\circ</math> respectively between 0.1 and 10Hz.</u>
<u>8. Power System Stabilizer (PSS)</u>	<u>Each synchronous <i>generation unit</i> shall have the following power system stabilizer capabilities: (a) A change of power and speed input configuration, (b) Positive and negative output limits not less than 10% and 5% of rated AVR voltage, (c) Phase compensation adjustable to limit angle error to within <math>20^\circ</math> between 0.2 and 2.0Hz, and (d) Gain adjustable up to an amount that either increases damping ratio above 0.1 or elicits poorly damped exciter modes of oscillation. Phase compensation angle error limitations shall be applicable at rated active output and unity power factor unless otherwise specified by the <i>IESO</i>.</u>
<u>9. Phase Unbalance</u>	<u>Each <i>generation facility</i> shall not exceed a 1% open circuit phase voltage unbalance at its <i>connection point(s)</i> and shall be able to continuously operate with a phase unbalance as high as 2%.</u>
<u>10. Protection and Limiters</u>	<u>Each <i>generation facility</i> shall coordinate protection and limiters with short-time capabilities identified in IEEE/ANSI 50.13 except where permitted by the <i>IESO</i> and continuous capability determined by either armature current, or field current, or end-region heating.</u>
<u>11. Performance Characteristics</u>	<u><i>Connection point</i> performance shall be comparable to an equivalent synchronous <i>generation unit</i> with characteristic parameters within typical ranges. Inertia, unsaturated transient impedance, transient time constants and saturation coefficients shall be within typical ranges (e.g. <math>H &gt; 1.2</math> Aero-derivative, <math>H &gt; 1.2</math> Hydraulic less than 20MVA, <math>H &gt; 2.0</math> Hydraulic 20MVA or larger, <math>H &gt; 4.0</math> Others, <math>X'd &lt; 0.5</math>, <math>T'do &gt; 2.0</math>, and <math>S1.2 &lt; 0.5</math>) except where permitted by the <i>IESO</i>.</u>






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## Market Rule Amendment Proposal

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### PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00359-R01		
Subject:	Generation Facility Requirements		
Title:	Changes to Facilitate Connections		
Nature of Proposal:	<input checked="" type="checkbox"/> Alteration	<input type="checkbox"/> Deletion	<input type="checkbox"/> Addition
Chapter:	4	Appendix:	
Sections:	3.1.3, 3.4.1		
Sub-sections proposed for amending:			

### PART 2 – PROPOSAL HISTORY – REFER TO MR-00359-R00

Version	Reason for Issuing	Version Date
Approved Amendment Publication Date:		
Approved Amendment Effective Date:		

**PART 3 – EXPLANATION FOR PROPOSED AMENDMENT**

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IESO-administered markets* if the amendment is not made.
- Alternative solutions considered.
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IESO-administered markets*.

**Summary**

These amendments are consequential to the changes proposed under MR-00359-R00.

**Background**

Refer to MR-00359-R00

**Discussion**

- Chapter 4, section 3.1.3 specifies that Appendix 4.2 applies to an embedded generation unit rated at 10 MVA or higher (or an embedded facility whose net output is greater than 50 MWA. However, the Chapter 11 definition of “connection applicant” refers to generators seeking approval to establish a new or modified connection for a facility that is directly to the IESO-controlled grid or for an embedded facility greater than 10 MW. A “connection applicant” would be required to satisfy the requirements in Appendix 4.2. Therefore, for the sake of consistency, it is proposed to change the thresholds in section 3.1.3 such that they align with the connection applicant definition.
- Since section 3 of Chapter 4 is being amended, it is also proposed, as a matter of clean-up, to delete the reference to section 3.4.1.1 in section 3.4.1.9, since section 3.4.11 is blank.

**PART 4 – PROPOSED AMENDMENT**

**Chapter 4, section 3.1.3**

3.1.3 Each *embedded generator* whose *embedded generation facility* includes a *generation unit* rated at greater than 10 MVA-MW or higher or whose *embedded generation facility* is comprised of *generation units* whose net output is greater than 50 MVA-MW shall ensure that its equipment meets all applicable performance standards in Appendix 4.2.

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**Chapter 4, section 3.4.1****3.4 Obligations of Generators**

- 3.4.1 Each *generator* that participates in the *IESO-administered markets* or that causes or permits electricity to be conveyed into, through or out of the *IESO-controlled grid* shall:
- 3.4.1.1 [Intentionally left blank]
  - 3.4.1.2 [Intentionally left blank]
  - 3.4.1.3 permit and participate in any commissioning, inspection, and testing that the *IESO* requires of its equipment that is or is to be *connected to the IESO-controlled grid*;
  - 3.4.1.4 [Intentionally left blank]
  - 3.4.1.5 [Intentionally left blank]
  - 3.4.1.6 operate its equipment in accordance with its *connection agreement*;
  - 3.4.1.7 [Intentionally left blank]
  - 3.4.1.8 complete and return to the *IESO* those portions of the *IESO catalogue of reliability-related information* relevant to its *facilities*; and
  - 3.4.1.9 notify the *IESO* upon the submission of a *connection request* to a *transmitter* ~~pursuant to section 3.4.1.1.~~

**PART 5 – IESO BOARD DECISION RATIONALE – REFER TO MR-00359-R00**

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*Table of Concordance and existing Appendix 4.2 (attached for reference)*

**TABLE OF CONCORDANCE – REVISION TO APPENDIX 4.2**

**How to use this table:** The left-hand column lists provisions by reference numbers assigned in the existing Market Rule Appendix 4.2. The middle column identifies where the provision would be located after the proposed changes. The comments in the right-hand column describe shortcomings of existing provisions and the nature of proposed changes.

<b>Current Ref</b>	<b>Future Ref</b>	<b>Comments</b>
1	5	Requirements for distribution-connected generation have been removed and for transmission connection generation have been re-expressed and simplified. To assist proponents and to cater for a wider range of technology, reactive requirements have been expressed at the connection point to the ICG. The capability to withdraw reactive power has been reduced for transmission-connected generation and a provision has been made to enable a lesser dynamic requirement for intermittent generation.
2	4	The capability at operate at full active power operate over a $\pm 5\%$ terminal voltage range has been corrected to require this capability at all active power output levels. The reference has been re-labeled as “Active Power Capability”
3	1	The gap in existing requirement for off-nominal frequency capability between 300s and continuous operation has been filled. An editorial change has been proposed to require this capability be available at all active power levels.
4	9	The phase unbalance requirement has been fine-tuned to avoid being unnecessarily onerous by specifying at point of connection to the transmission system as the measurement point.
5	deleted	The requirements for connection equipment are not necessary in Appendix 4.2 as suitable provisions exist elsewhere.
6	deleted	“Intentionally left blank” removed
7	10	The existing requirement “Protection systems shall be constructed and maintained in accordance with all applicable reliability standards” is already specified in Ch 4 §2. Experience has shown the present rules need improvements to avoid tendencies that unduly restrict equipment capability. The proposed change makes it explicit that protection systems and limiters must not unduly restrict equipment capability.
8	deleted	“Intentionally left blank” removed
9	deleted	Telemetry requirements are not needed in Appendix 4.2 as suitable provisions exist in Ch 4 §7.
10	deleted	Communication requirements are not needed in Appendix 4.2 as suitable provisions exist in Ch 4 §7.

Current Ref	Future Ref	Comments
11	deleted	Testing and compliance requirements are not needed in Appendix 4.2 as suitable provisions exist in Ch 4 §4 and §5.
12	7	Excitation system performance requirements intended for distribution-connected generation have been removed. The requirements for transmission-connected generation have been re-expressed in more measurable manner to better guide proponents. The voltage response time requirement has been more clearly worded to apply to both positive and negative exciter ceilings. A requirement to limit ceiling drop under load has been proposed to plug a gap.
13	6	A capability requirement for droop systems consistent with present for non-droop systems has been proposed. Droop designs are common in wind farms.
14	deleted	Power factor regulation requirements intended for distributed generation have been removed.
15	8	Power system stabilizer requirements have been made more measurable to provide an appropriate level of guidance. Experience has shown the existing formulation tune stabilizers to the extent practicable to increase damping torque without reducing synchronizing torque needs improvement. Experience has shown that it is necessary to require a capability to implement a ( $\Delta P\omega$ ) stabilizer design.
16	2	To take advantage of the capability of newer technology, droop requirements have been extended to all forms of generation. Experience has shown the present governor requirements are not specific enough to provide an appropriate level of guidance. The presently undefined notions of immediate and sustained are given clear measures in the proposed change.
n/a	3 (new)	A Low-Voltage-Ride-Through (LVRT) capability requirement has been added as this provision has been a standard feature in connection assessments. The requirement is necessary to mitigate the risk of insecure operation if material amounts of distributed-connected generation trip unexpected for contingencies on the transmission system. The proposed rule is cast in a form designed not only to assist IESO assessments but also to guide proponents.
n/a	11(new)	A requirement has been added that performance be consistent with an equivalent synchronous machine with characteristic parameters within typical ranges. Other Appendix 4.2 requirements have been formulated on the basis that machine characteristics are within these typical ranges. Experience has shown generation proponents are being driven towards lower cost options with characteristics that are outside of typical ranges that do not enhance reliability to the extent anticipated. This new requirement is intended to permit a proper balance to be struck between maintaining reliability and removing unnecessary barriers to connection.

