



# **Generation Interconnection Requirements (Applicable to Generation Interconnection Facilities 1 MW and Greater)**

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*This document revises and amends: “Non-Utility Generation Interconnection Requirements at Voltages 72 kV and Above”. As of the effective date noted below, this document is deemed to be a revised and amended, version of SaskPower’s “Non-Utility Generation Interconnection Requirements at Voltages 72 kV and Above”.*

This Generation Interconnection Requirements (Applicable to Generation Facilities 1 MW and Greater) document is effective as of 2022 November 04.

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# 1. INTRODUCTION

## 1.1. Purpose

The purpose of this document is to define technical requirements to electrically interconnect a Generation Interconnection Facility (GIF), Conventional Sources, and Non-Conventional Sources to the Transmission System owned and operated by SaskPower (“SaskPower Transmission System” or “STS”). These requirements may also apply to any other facility and/or facilities as determined by SaskPower on a case-by-case basis and in SaskPower’s sole discretion, including, but not limited to, Distributed Energy Resources/Variable Energy Resources (DER/VER), customer Self-Generation facilities, and any motor load facilities that have the capacity to export power. This Generation Interconnection Requirements document shall come into effect on 2022 November 04. The scope of this document is primarily technical in nature. Contractual provisions and requirements not included in this document such as agreement terms, costs, ownership, billing etc. will be addressed separately as part of the business processes.

## 1.2. Scope

This document (including all generation interconnection requirements in this document) applies to a GIF with an aggregated capacity  $\geq 1$  MW. This document may also apply to any other facility (including, but not limited to facilities with  $< 1$  MW interconnection to STS at voltages 66 kV and greater) as determined by SaskPower in SaskPower’s sole discretion. Further, this document may also apply to a Load Customer as determined by SaskPower in its sole discretion. Notwithstanding any other provision of this document, SaskPower may, in its sole discretion, for any reason and at any time, on a case-by-case basis: (i) waive any provision, requirement or obligation of this document; (ii) substitute any provision, requirement or obligation in this document with an alternate provision, requirement or obligation; and/or (iii) add any supplemental or additional requirements to this document.

Prior to interconnecting to STS, the Entity must engage the services of Professional Engineers and/or a registered consulting firm licensed by the Association of Professional Engineers & Geoscientists of Saskatchewan (APEGS) to perform engineering related activities for the proposed interconnection. Such professional engineers/consulting firm must have relevant experience acceptable to SaskPower to perform the work.

## 1.3. Ownership of Facilities

SaskPower will own, maintain, and operate all facilities on STS side of the Point of Interconnection (POI).

The Entity is responsible for the supply, installation, ownership, maintenance, testing (including periodic re-testing) and operation of all facilities on the Entity’s side of the POI. The exception to this

may be the provision of communication and SCADA facilities as noted in Sections 3.11 and 3.12 of this document.

## **1.4. Compliance Requirements**

Notwithstanding any other provision of this document, the Entity, and the Generation Interconnection Facility, must comply with all NERC reliability standards<sup>1</sup> adopted by the Saskatchewan Electric Reliability Authority (SERA), and as updated or revised from time to time. In addition, the Entity must meet all requirements set forth in this document and any other additional requirements as specified by SaskPower.

The Entity, and the Generation Interconnection Facility, must also conform to the latest revisions of all applicable standards, guides, codes, and policies in existence at the time of engineering the design of the Generation Interconnection Facility (GIF) that are issued by the following organizations:

- Canadian Standards Association (CSA)
- Institute of Electrical and Electronics Engineers (IEEE) & International Electrotechnical Commission (IEC)
- National Electrical Manufacturers Association (NEMA)

In the event of a conflict between any requirements of this document and those from the listed standards in the second paragraph in 1.4, the SaskPower requirements must prevail.

Any exceptions to any requirements of this document, including but not limited to, the requirements under this Section 1.4, need SaskPower's prior written approval.

## **1.5. Business Processes**

Prior to connecting to STS, the Entity will be required to enter into an agreement (or agreements) with SaskPower in relation to the proposed interconnection. Such agreement(s) may include, among other things, the financial and business aspects of the proposed interconnection to STS, as well as license, permit and approval requirements and obligations.

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<sup>1</sup> Refer to: <http://www.sera-sk.ca/standards>

## **1.6. General Interconnection Process**

The generation interconnection process will be addressed separately from this Generation Interconnection Requirements document. SaskPower will provide the Entity with the interconnection process requirements. Technical process documents (if any) are available through Open Access Transmission Tariff (OATT) website.

## **1.7. Safety**

The GIF must be constructed and maintained by the Entity such that it does not pose a safety hazard to itself, to others (including STS and other customers), the operating personnel, public or the environment.

## **1.8. Environment**

The Entity must comply with any instructions/requirements issued by SaskPower, Occupational & Safety Assessment (OHSAS), and Occupational Health & Safety programs. This includes, but is not limited to, instructions/requirements respecting safety, system protection, operating procedures, schedules, and testing of all (or portions) of the GIF as part of the operation and maintenance of the GIF

## **1.9. Information**

The information contained within this document is subject to change due to evolving standards, emerging technologies, or industry trends and therefore, may be revised by SaskPower at any time in SaskPower's sole discretion. The Entity may contact SaskPower's Technical Development & Standards group at: "transmission-standards@saskpower.com" regarding the current applicability of any requirement or for providing any feedback/suggestions for changes to this document. For general inquiries, please contact SaskPower at: 1-888-757-6937.

## 2. STS CHARACTERISTICS

The Entity must take into consideration the following aspects associated with the characteristics of STS, when designing the GIF:

### 2.1. General System Configuration

STS consists of an interconnected Southern Grid System as well as the Far North<sup>2</sup> grid system. The Southern Grid System voltages are 230 kV and 138 kV. The Far North Grid System has voltages at 138 kV and 115 kV. SaskPower also has some 230 kV, 138 kV and 72 kV radial lines. The Southern Grid System of STS is interconnected with Manitoba and the United States through synchronous ties. The Southern Grid System of STS is also interconnected to Alberta via a back-to-back HVDC tie. The Far North Grid System is connected to SaskPower through Manitoba Hydro.

STS is designed to be Effectively Grounded for these voltages.

STS is operated under the control of a centrally located Grid Control Centre (GCC), and utilizes the SaskPower owned, operated, and maintained communication systems, as well as some leased lines from a communications provider.

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<sup>2</sup> Refer to Far North 66kV system on SaskPower's system map:

- a) [Click Here](#), OR
- b) Go to: <https://www.saskpower.com/our-power-future/our-electricity/electrical-system/system-map>,  
And click on "full map" found on the top corner of the page under "Printable System Map".

## 2.2. System Voltage Unbalance and Operating Ranges

The voltage unbalance under normal operating conditions will be less than 3 percent. The voltage unbalance is as defined by ANSI/NEMA MG1 14.36 and ANSI/NEMA MG1 20.24, 2014. During abnormal conditions such as faults and single-phase tripping and reclose as one example, the unbalance may exceed 3<sup>3</sup> percent.

The SaskPower Voltage Operating Range:

Table 1 shows STS intact and post contingency operating voltage range along with the corresponding time durations.

**Table 1: SaskPower Transmission System - Intact and Post Contingency System Operating Voltages (60 Hz values)**

Nominal Voltage (kV)	Existing Equipment					New Equipment	
	Typical System Intact Steady State Operating Voltage Range (kV)	Post Contingency Maximum Transient Voltage (kV)	Post Contingency Transient Voltage Range (kV)		Post Contingency Steady State Temporary Range (kV)	Post Contingency Steady State Operating Range (kV)	Maximum Continuous Voltage Rating (kV)
230	207 – 253	322	161 – 276	195 - 265	207 - 253	207 - 253	253
138	124.2 – 145	193	97 – 166	117 – 159	124 - 152	124 - 145	152
72	64.8 – 76	n/a	n/a	n/a	65 - 76	65 - 76	79
<b>Per Unit (pu)</b>							
230	0.90 – 1.10	1.40	0.70 – 1.20	0.85 – 1.15	0.90 – 1.10	0.90 – 1.10	1.10
138	0.90 – 1.10	1.40	0.70 – 1.20	0.85 – 1.15	0.90 – 1.10	0.90 – 1.05	1.10
72	0.90 – 1.05	1.40	n/a	n/a	0.90 – 1.05	0.90 – 1.05	1.10
Time Duration	Continuous	8 cycles	2.5 second	5 seconds	30 minutes	Continuous	Continuous

<sup>3</sup> Based on the magnitude of negative sequence to positive sequence and can be voltage or current (for current the percentage may be considerably higher due to single phase loads).

## 2.3. Frequency and Frequency Variation

The nominal frequency of STS is 60 Hz in steady state operation. The Compliance Factor “CF” is expected to be  $\leq$  the constant " $\epsilon_{11}$ "<sup>4</sup> of  $\pm 0.018$  Hz targeted frequency bound (error) on sliding window of 365 days basis. Momentary instantaneous frequency excursions outside of the above range do occur, especially during disturbances.

## 2.4. Harmonic Voltage Distortion

The background harmonic voltage distortion is expected to be less than 1% of the Total Harmonic Distortion. Under no circumstances will the harmonic levels be allowed to exceed the levels established in Table 2<sup>5</sup>, as applicable to STS:

**Table 2: Voltage Distortion Limits**

Bus Voltage V at PCC	Individual Harmonic (%)	Total Harmonic Distortion THD (%)
$V \leq 1.0$ kV	5.0	8.0
$1 \text{ kV} < V \leq 69.0$ kV	3.0	5.0
$69 \text{ kV} < V \leq 161.0$ kV	1.5	2.5
$161 \text{ kV} < V$	1.0	1.5

## 2.5. SaskPower Equipment Characteristics

### 2.5.1. SaskPower Design Specifics

- Effectively Grounded system is applied to all the 230 kV, 138 kV and 72 kV equipment.
- All voltage specifications are phase-to-phase (line-to-line) unless otherwise specified.
- All voltage specifications in per unit (pu) are expressed on nominal phase-to-phase (line-to-line) voltage base.
- All currents and voltages are in RMS unless stated otherwise.
- All short circuit currents are based on symmetrical current basis.
- All outdoor equipment is capable of continuous operation over the full ambient air temperature range from  $-50$  °C to  $+45$  °C, in sunshine and cross wind of 0.6 m/s.
- All indoor equipment is capable of continuous operation over the full ambient air temperature range from  $0$  °C to  $+40$  °C, with 10 % to 40 % relative humidity.