# Appendix 4.2 – Generation Facility Requirements (Embedded and Non-Embedded)

Each *generation facility* shall comply with the following requirements, provided that a *generation facility* that was in service or that existed and was *licensed* on the date of coming into force of this Chapter 4 shall preserve original excitation system design capabilities and shall not be required to comply with the requirements set forth in rows 12 to 15 of this Appendix until its exciter is replaced. Such *generation facility* shall, until that time, be required to operate in accordance with the design capabilities applicable in respect of each of the items referred to in rows 12 to 15 of this Appendix.

<b>Ref</b>	<b>Item</b>	<b>Requirement</b>
1	Reactive Power Capabilities	<p>1. A synchronous <i>generation unit</i> shall have the capability to supply at its terminal reactive power within the range 90% lagging (overexcited) to 95% leading (underexcited) power factor based on rated active power at rated voltage. Rated active power shall be the lesser of registered maximum continuous real power and 90% of the unit nameplate MVA.</p> <p>2. A non-embedded <i>generation unit</i> within a <i>generation facility</i> shall have the capability to supply its entire range of reactive power for at least one constant voltage at a <i>connection facility</i> terminal greater than 50 kV. A non-embedded <i>generation unit</i> within a <i>generation facility</i> for which a licence has first been issued on or before the date of coming into force of this Chapter 4, and lacking the capability to meet this requirement, shall maintain its existing capability and shall establish the capability to supply its entire range of reactive power for at least one constant voltage at a <i>connection facility</i> terminal greater than 50 kV upon upgrading of all of the limiting components of its <i>connection facilities</i>.</p> <p>3. Where modifications to a <i>generation facility</i> made before the date of coming into force of this Chapter 4 make it no longer possible to meet these reactive requirements at a new higher active power, <i>generation units</i> within such <i>generation facility</i> shall, if so requested by the IESO, satisfy reactive power requirements based on rated active power before this modification.</p> <p>4. An induction <i>generation facility</i> that is injecting electricity at a nominal voltage of greater than 50 kV, shall have, as measured at its <i>connection point</i>, the same capability to supply reactive power as required of a synchronous <i>generation unit</i> of the same apparent power.</p> <p>The IESO may permit a lower requirement for an induction <i>generation facility</i> if the IESO identifies during the <i>connection assessment</i> for the <i>facility</i> that the lower requirement will not adversely affect the <i>reliable</i> operation of the IESO-controlled grid. At any time after the <i>connection assessment</i> is complete, the IESO may impose a higher requirement than that identified at the time of the <i>connection assessment</i>, up to the capabilities required of a synchronous generation unit of the same apparent power, if the IESO determines that the higher requirement is necessary to maintain <i>reliable</i> operation of the IESO-controlled grid.</p> <p>5. An induction <i>generation facility</i> that is injecting electricity at a nominal voltage equal to or less than 50 kV, shall have, as a minimum, the capability to reduce its reactive power flow to zero, as measured at the <i>facility's connection point</i>.</p> <p>The IESO may impose additional reactive power capability requirements, up to the capabilities required of a synchronous <i>generation unit</i> of the same apparent power, if the IESO identifies during the <i>connection assessment</i> for the <i>facility</i> that the additional capability is required to maintain <i>reliable</i> operation of the IESO-controlled grid.</p>
2	Voltage Variations	Each <i>generation facility</i> shall be capable of operating continuously at full output within $\pm 5\%$ of the <i>generation facility's</i> rated terminal voltage. All plant auxiliaries shall be capable of running continuously within this range. Each <i>generation facility</i> shall not be expected to operate continuously outside this voltage range to satisfy reactive power requirements.
3	Frequency Variations	Each <i>generation facility</i> shall be able to operate continuously at full power in the range 59.4 to 60.6 Hz. Each <i>generation facility</i> shall be capable of operating at full power for a limited period of time at frequencies as low as 58.8 Hz. Each <i>generation facility</i> shall not trip for underfrequency excursions that are above a straight line defined on a linear-log plot of time and frequency by the points (300s,

<b>Ref</b>	<b>Item</b>	<b>Requirement</b>
		59.0Hz) and (3.3s, 57.0 Hz) unless the <i>IESO</i> accepts other trip settings. Immediate tripping is allowed below 57.0 Hz.
4	Phase Unbalance	Phase voltage unbalance of <i>generation facilities</i> shall be limited to 1% measured with the units operating unsynchronised. <i>Generation facilities</i> shall be able to continuously operate with a phase unbalance of 2%.
5	Connection Equipment	All equipment connecting the <i>generation unit's</i> terminal to the <i>IESO-controlled grid</i> shall be able to conduct for at least 4 hours the <i>generation unit's</i> rated apparent power, being the product of root-mean-square (rms) voltage and the rms current, minus auxiliary power requirements necessary to operate the unit at maximum output and minus a fair portion of the common service load required to run the entire <i>generation facility</i> .
6	[Intentionally left blank]	
7	Protective Systems and Relaying System Requirements	Protection systems shall be constructed and maintained in accordance with all applicable <i>reliability standards</i> .
8	[Intentionally left blank] Line	
9	<i>IESO</i> Monitoring and Telemetry Requirements	<i>Generation facilities</i> that are required by this Chapter 4 to be monitored shall provide suitable space and facilities for the installation of telecommunications equipment to interface with the <i>generator's</i> data acquisition equipment. Data monitoring equipment shall be compatible with the <i>IESO</i> telecommunications interface and meet the requirements of this Chapter 4 and of Appendix 2.2 of Chapter 2, if such equipment is not already installed on the date of coming into force of this Chapter 4. Any such new installation shall be done at the <i>generator's</i> cost.
10	Communication Facilities	Communication facilities are required for several or all of the following functions: protective relaying, SCADA, <i>IESO energy</i> management system, voice communication, <i>automatic generation control (AGC)</i> , and <i>special protection systems (generation rejection or runback)</i> . Details depend on the size and specific location of the generating plant under consideration
11	Testing/ Compliance Monitoring	<i>Generators</i> shall test and maintain their equipment in accordance with all applicable <i>reliability standards</i> .
	<b>Generator Controls</b>	
12	Excitation System Performance	<ol style="list-style-type: none"> <li>Each synchronous <i>generation unit</i> rated at 10 MVA or higher shall be equipped with an excitation system with: <ul style="list-style-type: none"> <li>A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%;</li> <li>A positive ceiling voltage of at least 200% of the rated field voltage, and</li> <li>A negative ceiling voltage of at least 140% of the rated field voltage.</li> </ul> <p>This performance requirement would not apply to a <i>generation unit</i> rated at 10 MVA or higher where the <i>IESO</i> determines through the <i>connection assessment</i> for that <i>generation unit</i>, that a lower requirement would not adversely impact the <i>reliable</i> operation of the <i>IESO-controlled grid</i>. In these circumstances, the synchronous <i>generation unit</i> shall be equipped with an excitation system with:</p> <ul style="list-style-type: none"> <li>An excitation system nominal response of at least 0.50 and</li> <li>A positive ceiling voltage at least 150% of rated field voltage</li> </ul> </li> <li>Each synchronous <i>generation unit</i> rated at less than 10 MVA shall be equipped with an excitation system with: <ul style="list-style-type: none"> <li>An excitation system nominal response of at least 0.50 and</li> <li>A positive ceiling voltage at least 150% of rated field voltage</li> </ul> <p>This performance requirement would not apply to a <i>generation unit</i> rated at less than 10 MVA where the <i>IESO</i> determines through the <i>connection assessment</i> for that <i>generation unit</i>, that a higher requirement is required to maintain <i>reliable</i> operation of the <i>IESO-controlled grid</i>. In these circumstances, the synchronous <i>generation unit</i> shall be equipped with an excitation system with:</p> <ul style="list-style-type: none"> <li>A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%;</li> <li>A positive ceiling voltage of at least 200% of the rated field voltage, and</li> <li>A negative ceiling voltage of at least 140% of the rated field voltage.</li> </ul> </li> </ol>
13	Automatic Voltage Regulator	Each synchronous <i>generating unit</i> shall be equipped with a continuously acting automatic voltage regulator (AVR) that can maintain terminal voltage under steady state conditions within $\pm 0.5\%$ of any set point within $\pm 5\%$ of rated voltage.