<sup>4</sup> NERC BAL-001-2, Attachment 1, for Eastern Interconnection. Also referred as the discrete root mean square (D.R.M.S.) targeted frequency error.

<sup>5</sup> Table 2 is taken from IEEE Std. 519 – 2014 (Table 1) and reproduced here for ease of reference. The values in Table 2 reflect possible total harmonic voltages, which include quantities generated by other entities connected to STS over and above the background 1%.

## 2.5.2. SaskPower Equipment Capabilities

The connecting equipment meets the voltage requirements for continuous, short term, emergency, Lightning Impulse Level (LIL) and short circuit capabilities of the SaskPower system (refer to Table 3 below).

**Table 3: SaskPower Equipment Capabilities**

Equipment Rating					
Nominal Voltage (kV)	Continuous Operating Voltage (kV)	Short Term Operating Voltage (kV)	Emergency Operating Voltage (kV)	Lightning Impulse Level: Phase to Ground & Phase to Phase (kV peak)	Maximum Design Fault Levels (kA)
230	195.50 – 253.00	276.00	172.50 – 322.00	900 <sup>6</sup> or 1050 <sup>6</sup>	≥ 31.50
138	117.30 – 151.80	165.60	103.50 – 193.20	650	≥ 31.50 to 40
72	61.20 – 75.60	86.40	54.00 – 100.80	350	≥ 31.50
Per Unit (pu)					
230	0.85 – 1.10	1.20	0.75 – 1.40	-	-
138	0.85 – 1.10	1.20	0.75 – 1.40	-	-
72	0.85 – 1.05	1.20	0.75 – 1.40	-	-
Time Duration	Continuous	5 min	1 s	-	-
Based on SaskPower's Equipment General Requirements: R1.0					

The system fault levels, and system impedances vary depending upon system configurations which may change the system impedances and therefore the system fault levels. The specific fault levels are used for protection coordination, ground potential voltage rise studies among others. However, SaskPower designs the system apparatus to withstand the “Maximum Design Fault Levels” as listed in Table 3 to ensure future increases in fault levels do not exceed the installed capabilities.

## 2.6. Fault Clearing

For new facilities, faults on the 138 kV and 230 kV grid lines are designed to be normally cleared in ≤ 100 ms.

Fault interrupting on radial lines, the Far North grid system and some older existing facilities may be slower to facilitate coordination.

<sup>6</sup> Dependant on equipment connected, refer to Annex I, Table I.1, Page 89 of IEEE Standard C37.100.1 (2018).

## 2.7. Automatic Reclosing

SaskPower typically applies High Speed automatic reclose (auto reclose) on 230 kV and 138 kV transmission lines. Where auto reclose is not applied, SaskPower may add this functionality in the future.

Some 230 kV transmission lines utilize single-phase tripping and High-Speed auto reclose, with Line Dead Time designed for 45 cycles (0.75 s).

138 kV lines and some 230 kV lines use three-phase auto reclose with Line Dead Time designed for 30 cycles (0.5 s).

High-Speed auto-reclose is only attempted for line to ground faults whether the line is designed with the capability to operate in single phase or multi-phase tripping.

Lines that are transformer ended with no intervening high-speed breaker devices between the line and the transformer will not be capable of single-phase tripping.

Only one attempt is made to auto reclose following a fault. If the initial reclose attempt is unsuccessful, a non-lockout three phase trip occurs. Subsequent reclose attempts may be initiated remotely by SaskPower's Transmission System Operators. During this time, the Entity must not take any action (i.e., attempt(s) to reclose) unless contact with the SaskPower GCC or BUCC confirms that any action by the Entity is permitted and safe to do so.

Auto-reclose is blocked for multi-phase faults. Some lines have slow speed auto reclose where the Line Dead Time is greater than one second.

## 2.8. System Grounding

STS has been designed to be Effectively Grounded on the 230 kV, 138 kV and 72 kV systems. All SaskPower-owned generator step-up transformers at these voltages are  $\Delta Y$  connected with the grounded Y on STS side. The transmission uses 230-138 kV and 138-72 kV auto transformers, with  $\Delta$  tertiaries. All these transformers have Solid Ground Connections between the transformer neutral and the station ground grid.

An Effectively Grounded System is defined<sup>7</sup> as:

A system that is grounded through a sufficiently low impedance (inherent or intentionally added, or both) so that the Coefficient of Grounding (COG) is less than 80% under all system conditions.

### 2.8.1.2 For Conventional (Rotating) Generators:

The COG value of less than 80% is obtained approximately when, for all system conditions, the ratio of the zero-sequence reactance to the positive-sequence reactance ( $X0/X1$ ) is positive and  $\leq 3$ , and the ratio of zero-sequence resistance to positive-sequence reactance ( $R0/X1$ ) is positive and  $\leq 1$ .

### 2.8.1.3 For Inverter Interface (voltage source & current source) Generators:

Generation Facility connecting to STS shall be grounded such that it meets COG<sup>8</sup> value of less than 80% under all system conditions. SaskPower reserves the right to require a COG value of less than 75% depending on Point of Interconnection (POI) to STS.

The Far North 66 kV System comprising of the Athabasca hydroelectric generation system, is delta connected and is not Effectively Grounded.

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<sup>7</sup> IEEE Std C62.92.1-2016 - IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems—Part I: Introduction

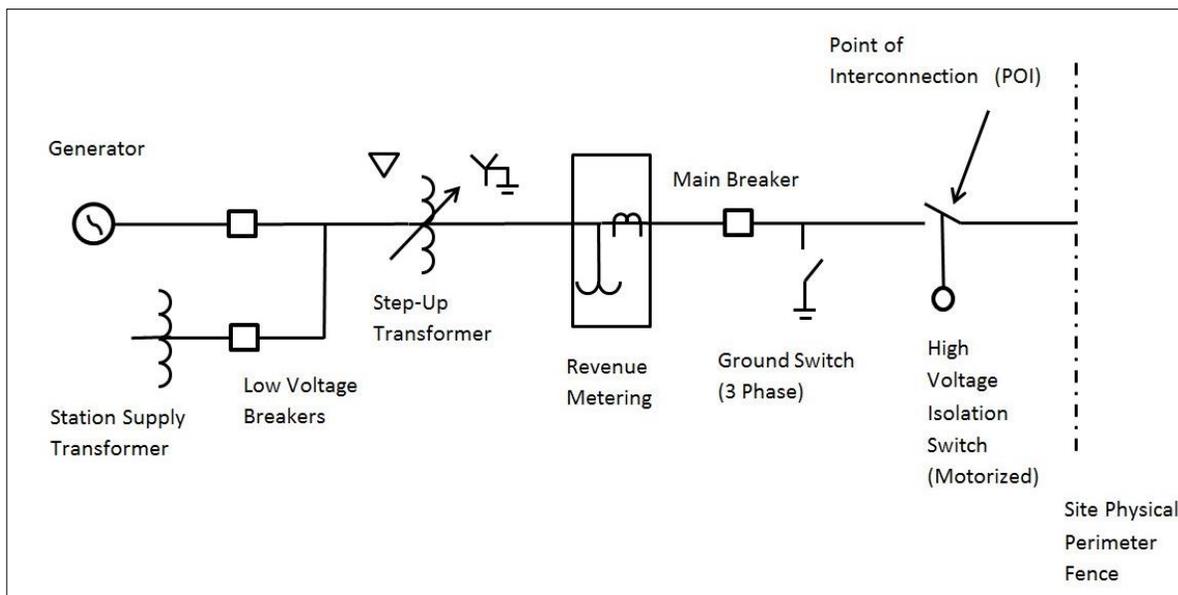
<sup>8</sup>Refer to IEEE Std C62.92.6-2017 – IEEE Guide for Application of Neutral Grounding in Electrical Utility Systems, Part VI – Systems Supplied by Current - Regulated Sources

### 3. GENERATION INTERCONNECTION FACILITY REQUIREMENTS

The requirements for the GIF are determined based on the characteristics of STS and the characteristics of the proposed GIF. The design and operation of the GIF shall be compatible and coordinated with STS intact and post contingency operating voltage range shown in Table 1.

#### 3.1. Typical Generation Interconnection Facility

For illustration purposes, a typical GIF configuration is shown in Figure 1 below. Actual configuration could vary with the generator representing a cluster of units on the low voltage side of the step-up transformer. The Entity must provide the proposed facilities protection single line drawings to SaskPower with the actual configuration.



**Figure 1 : Typical GIF**

- Point of Interconnection (POI): is the point of delivery to STS defined by the system side of the isolation switch.
- Maintenance Interface: defined by the system side of the isolation switch.
- Operating Interface: defined by the high voltage isolation switch that is a visible break device suitable for locking. It is located on the line side of the metering transformers and any Entity's equipment. It is recommended that the Entity consider a 3-phase manually operated ground switch to be used on the generator side of the isolation switch.

## 3.2. Equipment Ratings

All aspects of the equipment rating must be designed by the Entity to ensure long term requirements are met or exceeded. These equipment ratings include continuous operation capability, fault withstand capacity and fault interrupting device capability. All fault interrupting devices must comply with ratings that satisfy Design Maximum bus short circuit current withstand capability. The Entity must also ensure that electrical voltage insulation coordination requirements are met at the GIF. These requirements must comply with electrical voltage levels of the equipment on STS.

### 3.2.1. Overvoltage Withstand Capability Requirements

The Entity must ensure that the GIF is designed to withstand temporary voltage surges without damage or equipment loss of life, which are consistent with IEEE standards and Table 3 of this document.

#### 3.2.1.1. Impulses

GIF equipment exposed to lightning impulses must be electrically insulated by the Entity to levels consistent with requirements stated in Table 4 below as derived from Table 1 of the IEEE Std. C62.82.1-2010:

**Table 4: Basic Insulation Level or Lightning Level**

System Voltages (kV)	Impulse Level (kV)
72	350
138	650
230	1050

#### 3.2.1.2. Switching Surges

The Entity must ensure the equipment can withstand switching surge of several cycles and design the electrical equipment voltage withstand capability to three (3) times the nominal.

#### 3.2.1.3. Dynamic Overvoltage

The Entity must ensure that the GIF can withstand dynamic overvoltage which occurs for full load rejection of the generation due to separation from STS.

### 3.3. Interconnection Voltage

The Entity must participate in SaskPower system interconnection studies that determine the nominal interconnection voltage used for identifying equipment ratings specified in Section 2.5 of this document.

### 3.4. Transformer Requirements

#### 3.4.1. Winding Configuration

The Entity, in consultation with SaskPower, must ensure that the transformer winding configuration will result in an Effectively Grounded power system.

The transformer winding configuration chosen must block triplen harmonics as well as DC currents from being injected into STS by the GIF.

#### 3.4.2. Tap Changer Requirements

The Entity must ensure that the GIF matches the operating voltage range as specified in Table 3 of section 2.5.2 of this document. Utilization of on-load tap changers will assist GIF operations to match operating voltage of STS.

### 3.5. High Voltage Fault Interrupting Devices

The Entity must include a high voltage circuit breaker rated as per Section 3.2 to interrupt fault current contribution from STS or interrupt fault contribution from the GIF in event of fault on STS. The fault interrupting time of the connecting breaker will be determined by SaskPower during interconnection studies. The Entity must also ensure that the high voltage breakers and disconnect switches are rated to withstand 120 % of the system nominal voltage for five (5) minutes and **220 %<sup>9</sup> of the system nominal voltage continuously across the open contacts of the breaker.**

The Entity must design their protection systems to coordinate with STS's protection and ensure that the faulted GIF continues to trip even if the upstream STS protection trips before the local protection, at the GIF for the removal of the downstream fault. This is required to prevent STS from closing back onto faulted equipment at the GIF if the incoming breaker is not tripped.

SaskPower may require the high voltage interrupting device that connects the GIF's incoming transformer to STS to be capable of 'Point-on-Wave' switching to reduce the impact of energizing a transformer onto STS.

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<sup>9</sup> Required as per IEEE Std C37.100.1-2018 Section 5.3 Table 1b and IEEE Std. 1547 (Section 4.11.3) and to address system voltage slip seen by the open contacts of the breaker between STS and the GIF.

### **3.6. Disconnect Switch Requirements**

The Entity must ensure that a high voltage isolation visible break disconnect switch allows motorized control to disconnect the GIF from STS. As shown in Figure 1 of Section 3.1, the disconnect switch is located on STS side of the revenue metering instrumentation transformers. For maintenance, safety and system considerations, the Entity must include a three-phase maintenance ground switch connected between the high voltage isolation switch and the main breaker.

### **3.7. Anti-Islanding Scheme**

The Entity must collaborate with SaskPower to ensure coordination and implementation of an anti-islanding scheme which will remove the GIF to prevent a power island with any portion of STS. An anti-islanding scheme will include a local passive and/or active protection system component at the GIF and may include a communications-based transfer trip scheme which will trip the remote breaker(s). The Entity must demonstrate to SaskPower that the anti-islanding scheme will not negatively impact STS.

Passive anti-islanding may include:

- Underfrequency/overfrequency protection
- Rate of Change of Frequency protection
- Undervoltage/overvoltage protection
- Reverse Power/Under Power protection
- Vector Jump protection.

Active anti-islanding protection may include:

- Direct Transfer Trip
- Other active methods approved by CSA or ANSI/IEEE or UL.

The Entity must demonstrate to SaskPower any active protection chosen, other than the Direct Transfer Trip will not adversely impact STS.

### **3.8. Auto-Reclosing Requirements**

The Entity must comply with auto-reclose requirements of STS transmission lines which connect to the GIF. Auto-reclose is not an applied function at a GIF. For interconnected facilities, the main breaker must be tripped using a Direct Transfer Trip (DTT) signal from STS, to disconnect the GIF from STS during the line auto-reclose event.

## **3.9. Protection System Requirements**

Entity must ensure that the protection systems satisfy the functionality to protect primary electrical equipment and location-specific requirements of STS. The location-specific requirements will be specified by SaskPower for the protection scheme, coordination, and timing at the time of design.

### **3.9.1. Protection Operating Times**

For faults within the GIF, the Entity must ensure detection and clearance of faults in less than 100 ms total interrupting time. Transformer differential, bus differential and line impedance functions are some of the protection functions that fall within this total interrupting time requirement.

### **3.9.2. Internal Faults**

The Entity must ensure that the protection systems will utilize Dual Diverse protection schemes that will isolate the GIF from STS utilizing fault interrupting devices on occurrence of faults within the GIF. The protection non-lockout tripping must (seal in) for a specific fixed duration to assure that the local breaker will complete the trip, even if the protection functions reset due to removal of measured fault current by faster upstream protection. The circuit must reset and must repeat (pulse) if the fault persists.

### **3.9.3. External Faults**

In collaboration with SaskPower, the Entity must ensure that the GIF utilizes Dual Diverse line protection schemes that detect external fault conditions on the transmission lines connecting to the GIF and must provide accurate phase discrimination. These protection schemes will isolate the GIF from STS by tripping the main breaker. The protection non-lockout tripping circuit must seal-in and pulse similarly as described in Section 3.9.2. The Entity must ensure that the protection scheme coordination with the SaskPower protection scheme is documented in-regards-to communication requirements, protection functionality, thresholds, and logic to illustrate the design to SaskPower.

Communication system requirements will be based on communication aided tripping to accelerate total Fault Clearing Times to less than 100 ms.

The protection scheme(s) and settings will be determined by SaskPower and provided to the Entity to install and apply. SaskPower may specify the vendor and models to use, or SaskPower may supply the relays to ensure compatibility and operability of the protection scheme.

### **3.9.4. Abnormal Conditions**

The Entity must ensure that the GIF will self-protect, to prevent equipment damage for abnormal conditions such as faults, geomagnetic induced currents, harmonics, lightning, resonance conditions, self-excitation and switching surges which may occur on STS.

The normal operating frequency range is stated in Section 2.3 and the steady state voltage levels are listed in Section 2.2 for STS. The Entity must ensure that protection functionality is documented in-regards-to coordination with over/under voltage and over/under frequency protection of STS. The Entity must ensure that identification of all abnormal operating conditions is documented, studied, and mitigated to prevent equipment damage during disturbances.

### **3.9.5. Remedial Action Scheme (RAS)**

The Entity must collaborate with SaskPower and ensure implementation of a RAS if it is required to integrate the GIF into STS. The RAS could include generator run back, generator dumping and/or direct transfer tripping of the main breaker.

### **3.9.6. Breaker Failure**

The Entity must ensure that all GIF breakers include breaker failure functionality to isolate from STS utilizing a fault interrupting device that is not the failed breaker. This interrupting device may be local or remote and must incorporate a secure High-Speed communication, which may utilize SaskPower's or other leased line optical fibres. The breaker device that is electrically adjacent to STS must send breaker fail signal to SaskPower for breaker failure scenarios.

**The Entity must be responsible for designing their facilities to ensure a safe design for breaker failure situations. SaskPower will not assume responsibilities for any breaker failure scenarios.**

### **3.9.7. Coordination**

The Entity must ensure that documentation describing the protection relay settings, coordination timing charts, communication systems and logic is submitted to SaskPower at least six months before the in-service date for review to verify adequate coordinated protection functionality will be applied base upon SaskPower's protection design criteria. All protection work performed must be signed and sealed by a Qualified Consulting Engineer.

The Entity must ensure submission<sup>10</sup> of protection relaying devices technical information to SaskPower at a period of one year prior to the proposed in-service dates and prior to procurement of relay equipment to allow verification of compatibility with SaskPower systems. The Entity must ensure that SaskPower is advised of any future GIF changes including all relay setting changes<sup>11</sup> to facilitate protection coordination reviews prior to installation of changes, with the lead times stated in this section.

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<sup>10</sup> SEE APPENDIX A: PROTECTION – TECHNICAL INFORMATION REQUIREMENTS: for the specific requirements.

<sup>11</sup> Refer to NERC Standards: PRC-001-1.1(ii), PRC-019-2, PRC-024-2, PRC-025-2 & PRC-026-1 for requirements. The requirements specified in PRC-019-2 apply to units  $\geq 20$  MVA for single or the  $\geq 75$  MVA aggregate installations, where coordination is a requirement.

### **3.9.8. Testing**

The Entity must ensure that proper testing and commissioning of protection systems occur during the initial construction period and during subsequent regular maintenance test intervals and follow NERC PRC-005-1.1b. The Entity must provide SaskPower at least thirty days of notice for planned testing to allow witnessing of these tests.

The Entity must ensure that the protection relay system testing includes:

- a) Equipment manufacturer recommended tests.
- b) End to end communication system tests.
- c) Test equipment based electrical system simulation injection tests as identified by the interconnection studies.
- d) Any additional tests required by SaskPower.
- e) Submission to SaskPower of initial commissioning and periodic test result documentation must be signed and sealed by a Qualified Professional Engineer.

Any test information or reports provided to SaskPower by the Entity is for informational purposes. There is no inference that SaskPower approves the results or accepts any responsibilities for the application or design.

### **3.9.9. Protection Systems**

The Entity must ensure that all components of the protection systems installed within the GIF meets the IEEE C37.90-2005(R2011) standards for relays and relay systems as identified in Section 13 of this document. Where there are conflicts between the above standard and the requirements of SaskPower, the more stringent requirement should prevail.

### **3.10. Momentary Interconnection**

The Entity must ensure that momentary interconnections will not occur unless specifically stated and agreed upon and where the Entity will notify SaskPower in advance of each momentary interconnection. Momentary interconnection of a GIF could occur for transfer of loads to emergency generator bus using an automated high-speed load transfer switch to disconnect from STS. This process must be a fully automated make before break scheme that will disconnect the GIF from STS in < 100 ms after initiation.

Anti-islanding protection, effective grounding, and communications for tripping, protections to detect faults or other conditions on the STS are not required.

### **3.11. Communications**

The communication system must include an operational voice communication with the SaskPower Grid Control Centre (GCC) when the size exceeds 5 MVA for aggregated generation or for a single generator at the GIF. The communication terminal equipment is a dedicated integral system that is installed by SaskPower for protection and monitoring by a SCADA system Remote Terminal Unit (RTU). The Entity must provide physical space in an environmentally controlled building for the communication terminal equipment with a secure non-interruptible power supply for the equipment, which is always accessible to SaskPower.

### **3.12. Monitoring and Sequence of Event Recording**

The Entity must provide physical space in an environmentally controlled building for remote terminal unit (RTU) to provide monitoring and status time-tagged Sequence-of-Event Recording (SER) to facilitate fault event analysis and normal operating activity. Depending on the location, system conditions and generator capability, this requirement may be excluded by SaskPower. When an RTU is required, SaskPower will provide the device hardware that is compatible to the master SCADA system. The Entity will ensure that the RTU always has a secure non-interruptible power source for the RTU and provide access to SaskPower.