<b>Ref</b>	<b>Item</b>	<b>Requirement</b>
		<p>Each induction <i>generation facility</i> that is injecting electricity at a nominal voltage of greater than 50 kV shall be equipped with a voltage regulation system (VRS) that provides comparable performance to that of the AVR of a synchronous <i>generation unit</i> of the same apparent power.</p> <p>Each AVR and VRS shall regulate voltage except where permitted by the IESO.</p> <p>Automatic set point adjustments shall be suspended when terminal voltage deviates from a fixed set point by an amount not to exceed <math>\pm 2\%</math> of the fixed set point.</p> <p>Where multiple <i>generation units</i> are connected to a common bus, each <i>generation unit's</i> AVR reference shall be compensated to a point as close a practicable to but not farther than this common bus. The reach of AVR compensation shall not exceed 10% of the <i>generation unit's</i> synchronous direct axis impedance from the common bus. IESO approval is required for all other schemes that compensate the AVR to a point other than the <i>generation unit's</i> terminals.</p>
14	Power Factor Regulator	Each synchronous <i>generation unit</i> connected to the system at a voltage under 50 kV shall be provided with a power factor regulator or VAR regulator. A power factor regulator shall be capable of maintaining a power factor within $\pm 1\%$ between 90% lagging and 95% leading. A VAR regulator shall be capable of maintaining reactive power within $\pm 2.5\%$ of rated MVA. The power factor or VAR regulator shall have an adjustable effective response time between 10 to 60 seconds.
15	Power System Stabilizer	Each synchronous <i>generating unit</i> that is equipped with an excitation system that meets the performance requirements specified in sub-section 1 of section 12 above, shall also be equipped with a power system stabilizer. The power system stabilizer shall, to the extent practicable, be tuned to increase damping torque without reducing synchronizing torque.
16	Speed Governor	<ul style="list-style-type: none"> <li>• Each synchronous <i>generation unit</i> with a nameplate rating of greater than 10 MVA shall be operated with a speed governor. The governor shall have a permanent speed droop that can be set in the range between 3% and 7% and the intentional deadband shall not be wider than <math>\pm 36</math> mHz .</li> <li>• The above droop and deadband requirements shall apply to an entire combined-cycle <i>generation facility</i>.</li> <li>• The governor shall be able to arrest the unit's speed, following full load rejection to prevent a trip due to overspeed, and shall demonstrate stable performance with adequate damping under all operating conditions.</li> <li>• Governors shall control speed in a stable fashion during both island and interconnected operation.</li> <li>• To the extent practical governors shall provide immediate, appropriate and sustained response to abnormal frequency excursions.</li> <li>• Control systems that inhibit governor response shall be automatically disabled by frequency deviations not larger than <math>\pm 100</math> mHz.</li> </ul>