The RTU will provide the following data:

- Status of all high voltage breakers
- Status of disconnect switch
- Status of ground switch
- Status of low voltage breakers
- Net MW and (MVA<sub>r</sub>) at POI
- Net MW and (MVA<sub>r</sub>) at voltage side of station where generator is located or at point of main collector location.
- Voltage and frequency at POI
- Protection relay trip statuses
- Status of tele-protection schemes send and receive signals.
- Information specific to technology used, see Appendix D & E.
- The Entity must consult SaskPower to confirm if additional status points are required prior to design.

## Dynamic Disturbance Recorder (DDR)

The Entity must also install dynamic disturbance recording apparatus (unless granted exemption from SaskPower) to confirm the GIF continually meets the dynamic performance requirements during and after commissioning tests. The recording device must provide enough analog and digital points to record the pertinent information. The information from the recorder, as requested by SaskPower must be archived by the GIF owner and supplied upon SaskPower's request.

The sampling rates, triggering methods, monitoring selections and reporting format (such as COMTRADE) must be accepted by SaskPower prior to the authorization for the interconnection of the GIF to STS. The measurements must be synchronized, with GPS to the UTC time scale, with an accuracy of  $\pm 2$  ms.

The analog quantities requirements are:

- High speed quantities, with sampling rate of  $\geq 100$  samples/cycle for  $\geq 1$  s.
- Slow-speed quantities, with a sampling rate of  $\geq 1$  sample/cycle for  $\geq 30$  s.
- Pre-event recordings must be  $\geq 200$  ms. and  $\geq 5$  s for the high speed and slow-speed quantities, respectively.
- These sampling rates are based on the fundamental frequency of 60 Hz.
- The values monitored must include the three phase voltages and currents from various monitored locations.

The DDR triggering method will be determined, with SaskPower on a project basis, as these points are location sensitive. Typical triggering quantities are:

- Low frequency
- Low positive sequence voltage
- High rate of change of real and/or reactive power

Figure 2 below illustrates possible typical monitoring points. Specific monitoring points, quantities and specifics must be determined in collaboration with SaskPower.

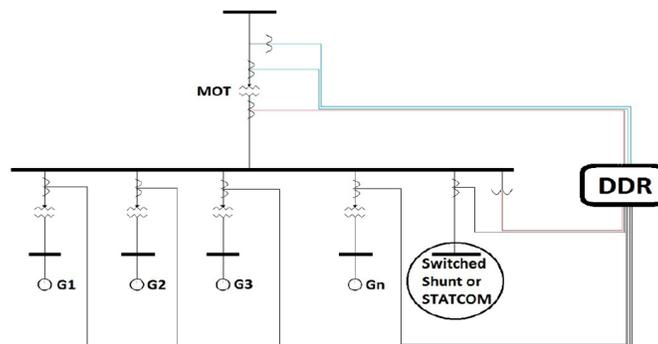


Figure 2 : Dynamic Disturbance Recorded Inputs<sup>12</sup>

<sup>12</sup> Borrowed from IESO document ID IESO\_REQ\_0208; Document Name: Part 2.20: Performance Validation, Issue 7.0

### **3.13. Revenue Metering**

In instances where a Power Purchase Agreement (PPA) or Generation Interconnection Agreement (GIA) is in place, the Entity must supply, install, maintain, and pay for all metering equipment, including instrument transformers, MWh-meters, gauges, monitors, data acquisition equipment, transducers, and associated equipment (collectively, the “Metering Equipment”) which shall be utilized to measure and record Metered Energy by the Entity’s GIF to SaskPower. This equipment must be Measurement Canada approved, verified, and registered. The metering equipment must be provided with dual register four quadrant revenues. All metering equipment must be revenue approved pursuant to the Electricity and Gas Inspection Act (Canada). The Entity is responsible for the supply and installation of SaskPower pre-approved communication devices to the revenue meter, for the exclusive use of SaskPower. If the Entity chooses SaskPower to install the metering equipment, then the Entity must provide space in an environmentally controlled building, suitable CT and PT mounting structures and conduits for instrumentation cables. The dual register metering equipment must be capable of recording real and reactive power delivery coming from or to the GIF separately.

### **3.14. Provision for Future Changes**

The Entity must ensure that all required GIF changes are made to meet new standards, revised standards, or SaskPower requests.

### 3.15. Control, Operating and Monitoring Requirements<sup>13</sup>

- The Entity must install and operate an aggregate GIF SCADA system which will allow individual generating unit monitoring and control, as well as aggregate control of the GIF's operating parameters to meet the specific requirements outlined in these interconnection requirements.
- The GIF's SCADA system must be capable of providing and accepting information required for the operation of the GIF via a SaskPower RTU within the conditions described in these interconnection requirements.
- The scope of the Entity's work for the GIF's SCADA system must include the connection to SaskPower's SCADA system via the SaskPower RTU, the GIF's main substation and the GIF's met towers and individual wind turbines, PV systems, aviation lighting, etc.
- Each wind turbine, PV cell bank, met tower, etc. must be equipped with a controller/Intelligent Electronic Device or similar equipment to interface with the Entity's aggregate SCADA system.
- The controller/Intelligent Electronic Device or similar equipment must continue to monitor the individual turbine, PV cell bank or met tower, storing up to one week of data and be capable of supplying the recorded data for retrieval, in the event of a communications network failure.
- An Uninterruptible Power Supply (UPS) system must be provided to ensure data collection is not interrupted by power disturbances.
- If requested, view-only remote monitoring capability that replicates the on-site GIF's SCADA screen(s) must be provided to SaskPower's Grid Control Centre (GCC) by the Entity.
- The Entity's SCADA system/controller must be capable of accepting a curtailment or increase signal from SaskPower's Grid Control Centre (GCC) via the local SaskPower RTU. The value received will represent the generated power to which the GIF will be curtailed or increased.
- The GIF's SCADA system/controller must be capable of requesting down to 0 MW of the GIF full rating curtailment range (equivalent to curtailment function off). The variation must be possible within the time frame determined by the ramp-rate control values entered the SCADA system/controller.
- The GIF's SCADA system/controller must accept a control value set by GCC via the local SaskPower RTU to enable/disable the ramp rate control function.
  1. The current ramp rate control status (on or off) and ramp rate value must be fed back into the local RTU for confirmation to GCC.
  2. Positive ramp rate control must be used during controlled (planned) start-up or other operation of the GIF.

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<sup>13</sup> This section supplements Section 3.12 of this document

3. Negative ramp rate control must be used during controlled (planned) shut-down or other operation including intermittent generation of the GIF (for example during the curtailment process or momentary cessation of wind or solar irradiance.)
  4. Under normal operating conditions following start-up, ramp rate control may be disabled by GCC via the local RTU, unless STS conditions require it.
  5. The current ramp rate in the GIF's control system must be fed back into the local RTU for confirmation to GCC.
  6. The GIF's SCADA system/controller must be capable of accepting a control value from the GCC via the local SaskPower RTU to provide a positive/negative ramp rate control of a specified %/min, of rating, depending upon the type of prime mover and generating technology used.
  7. If the ramp rate control function is enabled by GCC via the local RTU, the maximum positive ramp rate must not be exceeded during any controlled start-up and the maximum negative ramp rate must not be exceeded during any controlled shutdown or other operation of the GIF.
  8. Emergency shutdown of the GIF must not be controlled by the negative ramp control. Emergency shutdown must be used only during emergencies otherwise shutdowns are controlled via the ramp rate.
- The GIF's control systems must be able to regulate the interconnection voltage based on information received via the SaskPower RTU.
  - The following metering, status and indication values must be supplied to the SaskPower RTU from equipment in the GIF's main substation:
    1. Status and indication of all motorized switches and breakers.
    2. All power flow information at the interconnection (MW, MVA<sub>r</sub>, MVA, and power factor).
    3. All available voltages etc.

Appendix D includes information that the Entity must make available to the SaskPower RTU as per requirements listed in this document. The Entities are advised that the requirements in Appendix D are subject to revision by SaskPower.

### **3.15.1. Communication Systems**

The scope of the Entity's work includes any applicable GIF's dedicated communications links.

- The Entity must include details on the Entity's communications network (fibre optic, point-to-point wireless, etc.).
- The Entity must provide certification of network integrity and maximum attenuations, for the communications systems to different types of technology from individual generating units, including turbine generators, PV and met towers.

- All wireless communications must be encrypted using applicable industry best-practice solutions and updated as required.
- The type of wireless installation must be identified, together with the encryption technology that will be used.
- SaskPower will design and install the communications systems required between the local SaskPower RTU and SaskPower's GCC or BUCC.
- The Entity must provide the operational cyber security applications protecting the GIF's SCADA systems, including from SaskPower networks.
- The implemented operational cyber security systems must be designed and operated as per industry best practices relating to the protection of SCADA and industrial control systems.

The cyber security installations may or may not become subject to applicable NERC Critical Infrastructure Protection (CIP) cyber security standards.

### **3.15.2. Generation Forecast Data Requirements**

- The Entity must provide SaskPower with the data necessary to prepare electrical generation forecast for the GIF.
- The Entity must collect weather and other substation data as required and supply them to the SaskPower RTU on a near real-time basis, or with an update interval of no less than 5 s. SaskPower will poll its local RTU for related data with an interval of up to 10 s.
- The Entity must install and maintain permanent met towers around the Site to provide the capability of measuring and recording representative wind and solar data for all hours in the year.
- The number of permanent met towers required must be either (i) one (1) for wind farms with a nameplate capacity less than or equal to 90 MW or (ii) two (2) or more for wind farms with a nameplate capacity greater than 90 MW. Additional met towers may be required if the wind turbines are disbursed over a large geographical area.
- The locations and the quantities of the required met towers must be determined by SaskPower's generation forecasting service provider once the final locations of the turbines have been determined.
- The Entity is responsible for moving the met towers, if required.
- The Entity is responsible for the ongoing maintenance of the met towers.
- The Entity must provide SaskPower access to the met towers for the purposes of inspection and verification as SaskPower may reasonably request from time to time.
- The Entity is responsible for installing and maintaining enough measuring equipment at the GIF to collect the necessary data to reasonably determine the generating technologies' capabilities, including but not limited to wind turbines and PVs availability and the amount of derates.

- By noon Saskatchewan time on each Friday, the Entity must provide SaskPower the expected de-rates, on a per hour basis for the following two weeks, of rating. The Entity must provide an update to SaskPower of the expected de rates, if hourly changes are more than 5 MW or a specified percentage of installed capacity for any given hour.

## **4. GENERATOR REQUIREMENTS**

The following requirements pertain to the installation and operation of various types of generators including, but not limited to, conventional synchronous generators, non-conventional generators and other Distributed Energy Resources (DER) and Variable Energy Resources (VER). The generator requirements apply to any GIF that connects generating sources to STS and includes the generating source. Any references to aggregated generation will apply to conventionally connected synchronous generators as well as to the DERs and VERs.

The Entity must ensure that all required GIF changes are made to meet new standards. All generators must be capable of delivering rated output active power at a power factor of between +0.9 (lagging/over-excited) and -0.95 (leading/under-excited) at the step-up transformer LV side.

The GIF must operate to maintain the voltage set point specified by SaskPower's GCC within the continuous operating voltage levels of Table 3 with the reactive power capabilities and as per the mode(s) of operation identified in the facility studies.

Synchronous generators must comply with this document including, but not limited to, the SaskPower approved NERC requirements and the most recent applicable IEEE Std. C50.12-2005 (R2010), IEEE Std. C50.13-2014, IEC 60034-1-2017, and IEC 60034-3-2007.

Non-conventional generators must comply with this document, including, but not limited to, the SaskPower approved NERC requirements and applicable sections of-IEEE Std 1547-2018, as well as any additional requirements in the IEEE Std 2800, including grid forming capability. (Including,-but not limited to, inverter-based resources).

### **4.1. Excitation System Requirements for Synchronous Generation**

#### **4.1.1. Rated Current**

The excitation system must be capable of delivering continuously, at rated ambient temperature and within rated temperature rise, any value of field current from 0 to 110 % of the field current required by the generator at maximum overexcited capability, rated power factor, and over the full generator operating voltage range.

#### **4.1.2. Ceiling Current**

The excitation system must be capable of providing a ceiling current to the field of not less than 1.6 times rated field current for 30 s. For solid state excitation systems, the ceiling current must be attainable with one paralleled bridge removed, for units > 10 MVA.

### **4.1.3. Field Current at Reduced Voltage**

The excitation system, of synchronous generators, must be capable of continuous operation at full rated continuous current output at excitation system supply voltages ranging from 80 % to 110 % of generator-rated voltage. The entire excitation system must also be capable of operation at supply voltages of less than 80 % of generator rated voltage for loads, durations, and frequencies consistent with the generator manufacturer's run up and shutdown regimes, and with fault duty requirements.

### **4.1.4. Ceiling Voltage**

Ceiling voltage requirements are typically determined by system integration studies that include an assessment of transient stability. In cases where integration studies have not yet been conducted or machine characteristics are not well defined, the following may be used to establish a minimum requirement. Once integration studies, based on actual machine design parameters, are completed, the ceiling voltage or equivalent requirements may be increased, if required.

With exciter supply voltage, generator terminal voltage and field current at rated value, the exciter ceiling voltage must not initially be less than 2 times the excitation field voltage required for rated load field current.

At rated supply voltage and field current equal to 1.6 times generator rated field current, exciter ceiling voltage must be not less than 1.7 times generator rated load field.

In excitation systems where the ac supply voltage can be less than the rated value, the ceiling voltage may be reduced approximately in proportion to the reduction in supply voltage. Following restoration of the supply voltage, the excitation system must be capable of immediately going to ceiling voltage.

With positive field current flowing, the excitation system must be capable of supplying an adjustable negative ceiling voltage up to at least 0.70 pu of corresponding positive ceiling voltage positive field voltage defined above.

The excitation system is not required to supply negative field current unless identified by SaskPower.

### **4.1.5. Large Signal Response**

HIR excitation System Voltage Response Time must be equal to or less than 25 ms for a 0.05 pu deviation in terminal voltage, with the open loop DC gain of 200.

For a non-high initial response excitation system, the response ratio must be at least 1.0 pu/s (below 10 MVA).

#### **4.1.6. Small Signal Response**

The voltage regulating open loop DC gain (with the generator on open circuit and assuming operation on the air gap line) must be adjustable either continuously or in steps between 25 and 500. The gain characteristic must be linear, with the typical operating gain setting of approximately 200 located in the middle of the range of adjustment.

Maximum overshoot of generator output voltage to a step change when the generator is separated from the system under any conditions must not exceed 30 % and must be damped so that the number of swings does not exceed 2, nor extend beyond 2s.

#### **4.1.7. Voltage Regulation Capability Requirements**

The GIF must be capable of regulating the LV bus or the HV bus of the GIF's main substation step up transformer connected to STS. The regulating point will be determined by SaskPower during the interconnection process. The GIF must have voltage, power factor and reactive power control mode capabilities. Conventional synchronous generators and VERs must not cause STS service voltage to go outside the normal operating voltages defined in Section 2.2. (Also see section 7.4 of IEEE Std. 1547 for DERs & VERs).

The GIF must be equipped with a high-speed automatic voltage regulator capable of achieving 95 % of the reactive power final value within  $\leq 0.1$ s following a step change in voltage for synchronous generators equipped with a High Initial Response (H.I.R.) excitation system and for rotating excitation systems, a response ratio of  $\leq 2.0$ . The voltage regulator and reactive power resource (exciter system or equivalent) must be capable of controlling the generator terminal voltage without hunting, within  $\pm 0.5$  % of any voltage level (set point) between 95 % and 105 % of the rated generator voltage, provided the generator is operating within its (MVA) capability limits, linearly over the range from no load to full load.

An Automatic Voltage Regulator (AVR) or equivalent must be provided, having a negligible dead band and small signal response characteristics that enhance the transient stability of the generator (e.g., transient gain reduction or rate feedback).

The switching in of a reactive device must be delayed by 5 to 10 minutes immediately after disconnecting or tripping, when initiated either by the voltage regulation system or any other method. A shorter duration is acceptable if it is designed for a faster response to STS requirements and mitigates any stored energy in the reactive device.

The voltage regulation system must be capable of providing the reactive droop compensation to the range from 0 % to 10 %, where required by the generation technology.

The GIF must have at least one (1) continuously variable, continuously acting, closed loop, centralized control voltage regulating system or automatic voltage regulator that measures voltage compared to a set point, and will control reactive devices including generating units, dynamic reactive power resources, capacitor, and reactor banks.

A GIF and any approved external reactive power resource must have the capability to operate with the following requirements:

1. Automatic switching to manual control of the set point of the voltage regulating system of the GIF, precipitated by a PT or voltage regulator failure, or manually selected by operator.
2. Automated action of the voltage regulating system of the GIF, and
3. Controllable remotely from STS control facilities or local facilities.

The voltage regulating system or AVR must be able to operate in a voltage set point control mode to the exclusion of any other modes.

The voltage regulating system or AVR must measure voltage that represents the overall voltage response of the GIF.

SaskPower will specify in the functional specification for the GIF whether the reactive current compensation in the voltage regulating system or automatic voltage regulator must be implemented.

Excitation systems or equivalent for connected generators must be specified as High Initial Response (HIR) as defined by IEEE Std. 421.1-2007. The HIR must be applied to units'  $\geq 10$  MVA.

#### Voltage regulation requirement for non-synchronous/inverter-based resources

The GIF should operate in a closed-loop, automatic voltage control mode to stably maintain voltage at the Point of Interconnection (Point of change of ownership) to within the specified voltage schedule provided by SaskPower. The following shall be considered:

- A single plant connected to a bus should operate in voltage control that ensures no steady state error. In some scenario where other voltage controlling devices exist, some level of reactive droop may be required. Reactive droop control must be reviewed and approved by SaskPower.
- Multiple plants connected to a single bus should operate in reactive droop based on the droop setting provided by SaskPower. Reactive droop should be based on the scheduled voltage set point and the high and low schedule limits such that the entire capability of the resource from full leading to full lagging reactive power output should be utilized across the range of acceptable voltages. The reactive droop setting must be settable between 2% to 10%.

Overall Generating Facilities' reactive power-voltage control shall meet or exceed the performance requirements in Table 5 and

Table 6 for a step change in voltage due to small disturbance<sup>14</sup> and large disturbance<sup>15</sup>, respectively.

- The control system shall control voltage without hunting, within  $\pm 0.5\%$  of voltage set point.
- Reaction time should occur with no intentional time delay.
- Any overshoot in reactive power/current response should not cause voltage to exceed acceptable voltage limits.
- Varying grid conditions (i.e., grid strength) should be considered and behavior should be stable for the range of plausible grid impedances.
- The control set point must be adjustable and tunable in the field based on interconnection studies.

**Table 5: Dynamic Reactive Power - Voltage Performance for Small Disturbance<sup>16</sup>**

Parameter	Description	Performance Target for Small Disturbance
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change	<200 milliseconds
Rise Time	Time between a step change in control signal input (reference voltage) and when the reactive power output changes by 90% of its final value	<2 seconds
Overshoot	Percentage of rated reactive power output that the resource can exceed while reaching the settling band	<5%

<sup>14</sup> Where voltage remains within the continuous operating range and the plant-level controller maintains reactive power/voltage control

<sup>15</sup> Where voltage falls outside the continuous operating range.

<sup>16</sup> SaskPower Solar Interconnection Technical Requirements – Table 1 Dynamic Reactive Power – Voltage Performance for Small Disturbances & NERC Reliability Guideline – BPS-Connected Inverter-Based Resource Performance September 2018, Table 3.1

**Table 6: Dynamic Reactive Current-Voltage Performance for Large Disturbance<sup>17</sup>**

<b>Parameter</b>	<b>Description</b>	<b>Performance Target for Large Disturbance</b>
Reaction Time	Time between the step change in voltage and when the resource reactive current output begins responding to the change	<16 milliseconds
Rise Time	Time between a step change in control signal input (reference voltage) and when the reactive current output changes by 90% of its final value	<100 milliseconds
Overshoot	Percentage of rated reactive current output that the resource can exceed while reaching the settling band	Determined by SaskPower

#### **4.1.8. Reactive Power Capability Requirements at the POI**

**Synchronous generators must meet the following reactive capabilities:**

A minimum reactive power output (in MVar) equivalent to a power factor range of +0.95 pf (over-excited) to -0.95 pf (under-excited) or larger, measured at rated output and at 1.0 pu voltage on the HV terminals of the Facilities’ main substation step-up transformer connected to STS. This amount of output (in MVar) must be available over the entire real power operating range, down to the applicable minimum gross real power. The Entity must provide a capability curve for the synchronous generator(s).

#### **4.1.9. Power System Stabilizer (PSS) or Equivalent**

A PSS is required on all new synchronous generator installations. Existing synchronous generators must add a PSS upon new modifications to the generation system or upon renewal of the PPA and/or GIA.

The PSS must always be connected and engaged while connected to STS unless specifically exempted.