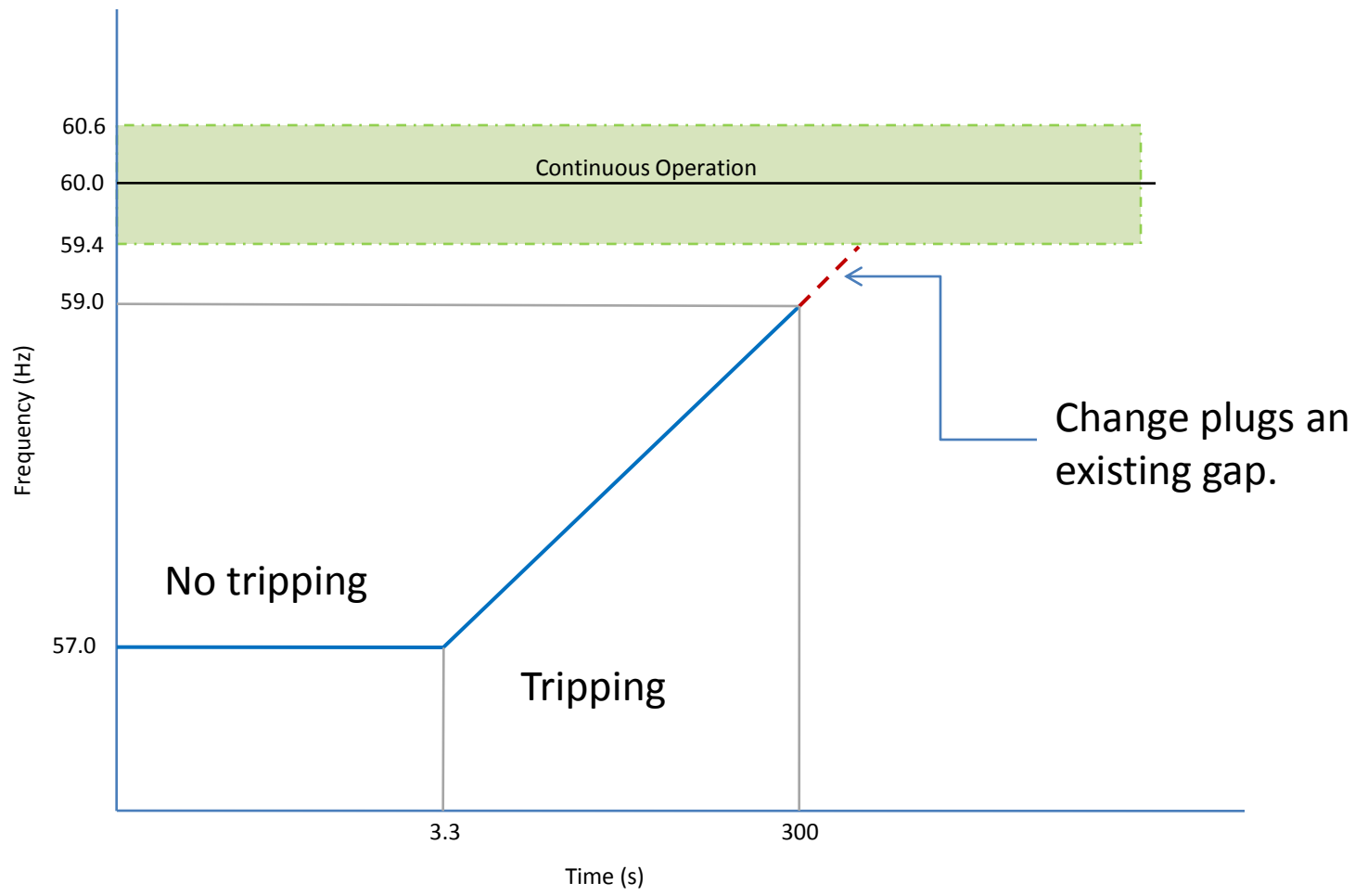


# Appendix 4.2 in Pictures

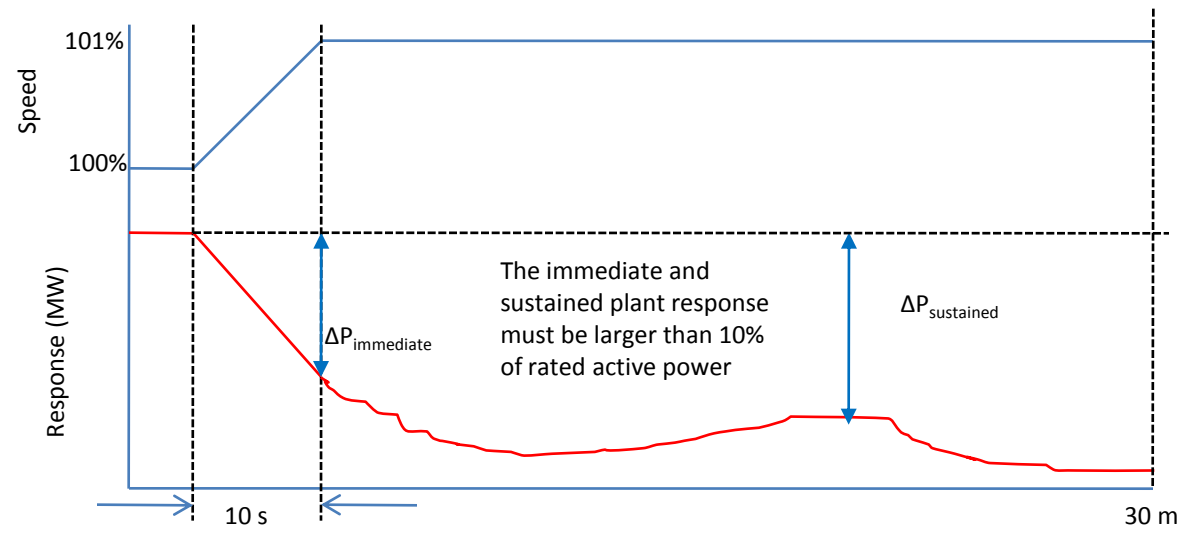
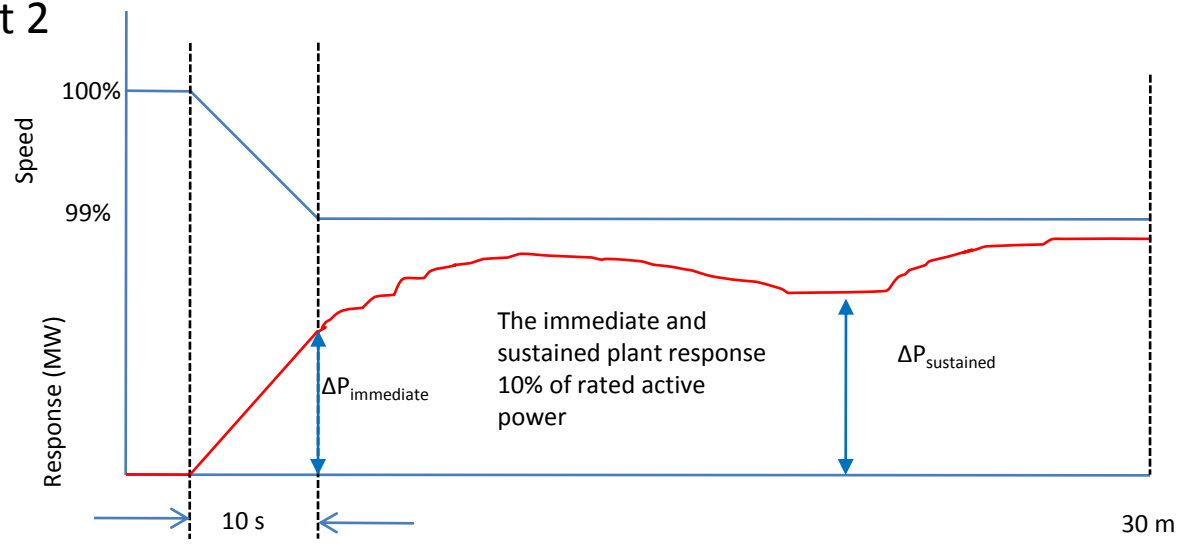
The following diagrams are for illustrative purposes only and are intended to further understanding of the intent of the proposed changes. These diagrams will be included in the appropriate market manual if amendment proposal MR-00359-R00-R01 is approved.



# Requirement 1

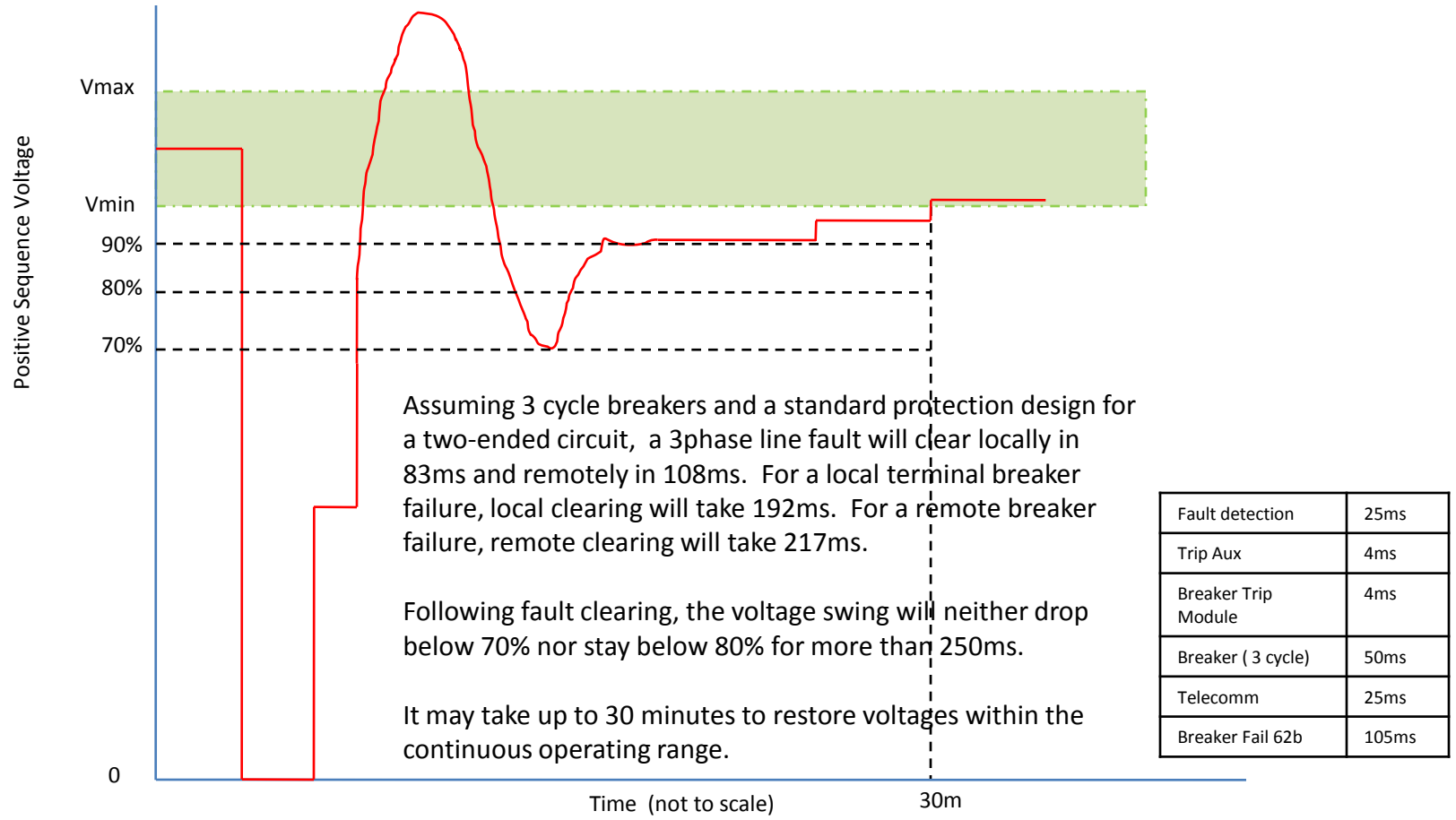


# Requirement 2



The present rule does not characterize immediate and sustained in a measurable terms and this is leading to very slow response times. A suitable combination of on-line , off-line tests and calculations could demonstrate this performance.