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<sup>17</sup> SaskPower Solar Interconnection Technical Requirements – Table 2 Dynamic Reactive Power – Voltage Performance for Large Disturbances & NERC Reliability Guideline – BPS-Connected Inverter-Based Resource Performance September 2018, Table 3.2

The Entity must advise SaskPower, in writing of known circumstances when a PSS will be out of service for prolonged periods, installation/maintenance of a PSS or change the settings of the PSS. This is required within 180 days of the known occurrence.

The PSS is expected to be in service 100 % of the time the generator is connected to STS, except for short delays of 30 min, regardless of reason. The PSS may be out of service for longer than 30 min for such incidents such as component failure, testing of elements, maintenance or upon agreement between the Entity and SaskPower.

The Entity must tune the PSS to accommodate the Inter-area mode criteria for the connection:<sup>18</sup>

- The PSS must be tuned to provide the measured, simulated, or calculated, compensated  $V_t/V_{ref}$  frequency response of the excitation system and synchronous machine such that the phase angle will not exceed  $\pm 30$  degrees through the frequency range from 0.2 Hz to lesser of 1.0 Hz of the highest frequency at which the phase of the  $V_t/V_{ref}$  frequency response does not exceed  $90^\circ$ .
- The PSS gain must be set to provide at least  $\pm 5\%$  of the synchronous machine's nominal terminal voltage.
- PSS gain must be set to  $\frac{1}{3}$  to  $\frac{1}{2}$  of Maximum Practical Gain.
- The PSS washout must not be any greater than 30 s.
- Units that have an excitation system or PSS that is incapable of meeting the tuning requirements for this inter-area mode are exempted from these requirements until the voltage regulator is either replaced or retrofitted such that the PSS becomes capable to meet the tuning requirements.

Contact SaskPower<sup>19</sup> for further guidance regarding tuning of the PSS.

The Entity must install and complete start-up testing of a PSS within 180 days of either:

- Connecting onto the BES after achieving commercial operation, or
- Replacement of the voltage regulator on the excitation system after achieving commercial operation.
- New connections of synchronous generators to STS.
- When additions/modifications are made to the existing synchronous generator or the signing of a new PPA and/or GIA.

The Entity must repair or replace the PSS within 24 months after the PSS becomes incapable to meet the tuning requirements.

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<sup>18</sup> The maximum gain available from the Power System Stabilizer based on the limitation of the system and equipment. From NEB VAR-501-WECC-3.1

<sup>19</sup> See Section 1.7 for contact information.

#### 4.1.10. Requirements During System Fault Conditions

The excitation system must not trip and must continue to operate during faults on the high voltage (HV) components of STS and must recover and return to normal operation immediately after the fault.

Controls should continue to operate down to generator terminal voltages approaching 20% of rated voltage and must continue to operate during the extremely unbalanced voltage conditions that could occur due to various HV faults.

The excitation system must be capable of withstanding switching surge voltages which may reach 2.5 times nominal supply voltage values and may persist for several cycles (60 Hz time basis).

The excitation system must be capable of withstanding 60 Hz dynamic overvoltage caused by load rejections as high as 1.5 times normal generator terminal voltage for several seconds.

Under system fault conditions, the excitation system must perform as described below, assuming initial loading at rating:

##### Case 1: Three-Phase Fault

A three-phase fault occurs on the HV bus. A HV breaker fails to clear the fault (stuck breaker). A backup breaker clears and isolates the fault. The generator remains online and returns to normal operation. Table 7 provides the approximate timing for the sequence of events.

**Table 7: Three-Phase Fault Timing and Sequence of Events**

Time	Description
At 0 cycles	A phase - high voltage fault occurs.
From 0 cycles to 21 cycles	The exciter goes to maximum available ceiling voltage.
At 21 cycles	The 3-phase fault is cleared.
From 21 cycles to 30 seconds	The exciter continues to operate at ceiling voltage until the field current equals 1.6 times rated field current; then at the voltage required to maintain this ceiling current (the exciter is assumed to maintain full ceiling current for rating the thermal side of the exciter).
Beyond 30 seconds	Exciter returns to, and continues, normal operation.

##### Case 2: Single Phase to Ground Fault

A single phase to ground fault occurs on a high voltage transmission line within the vicinity of the GIF. The fault on that phase is cleared by a single-phase breaker operation. The breaker recloses on the fault, then all three phases of the line breaker open. The generator remains online and returns to normal operation. **Table 8** provides the approximate timing for the sequence of events.

**Table 8: Single Phase to Ground Timing and Sequence of Events**

<b>Time</b>	<b>Description</b>
At 0 cycles	A phase to ground fault occurs on a high voltage line
From 0 cycles to 6 cycles	The exciter goes to maximum available ceiling voltage
At 6 cycles	The 1 phase to ground fault is cleared and the 2 un-faulted phases remain connected
From 6 cycles to 51 cycles	The exciter remains at ceiling voltage, attempting to restore generator voltage
At 51 cycles	The 1 phase to ground fault is reconnected
From 51 cycles to 57 cycles	The exciter remains at maximum available ceiling voltage.
At 57 cycles	The line is tripped
From 57 cycles to 30 s	The exciter remains at ceiling voltage until field current equals 1.6 times rated field current; then at the voltage required to maintain this ceiling current (the exciter is assumed to maintain full ceiling current for rating the thermal side of the exciter)
Beyond 30 s	Exciter returns to, and continues, normal operation.

## **4.2. Operating Voltage Requirements**

The Entity must ensure that the design and operation of the GIF is compatible and coordinated with the Equipment Requirements for the 60 Hz voltage values, along with the corresponding time durations are shown in Table 3, of Section 2.5.2.

## **4.3. Maximum Authorized Real Power**

The Entity must, upon receiving a request from SaskPower, determine the maximum authorized real power for the GIF and provide this value to SaskPower.

The Entity owning the GIF must consider the GIF’s capability and limitations under optimal conditions when determining the maximum authorized real power for the GIF.

## **4.4. Synchronizing and Reconnection to STS Facilities**

### **4.4.1. Voltage Fluctuation Limits**

The GIF must synchronize with STS without causing a voltage fluctuation at the POI and must meet the flicker requirements of Section 4.10 of this document.

#### **4.4.2. Synchronizing Equipment**

The GIF must be equipped with dual or (functionally alternate) automatic synchronizing equipment to minimize the impact of synchronizing to STS. The settings of the synchronizing system and the logic schematic drawings must be submitted to SaskPower for coordination. The Entity must ensure that the synchronizing settings will adequately protect the generator.

#### **4.4.3. Procedure to Synchronize**

The Entity must synchronize the GIF to STS by following applicable operating procedures, agreements, and instructions from the SaskPower GCC. This applies to the synchronizing of any portion of the GIF whether in its entirety or a single generating source with or without other sources at the GIF connected.

The GIF must only be synchronized to STS whenever the generation voltage regulation is available.

#### **4.5. Automatic Generator Control (AGC) or Equivalent**

The Entity must provide an interface on its governor or equivalent control that will accept an increase/decrease load signal from SaskPower's RTU, if SaskPower requests AGC or equivalent service. The rate at which the unit is to respond will be determined as part of the negotiation for the provision of this service.

#### **4.6. Station Service**

The Entity must determine, design, and specify the station service to meet the requirements for all operating conditions, such as post-contingency situations.

#### **4.7. Black-Start Capability**

SaskPower may request black-start capabilities of the Entity's facilities. Requirement details will be stipulated for governor or equivalent, voltage control, and synchronizing capability as part of the negotiation for the provision of this service. Communications between SaskPower and the various Black Start facilities is required to make system restoration possible.

#### **4.8. Reserve Requirements**

GIF may be required to participate in meeting the reserve requirements (spinning and non-spinning reserve). These values are to be determined by SaskPower.

## 4.9. Load Rejection

The GIF may be exposed to a full load rejection scenario.

## 4.10. Power Quality

Operation of the GIF must not result in deterioration of the power quality on STS and must meet the requirements as indicated in the following subsections. The SaskPower requirements will prevail over any other requirements.

### 4.10.1. Short Circuit Ratio and X/R Ratio Requirements

The Entity must determine and advise SaskPower, the minimum Short Circuit Ratio<sup>20</sup> (SCR) and X/R ratios that their GIF will operate with and confirm that the GIF will operate and meet the power quality requirements, stipulated in this document with respect to, voltage, frequency, harmonics, and flicker<sup>21</sup> when connected to a weak<sup>22</sup> system. SaskPower system grid information may be acquired from SaskPower to permit the Entity to perform the necessary analysis.

### 4.10.2. Voltage Fluctuation/Limitations of Flicker

The Entity must ensure the operation of the generator will not cause excessive voltage fluctuations or flicker<sup>23</sup> on STS as per the requirements of IEEE Std. 519-2014.

### 4.10.3. Voltage Distortion

The voltage distortion limits must meet with the general requirements for synchronous machines as described in the foot noted standards<sup>24</sup>. The requirements for voltage distortion for other forms of generation must also meet these requirements as well as other standards associated with the various other forms of generation listed in this document. To enable the Entity to design facilities to control voltage fluctuations; SaskPower will provide equivalent Transmission System impedances, upon request.

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<sup>20</sup> SCR is the ratio of the minimum fault level at the wind power plant LV voltage side of the transformer interconnecting to STS divided by the maximum rating of the wind generator or generator cluster.

<sup>21</sup> IEEE Std. 519-2014, IEEE Std. 1453 – 2015, IEEE Std. 1453.1 2012, IEC/TR3 61000-3-7:2008, IEC61000-4-15:2012, IEC 61400-21:2008, or most current version of each may be used for reference.

<sup>22</sup> A weak system location is defined as a location where the SCR is < 3 and the system X/R ratio is < 5.

<sup>23</sup> Voltage fluctuation includes but not limited to voltage drops due to transformer energization.

<sup>24</sup> IEEE Std. C50.12 2005(R2010), IEEE Std. C50.13 2014 or the most recent update, along with IEC 60034-1:2010, IEC 60034-3:2007.

#### 4.10.4. Limitation on Commutation Notches and Total Harmonic Voltage Distortion

Commutation notching of the 60 Hz fundamental voltage and the total harmonic voltage distortion must be limited to the values as described in Section 2.4 of this document and IEEE Std. 519-2014.

#### 4.10.5. Harmonics

The Entity must not inject harmonic currents into STS at the POI; the current distortion limits must comply with those specified in IEEE Std. 519-2014. Tables 3 and 4 from IEEE Std. 519-2014 are adapted herein and presented below in Table 9. The Entity must be exclusive of any harmonic currents due to harmonic voltage distortion present in STS prior to the connection of the GIF (See reference standards<sup>25</sup>).

**Table 9: Current Distortion Limits for Systems rated 66 kV through 161 kV**

Maximum Harmonic Current Distortion in Percent of $I_L$						
Individual Harmonics Order (Odd Harmonics) <sup>26,27</sup>						
Systems Rated 66 kV up to 161 kV						
$I_{sc}/I_L$	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h < 50$	TDD
$< 20^{28}$	2.00	1.00	0.75	0.30	0.15	2.50
$20 < 50$	3.50	1.75	1.25	0.50	0.25	4.00
$50 < 100$	5.00	2.25	2.00	0.75	0.35	6.00
$100 < 1000$	6.00	2.75	2.50	1.00	0.50	7.50
$> 1000$	7.50	3.50	3.00	1.25	0.70	10.00
Systems Rated $> 161$ kV						
$< 25^{28}$	1.00	0.50	0.38	0.15	0.10	1.50
$25 < 50$	2.00	1.00	0.75	0.30	0.15	2.50
$\geq 50$	3.00	1.50	1.15	0.45	0.22	3.75

As per IEC 60034-1-2017, the three-phase a.c. generators shall be suitable for supplying circuits which, when supplied by a system of balanced and sinusoidal voltages results in:

- a) Currents not exceeding a harmonic current factor of 0.05, and

<sup>25</sup> IEEE Std. 519-2014, IEC 61000-4-7:2009; CSA/IEC 61000-4-7: 2013, IEC 61000-4-30:2015, IEC 61000-4-15 – 2012 or most recent, IEEE Std. 1453-2015 & IEEE Std. 1453.1-2012 or most current version.

<sup>26</sup> Even harmonics are limited to 25% of odd harmonics above.

<sup>27</sup> Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

<sup>28</sup> All power generation equipment is limited to these values of current distortion, regardless of actual  $I_{sc}/I_L$ .

Where:

$I_{sc}$  = maximum short-circuit current at POI (PCC)

$I_L$  = maximum demand load current (fundamental frequency component) at the POI (PCC) under normal load operating conditions.

- b) A system of currents where neither the negative-sequence component nor the zero-sequence current component exceeds 5% of the positive-sequence component

HCF - harmonic current factor is defined by the expression:

$$\text{HCF} = \sqrt{\sum_{n=2}^k i_n^2}$$

where:

$i_n$  – is the ratio of the harmonic current  $I_n$  to the rated current  $I_N$  ;

$n$  – is the order of harmonic;

$k$  – 13

#### **4.10.6. Inter-harmonics**

The GIF must not inject inter harmonics<sup>29</sup> into STS. The 95 % percentile inter harmonics voltage injected by the GIF into STS must not exceed the values indicated in IEEE Std. 519-2014, Annex A, Figure A 1, and Table A 1.

#### **4.10.7. Limitation of DC Current Injection**

The GIF must not inject dc current > 0.5 % of the full load rated output current at the POI.

#### **4.10.8. Electromagnetic Interference**

The GIF must be designed to withstand Electro Magnetic Interference (EMI) including possible High-Altitude Electromagnetic Pulse (HEMP), High Power Microwave (HPM) and must not result in a change in state or cause mis-operation of the GIF as defined in IEEE Std. C37.90.2-2004 (R2010), IEEE 1613 2009, IEEE 1613.1 2013 or newer.

#### **4.10.9. Geomagnetic Induced Currents**

The GIF must be designed taking the expected effects of geomagnetic disturbances for the location of the GIF.

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<sup>29</sup> Reference to IEEE 519 – 2014, Annex A; IEC 61000-4-7:2009; CSA/IEC 61000-4-7: 2013; IEC 61000-4-15:2012; & IEEE 1453-2015. (Inter-harmonics are the frequencies that are not an integer multiple of the fundamental operating frequency of SaskPower. Inter harmonics are produced from such processes as variable speed drives, etc.)

## 4.11. Short Circuit Fault Contributions Requirements

The Entity may be required to design its GIF to limit fault contributions to STS to avoid exceeding the ratings on existing transmission facilities or limit infeed currents to permit STS protection to detect faults.

The GIF may be required to contribute fault currents, from the high voltage side of the interconnecting transformer for various fault configurations to STS with the following characteristics as follows:

- A momentary peak, immediately after fault inception occurs,
- A sub transient peak, 1 cycle of fundamental, after fault inception, and
- A transient peak, at 30 s after fault inception occurs.

## 4.12. Voltage Unbalance/Negative Sequence Capability Requirements

The GIF must be able to withstand the effect of voltage unbalance on STS, as indicated in Sections 2.2 and 4.12.

The negative sequence and zero sequence currents must not exceed 5 % of the positive sequence current under non-fault conditions.

The 3 phase GIF synchronous and induction (generators) connected to STS without any intervening power electronics, must be able to withstand the effect of negative sequence current<sup>30</sup> resulting from Transmission System disturbances. Besides the steady state unbalanced mentioned in the above paragraph, other factors which may result in negative sequence current, such as, faults, single phasing, must also be evaluated for impacts.

Single-phasing results from Transmission System faults with single-phase tripping and High-Speed auto reclose occurs (results in one out of three phases remaining open for up to 45 cycles). The Entity must ensure that the GIF is designed and protected, as per accepted standard practices, to avoid damage because of normal or delayed clearing faults, voltage surges or imbalances, off nominal frequency or voltage conditions and any other abnormal STS conditions. The Entity must also ensure that the GIF is protected to ensure an out-of-step (loss of synchronism) condition or other modes of instability do not result in equipment damage.

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<sup>30</sup> See IEEE Std C50.12 – 2005 (R2010) and IEEE Std C50.13- 2014 for reference.

### **4.13. Resonance and Self-Excitation Assessment Requirements**

The Entity must assess the effects and mitigation of potential resonance conditions such as:

- Ferro resonance,
- Sub synchronous resonance, and
- Harmonic resonance.

The Entity must assess the potential for self-excitation of generators and induction or synchronous motors within the GIF.

The Entity must ensure that self-excitation will not occur under any operating conditions (including islanding), and the effects of any possible resonance conditions do not result in any Transmission System performance violations.

### **4.14. Back-Up Power Requirements**

The Entity must identify any specific needs for back-up power for heat, marker lighting or generator parking during periods when the interconnection to the system is out of service.

### **4.15. Generator Protection**

The Entity must ensure that the generator is protected from all abnormal conditions.

The Entity's protection settings must coordinate with the SaskPower protection. The Entity must submit proposed relay settings to SaskPower for review. Any subsequent relay setting changes must also be submitted to SaskPower. The review by SaskPower does not infer any acceptance of responsibility or liability on SaskPower's part.

## 4.16. Inverter Based Resource (IBR) Requirements

### 4.16.1. Inertial and Frequency Response Requirements

The GIF must be capable of providing inertial and frequency response during under and over frequency events and system disturbances. The frequency response must have or be similar to a droop characteristic of 5 % (with a settable range of 1 % to 10 %) for all generating technologies as used by conventional generators, unless otherwise dictated by the interconnection study. The droop setting must be coordinated with SaskPower. See IEEE Std. 125-2007 for reference.

Wind power generation facilities are required to provide emulated inertia response based on the following:

- 1) The inertial response (active power boost) can be either proportional to the frequency deviation or a step increase when the frequency reaches a set threshold.
- 2) The inertial response activation threshold should be adjustable between -0.1 Hz to -1 Hz with respect to nominal frequency.
- 3) Proportional response must be triggered when the frequency is  $\leq 59.7$  Hz and provide a maximum boost at 59.3 Hz.
- 4) Step response must be triggered when the frequency is  $\leq 59.5$  Hz.
- 5) The boost activation must not exceed 1 s. For generation facilities with 4.0 MW or larger individual wind turbines, boost activation of up to 1.5 seconds will be acceptable.
- 6) The maximum boost must be  $\geq 6$  % of rated active power of each wind turbine generator in service.
- 7) The boost must last at least 10 s if the frequency remains under 59.964 Hz.
- 8) The boost must be cancelled if the frequency rises above 59.964 Hz.
- 9) The power withdrawn from the system during active power recovery must be  $\leq 20$  % of the pre-triggered active power.
- 10) The transition time duration from the maximum active power at  $\geq 6$  % to maximum generation reduction at  $\leq 20$  % must be  $\geq 3.5$  s.
- 11) Following activation, the boost capability must be available again in 2 minutes.

Inertial response must be available from each wind turbine generator generating at or above 25% of the rated power. Inertial response is not required from solar PV generation facilities unless notified by SaskPower.

All generation types (e.g., conventional, wind, solar, etc.) must reduce active power for frequency excursions outside of the  $\pm 0.06\%$  (i.e.,  $\pm 0.036$  Hz) deadband described in Section 4.16.2.

- The Governor must not be operated in isochronous mode while connected to STS.

Additional inertial response requirements may be specified in an interconnection study performed by SaskPower.

#### **4.16.2. Frequency Control Capability (Governor or Equivalent Operation) Requirements**

- The GIF must be capable of providing primary frequency control (frequency response) to frequency deviations from 60 Hz (under- and over-frequency events) and contribute to frequency control on STS. During STS under-frequency events, the GIF must be capable of providing an inertial frequency response in addition to the primary frequency response. The frequency response must be as stated in Sections 4.16.3 & 4.16.4, unless otherwise dictated by the interconnection study.
- The automatic control system design must have a frequency control setting equivalent to a droop setting in a conventional unit that is adjustable from 1 to 10 percent. Controls must be able to be tuned for stable steady state and transient response and must be capable of immediate and sustained response to frequency excursions greater than +/- 0.036 Hz. The fixed deadband must be between – 0.036 Hz to + 0.036 Hz. An additional adjustable portion of the deadband, for an over-frequency response must be settable from greater than + 0.036 Hz up to + 1.0 Hz. An additional adjustable portion of the deadband, for an under-frequency response must be settable from less than - 0.036 Hz down to - 1 Hz. The deadband settings are to be determined by SaskPower.
- The governor must have the capability of accepting manual set point adjustments within a range of 59.4 Hz and 60.6 Hz.
- The governor must have the capability of continuously monitoring the frequency of the electric system or the speed of a synchronous generating unit at a sample rate of at least 20 samples/s.
- The governor must have a resolution of at least 0.004 Hz.
- The GIF must limit the ramp rate capability to a percentage per minute of the unit(s) output power of the GIF. The percentage is dependent on the type of generating technologies associated with the prime mover. The ramp rate must not exceed in MW per min a range equal to 5 % to 20 % of the gross real power capability. The Entity must provide their proposed ramp rates to SaskPower. SaskPower reserves the right to request a different ramp rate. Therefore, the ramp rate will be determined jointly with SaskPower. New generating unit installations that are connected to STS with a gross real power capability  $\geq$  5 MW must have ramp rate control. A GIF with  $\geq$  5 MW must add ramp rate control, when new changes are made to an existing GIF or a new PPA and/or GIA is signed.