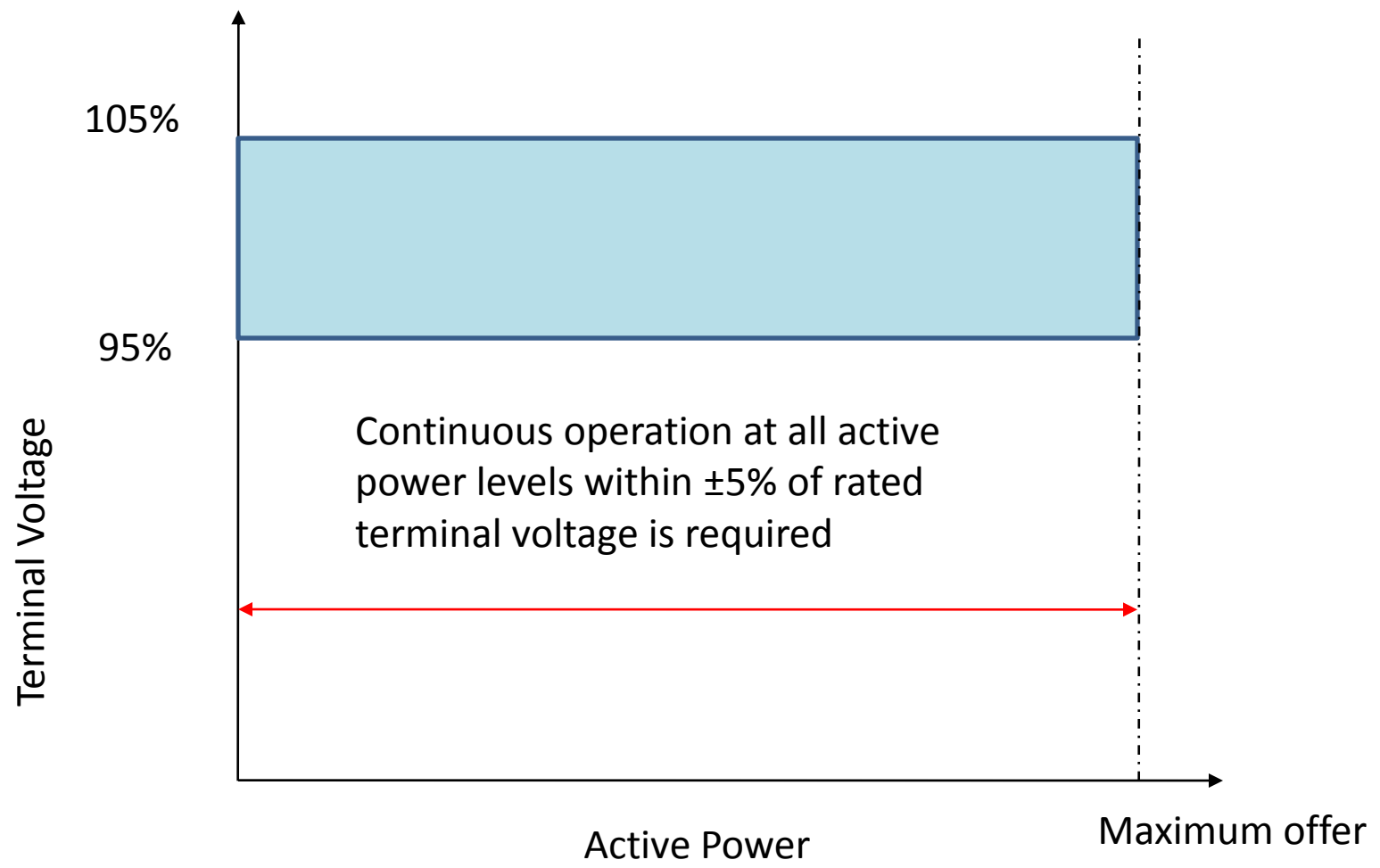
# Requirement 3



Settings on new or modified equipment should not result in out-of-zone tripping. A complete review of all downstream protection each time a change is made is not an IESO requirement . An acceptable level of confidence will result from the following process:

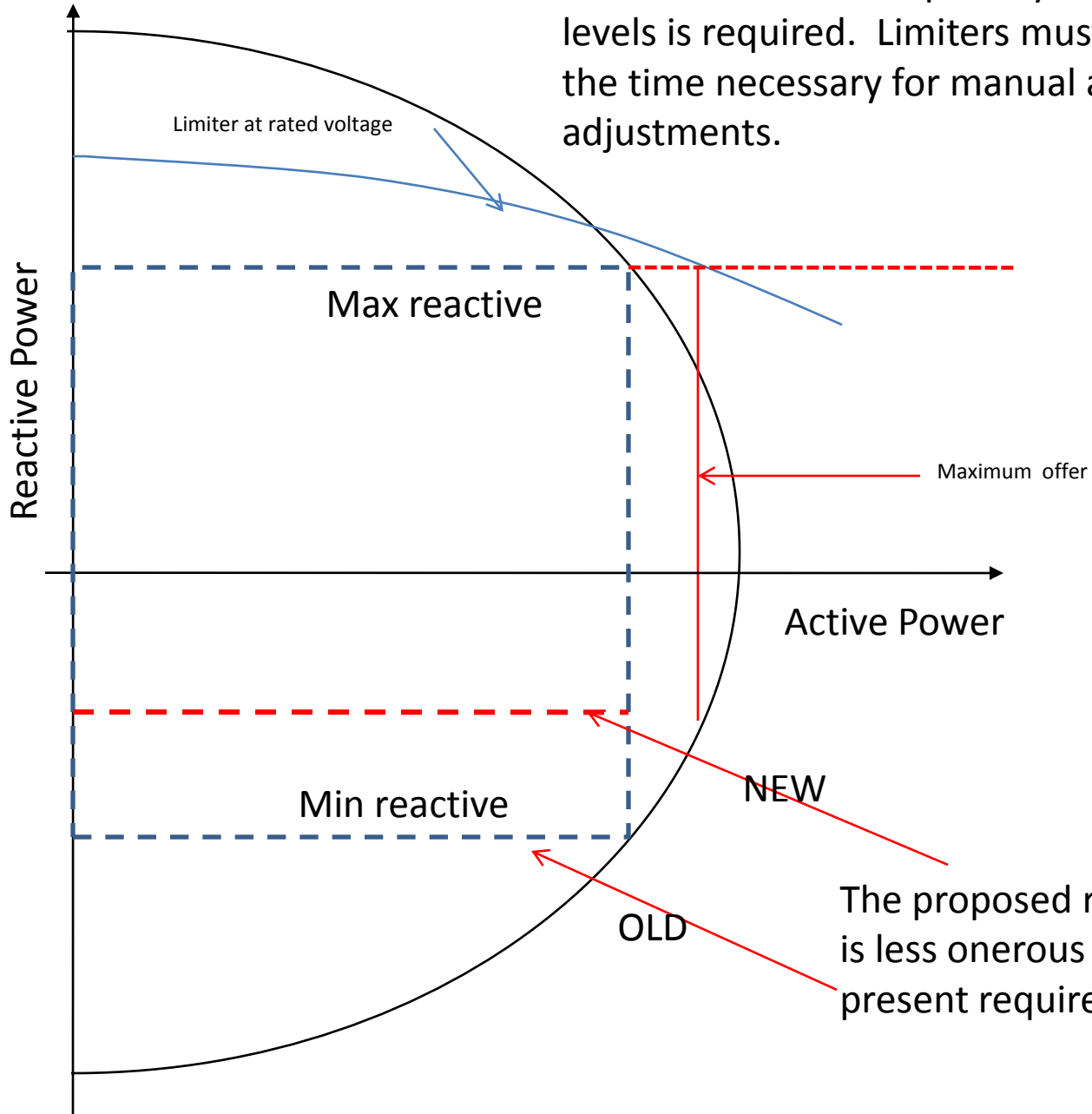
- No new problems may be introduced,
- All known problems must be fixed, and
- All other problems will be fixed when they become known.

# Requirement 4



# Requirement 4

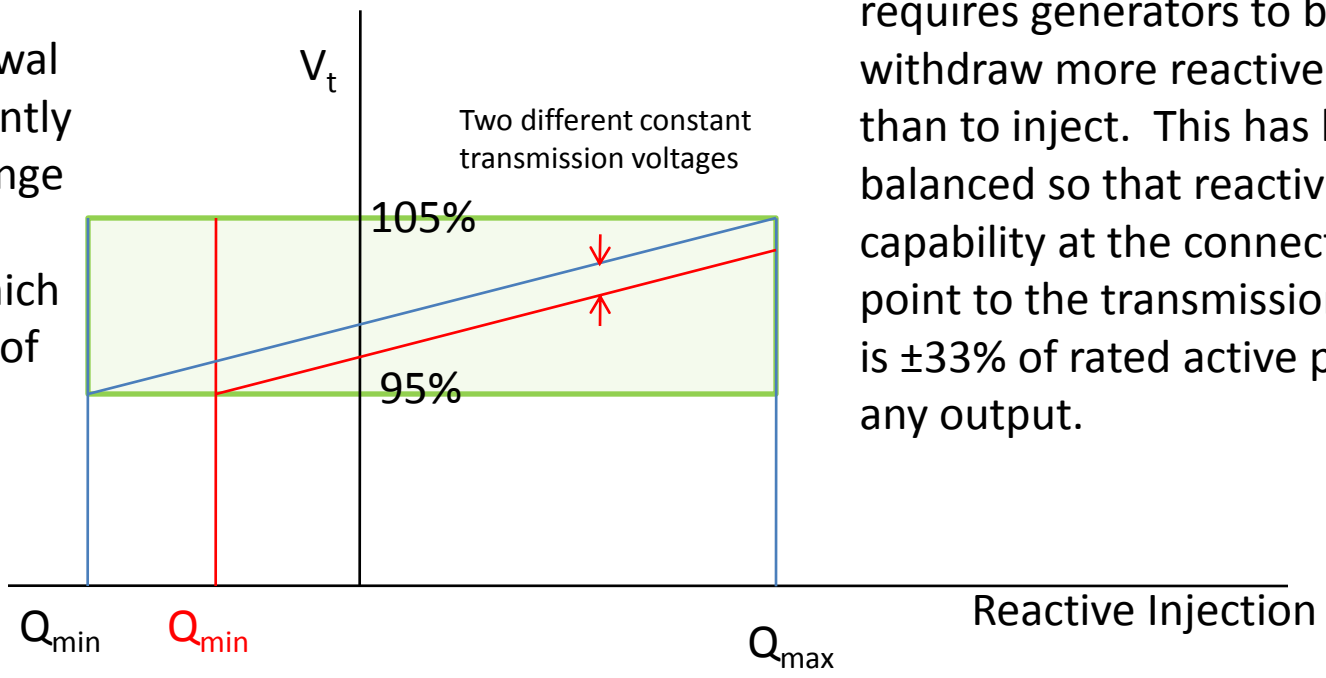
Maximum reactive capability at all active power levels is required. Limiters must coordinate with the time necessary for manual active power adjustments.



The proposed requirement is less onerous than the present requirement.

# Requirement 5

Reducing the reactive withdrawal capability inherently increases the range of transmission voltages over which the entire range of reactive can be supplied.

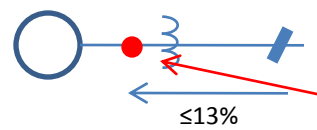


The present requirement requires generators to be able to withdraw more reactive power than to inject. This has been balanced so that reactive capability at the connection point to the transmission system is  $\pm 33\%$  of rated active power at any output.

OLD

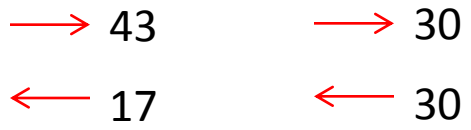


100 MVA  
90 MW



Voltage control point not more than 13% from high voltage terminal

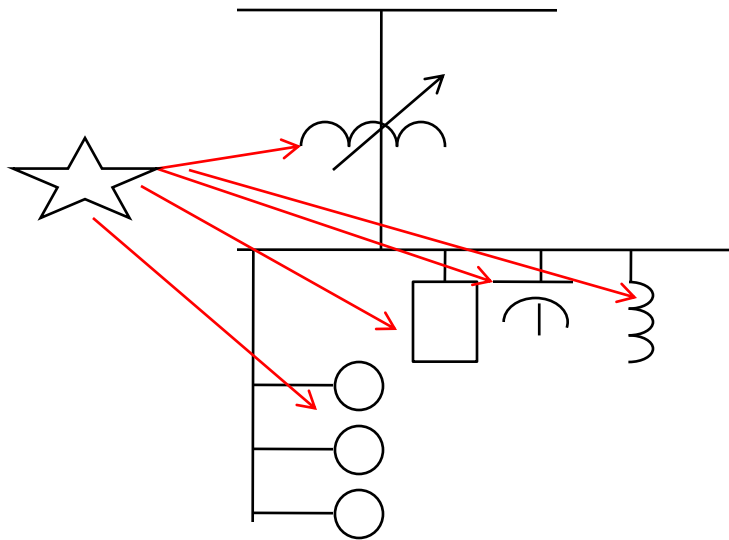
NEW



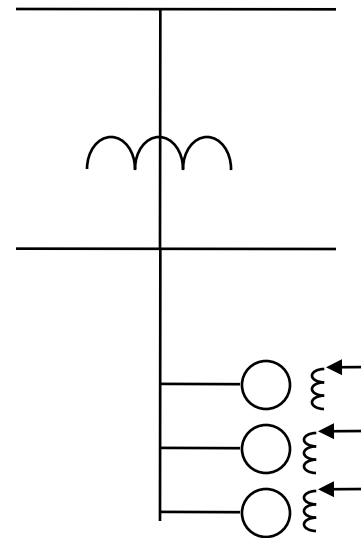
A 0.90lag/0.95 lead power factor generator with a transformer impedance not larger than 13% on generator Sbase power rating would be acceptable.

## Requirement 5 (cont.)

The proposed change specifies a lesser reactive capability that is continually available is permissible in some circumstances. For example, wind facilities that continue to control voltage even when there is insufficient wind to turn turbine blades will have a reduced reactive capability requirement. The advantage of having a reactive capability under windless conditions would have to be greater than the disadvantage of the reactive capacity reduction under windy conditions.

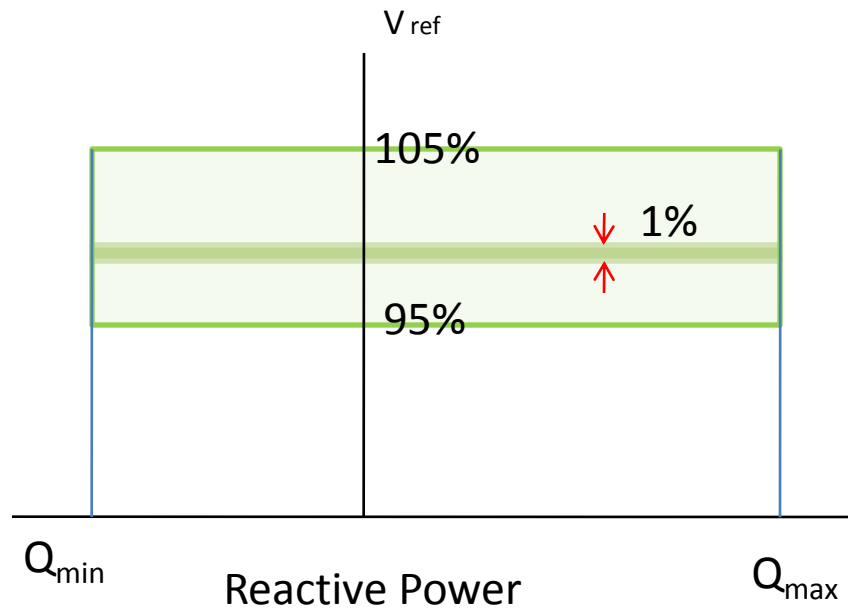


Complicated designs requiring close coordination of equipment from different vendors have arisen under the present requirements.



The rules ought to encourage designs that work better for all parties.

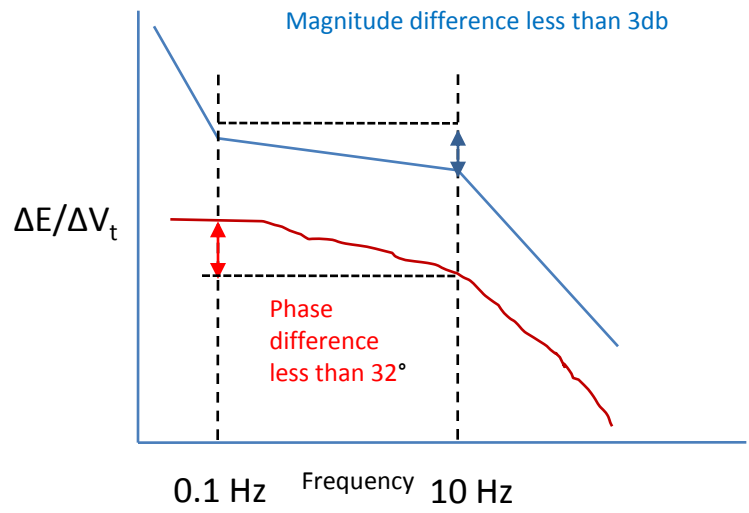
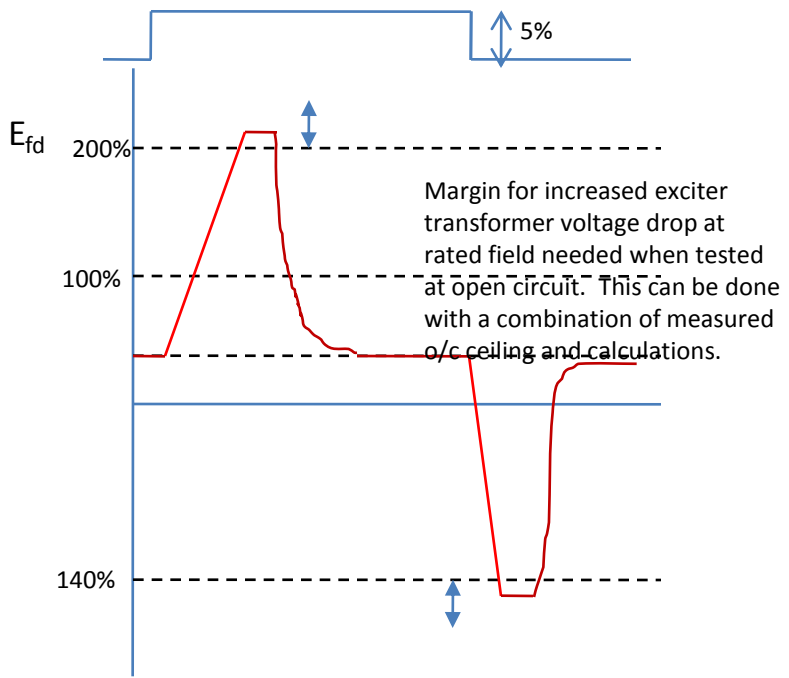
## Requirement 6



Reference voltage must be maintained within  $\pm 0.5\%$  of any set point within  $\pm 5\%$  of rated voltage. This requirement is not changed. The same requirement applies for droop systems and is captured with a minimum droop requirement.



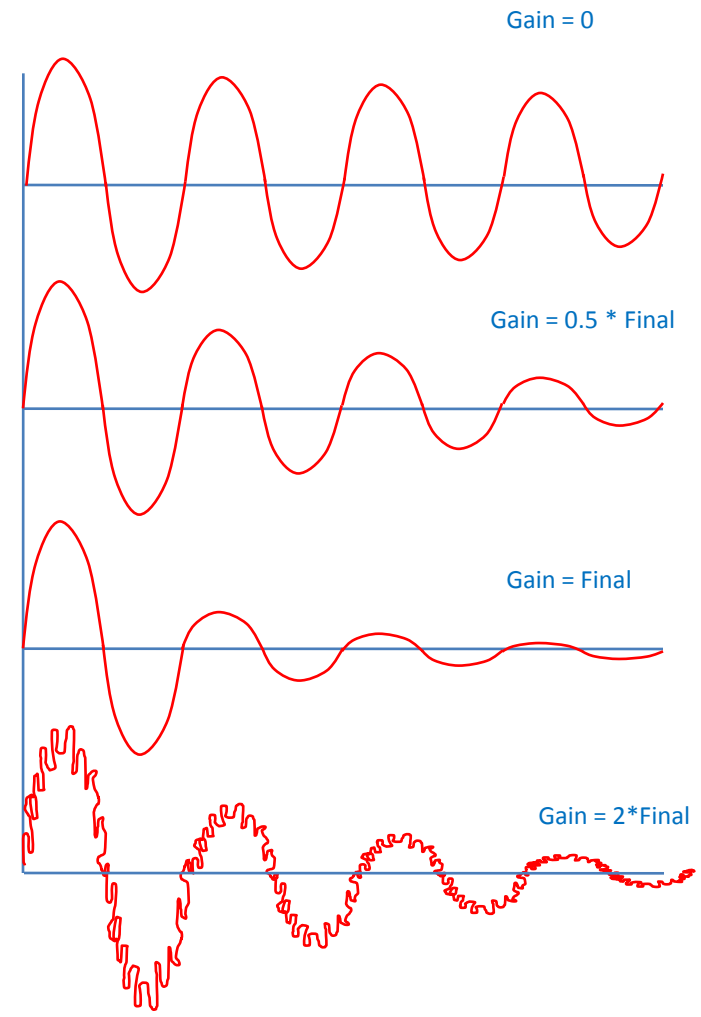
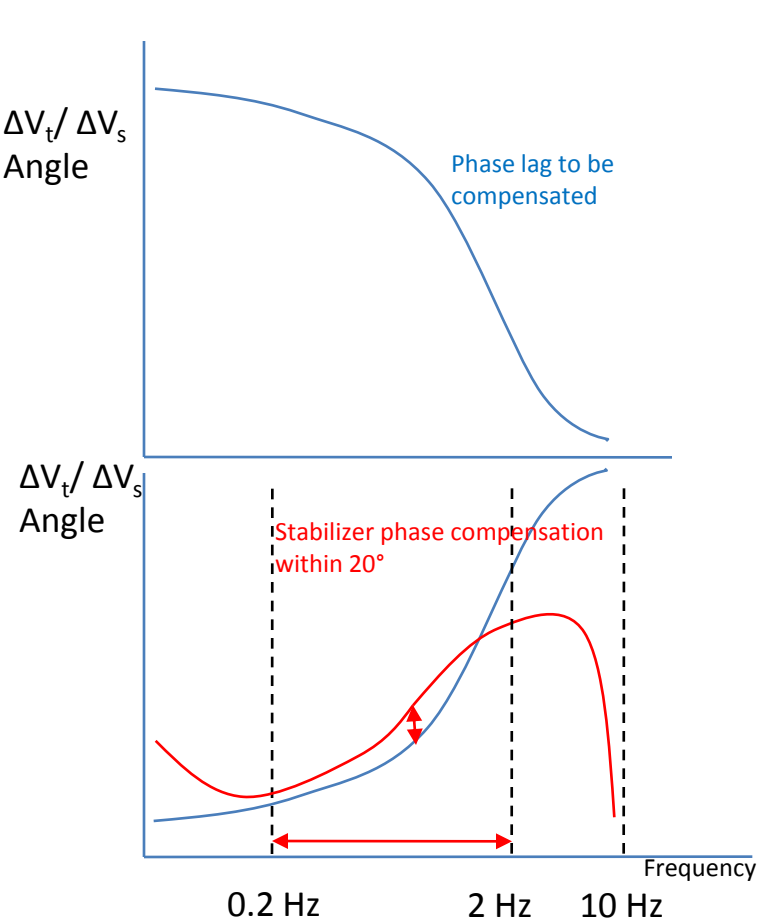
# Requirement 7



The changes to the excitation system requirements will remove uncertainty by providing measureable requirements.

A linear firing angle change in response to voltage error change will result in a non-linear exciter voltage change and this is not acceptable. The exciter gain is required to be linear.

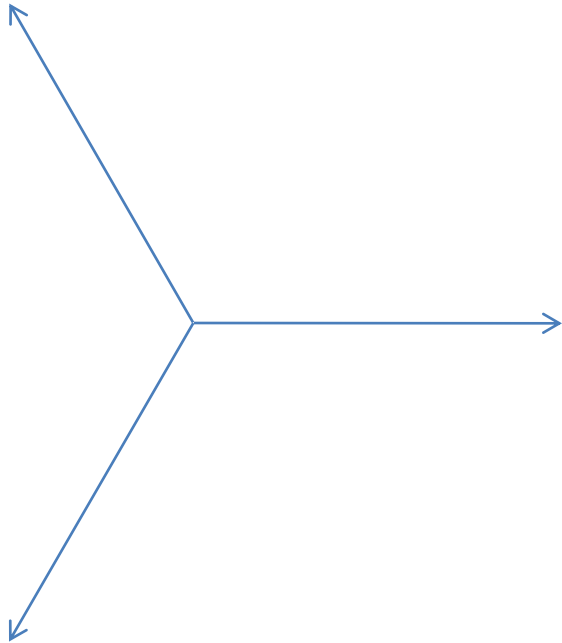
# Requirement 8



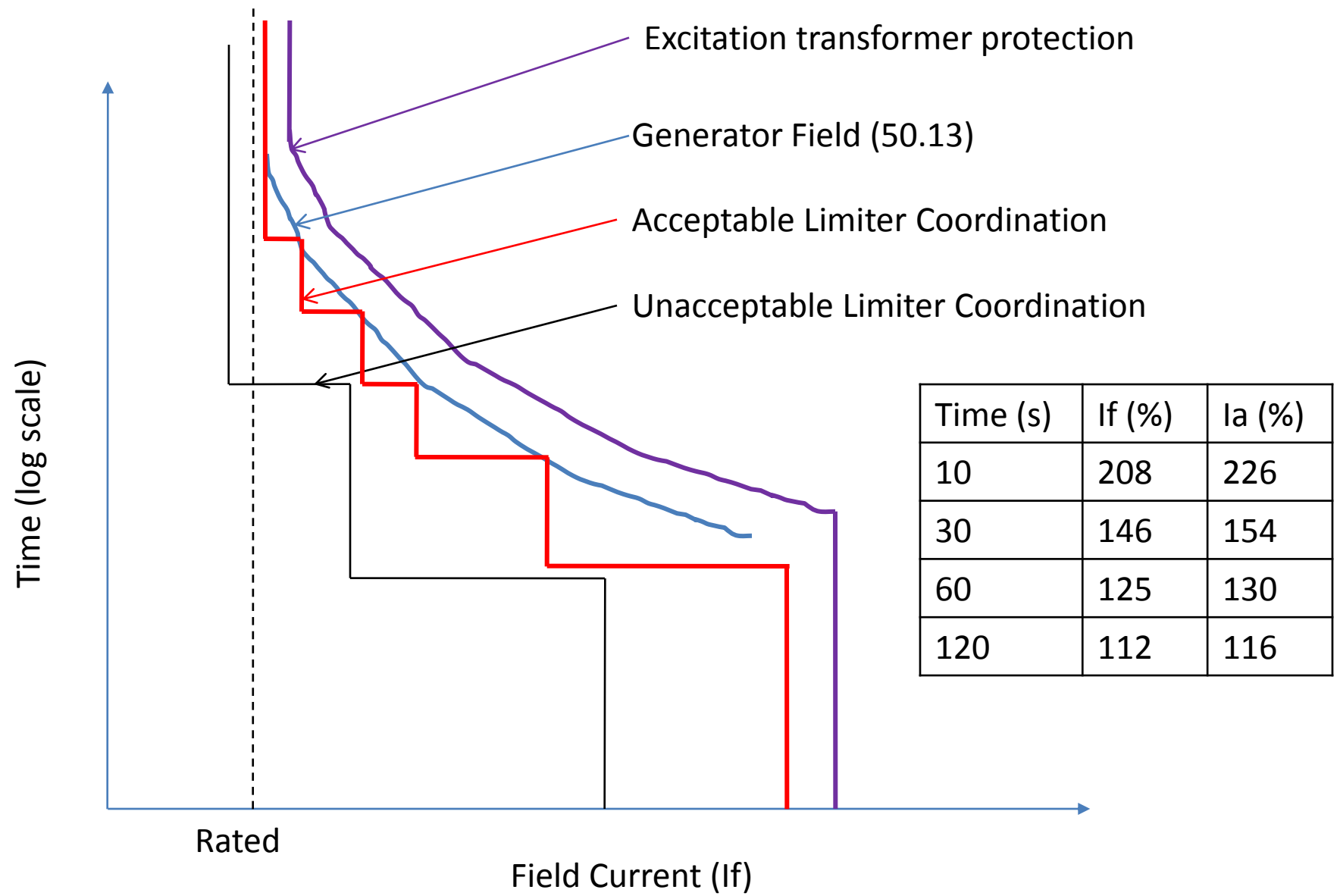
The onset of the exciter modes must be beyond twice rated gain at rated active power to meet the required gain margin.

## Requirement 9

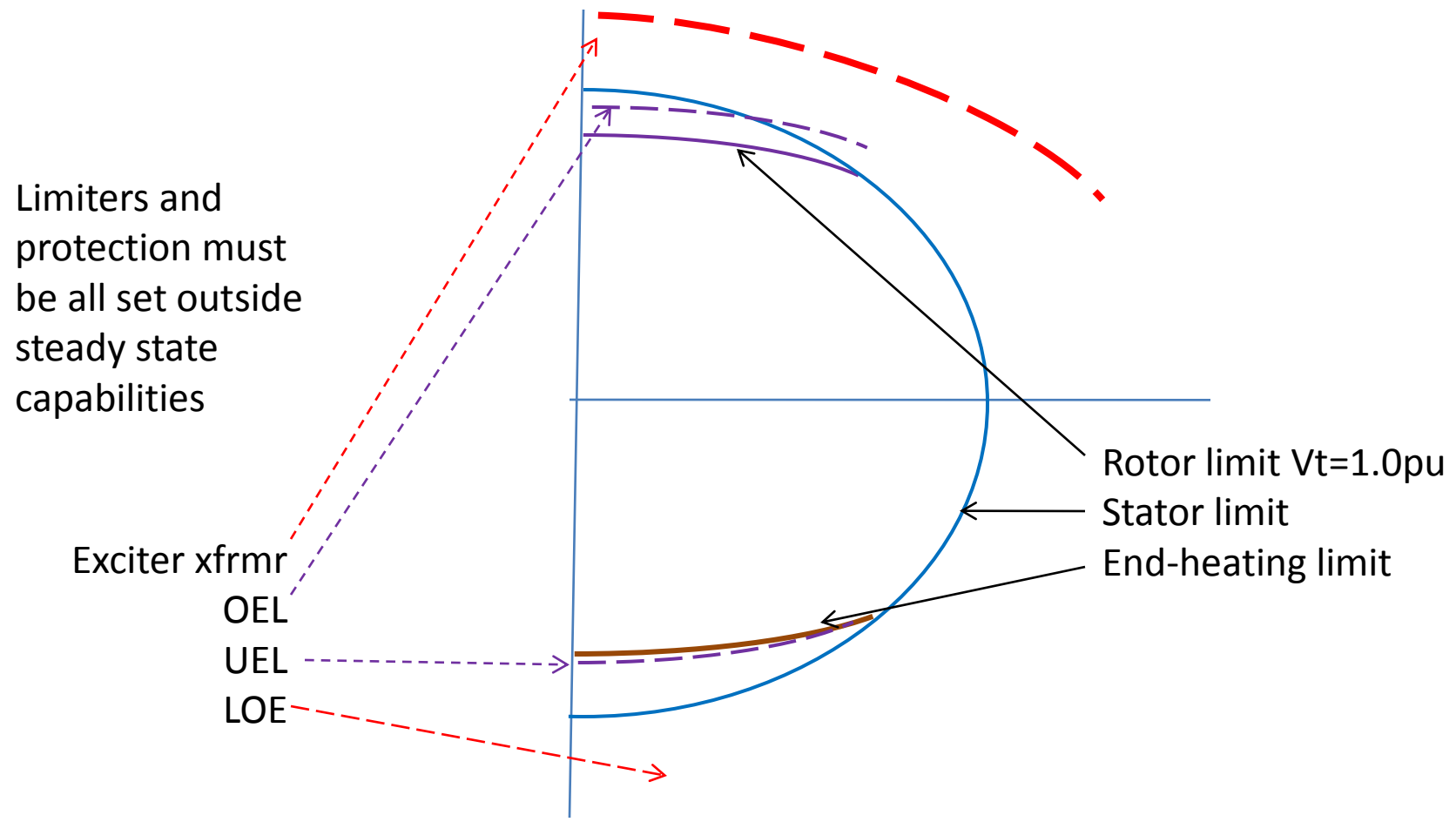
The twin requirements to produce a relatively clean waveform (e.g. shall not exceed 1% open circuit phase voltage unbalance) and to be capable of operating under less than perfect conditions (e.g. be able to continuously operate with a phase unbalance as high as 2%) are unchanged.



# Requirement 10



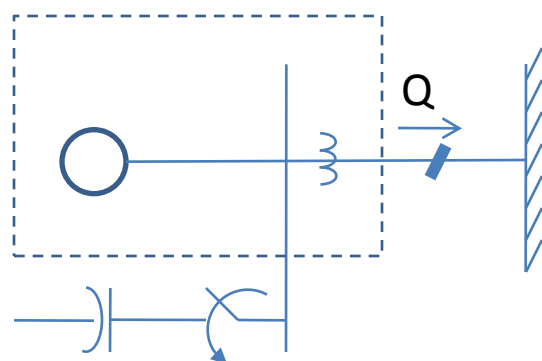
Requirement 10 (cont)



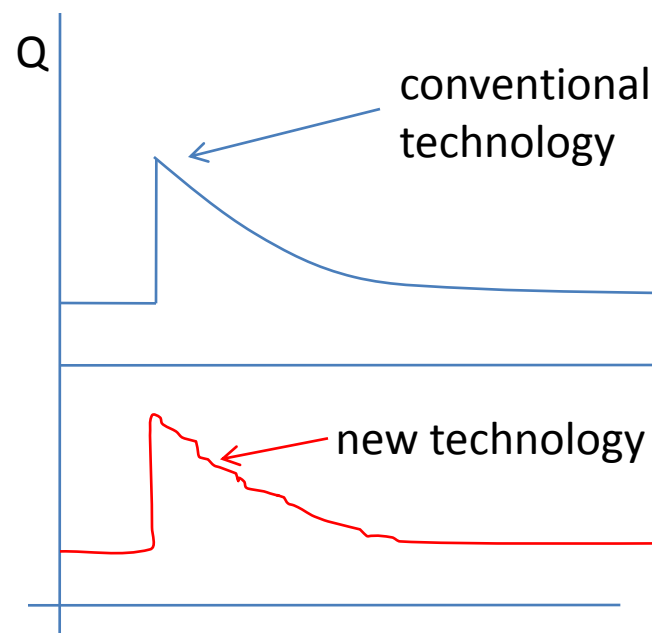
When damage can occur very quickly (e.g. end-heating on thermal units), limiters can be set as near to the steady state capability as reasonably achievable.

## Requirement 11

conventional or new technology



Switch capacitor in service to create a disturbance.



To provide a reasonable basis for judging the performance of new technologies, *connection point* performance shall be comparable to an equivalent size conforming synchronous *generation unit* with characteristic parameters within typical ranges. In the example above, the new technology has a comparable rate of response to a reactive power change as conventional and so this would demonstrate acceptable performance in this regard.

Inertia, transient impedance, transient time constants and saturation coefficients shall be within typical ranges (e.g.  $H > 1.2$  Aero-derivative,  $H > 1.2$  Hydraulic (small units  $< 20\text{MVA}$ ),  $H > 2.0$  Hydraulic (large units  $\geq 20\text{ MVA}$ ),  $H > 4.0$  Thermal,  $X'd < 0.5$ ,  $T'do > 2.0$ , or  $S1.2 < 0.5$ ) except where permitted by the IESO. Without placing qualifications on equipment characteristics, it may not be possible to maintain reliability even if other requirements (e.g. exciter ceilings, voltage response times) are satisfied.