In the absence of wind or solar irradiance, a specific output of a percentage of rated MW and duration may be requested based upon interconnection studies. (See item 3 in section 3.15)

#### **4.16.3. Fast Frequency Response (FFR)**

- The Generating Interconnection Facility<sup>31</sup> must be capable of providing Fast Frequency Response (FFR) to SaskPower system. The Generating Facilities' SCADA system/controller shall be capable of accepting a reserve required (headroom) signal from SaskPower's Grid Control Centre (GCC) via the local SaskPower RTU representing the amount of power that is reserved and available for up ramp to provide fast frequency response as defined in IEEE Std 2800. The Generating Facilities' SCADA system/controller shall be capable of providing reserve (headroom) range of 0 MW to full rating of the Generating Facility. The initial droop settings for FFR will be provided by SaskPower. These settings should be able to be updated as required and requested by SaskPower.

#### **4.16.4. Primary Frequency Response (PFR)**

- The Generating Interconnection Facility must be capable of providing Primary Frequency Response (PFR) to SaskPower system. The Generating Facilities' SCADA system/controller shall be capable of accepting a reserve required (headroom) signal from SaskPower's Grid Control Centre (GCC) via the local SaskPower RTU representing the amount of power that is reserved and available for up ramp to provide primary frequency response as defined in IEEE Std 2800. The Generating Facilities' SCADA system/controller shall be capable of providing reserve (headroom) range of 0 MW to full rating of the Generating Facility. The initial droop settings for PFR will be provided by SaskPower. These settings should be able to be updated as required and requested by SaskPower. (See section 4.16.2).

#### **4.16.5. Automatic Generation Control (AGC)**

- The Generating Interconnection Facility shall be capable of providing Automatic Generation Control (AGC) service to SaskPower. The Generating Facilities' SCADA system/controller shall be capable of accepting a set point signal from SaskPower's Grid Control Centre (GCC) via the local SaskPower RTU. The Generating Facilities' active power output should be able to be controlled between 0 MW and maximum available MW output by SaskPower's AGC system. (See section 4.5)

#### **4.16.6. Negative Sequence Current Injection**

The GIF must have the capability to inject negative sequence current at the POI during unbalance faults. See page 74, section 7.2.2.3.4 of IEEE Std 2800-2022 for information particulars.

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<sup>31</sup> Generating Facility means supplier's generating power plant including any associated facilities and equipment required to deliver energy to the point of interconnection (point of change of ownership).

#### 4.16.7. Design and Operation of the Facilities' Continuous and Dynamic Reactive Power Capability.

As defined in IEEE Std 2800<sup>32</sup>, the Generating Interconnection Facility must be capable of providing the rated reactive power output for the active power output range of 0 MW to full rating of the Generating Facility.

##### **Must Meet the Following:**

Reactive power output (in MVar) equivalent to a power factor range of +0.95 (over-excited) to -0.95 (under-excited) or larger, measured at rated output and at the high voltage terminals of the Facilities' main substation step up transformer connected to STS must be available over the full voltage range under normal operating conditions except for the following:

- The POI voltages higher than 1.08 pu, the facility is not required to deliver reactive power (over-excited mode) corresponding to the power factor of 0.95. (See Figure 3)
- The POI voltages lower than 0.93 pu, the facility is not required to absorb reactive power (under-excited mode) corresponding to the power factor of 0.95. (See Figure 3)

The reactive power capability variation with respect to the voltage is shown in Figure 3. The capability may also vary with the number of wind turbines in-service.

This amount of reactive power (in MVar) must be available down to 0% of the operating range of the Facilities for injection of active power, with the following exception:

- For an IBR plant consisting of type III WTGs that are not connected to the STS via a VSC-HVDC line, the minimum reactive power capability requirement when the active power output is less than  $0.1 \times$  IBR Continuous Absorption Rating (ICR) may vary with the power factor as shown by the dashed line in Figure 4 due to limitations of the technology.

Figure 4 & Figure 5 also applies to inverter – based WTG, and other IBR based Generation. Figure 4 represents active power injection and Figure 5 represent active power absorption.

Higher levels of reactive power capability may be required, if determined necessary, by SaskPower. The minimum reactive power capability and control within the continuous operating region must be dynamic as defined by time response specifications in Table 5 and Table 6.

Reactive power capability may be supplied by an auxiliary source upon approval from SaskPower. Auxiliary sources such as power electronics-based systems (e.g., the IBR units, static var compensator [SVC], static synchronous compensator [STATCOM], etc.), and rotating machines (e.g., synchronous machines) shall be considered dynamic. Reactive power compensation from

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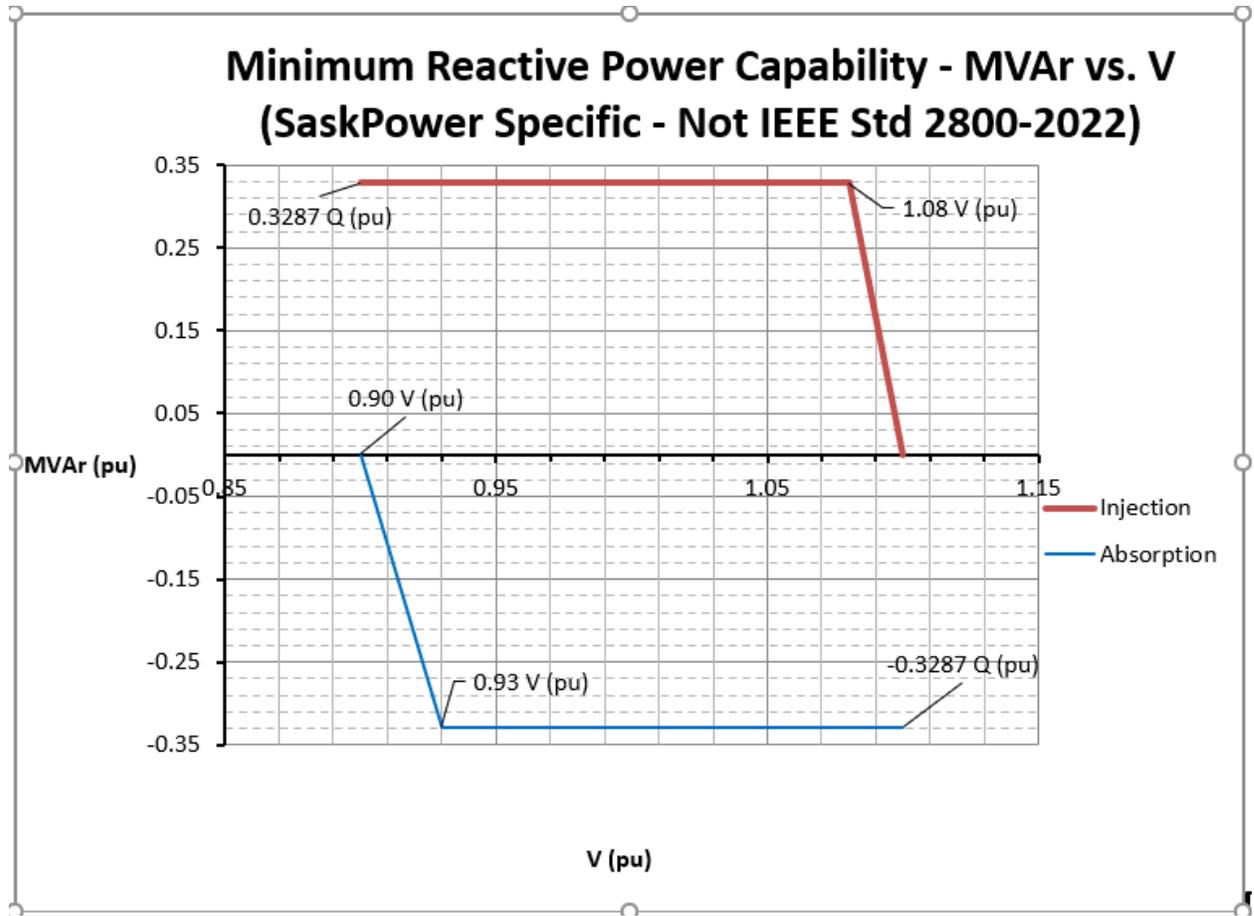
<sup>32</sup> Refer to Section 5.1 and Figure 6 of IEEE Std 2800-2022 or corresponding section of later versions.

synchronous machines shall be considered dynamic only if the excitation is automatically controlled to meet the IBR plant reactive performance requirements, including dynamic response.

- Electronically switched compensation devices (e.g., thyristor-switched capacitors) may be considered dynamic and may be used to meet a portion of the required minimum reactive power capability requirements if their switching is coordinated with variable reactive power sources such that the net IBR plant reactive power output is continuously variable.
- Reactive power from mechanically switched reactive power compensation devices (e.g., shunt capacitors and shunt reactors) shall not be considered dynamic. But such compensation devices may be used to compensate for the reactive power losses between IBR units and the Point of Interconnection (POI). If non-dynamic reactive power compensation devices are used to compensate for reactive power losses between IBR units and the STS, they must be automatically controlled such that the IBR plant maintains the minimum required dynamic reactive power capability. Mechanically switched compensation device switching shall be coordinated with the dynamic devices such that there are not significant discontinuities or step changes in the net IBR plant reactive power and must meet the SaskPower quality requirements. Determination of slow or fast switching of the reactive device shall be as per Section 4.1.7.

It is the GIF owner's responsibility to demonstrate that this will not result in any overvoltage violations following generation rejection, because of generator self-excitation, or due to any other condition. The Facilities owner is responsible for providing any needed redundancy for the auxiliary source of reactive power, enough to avoid impacts to its generation availability. If the auxiliary source of reactive power is off-line, the Facilities will be required to operate at a reduced MW output or be disconnected. If other equipment is out of service that affects the reactive power capability of the Facilities, the Facilities may be required to operate at a reduced MW output or be disconnected.

The Facilities owner must provide SaskPower a reactive power capability curve (including voltage dependency) for the Facilities over its operating range at the high voltage terminals of the Facilities' main substation step up transformer.



**Figure 3 : Reactive Power Capability Variation with Respect to the Voltage for Inverter Based Resource Generation**

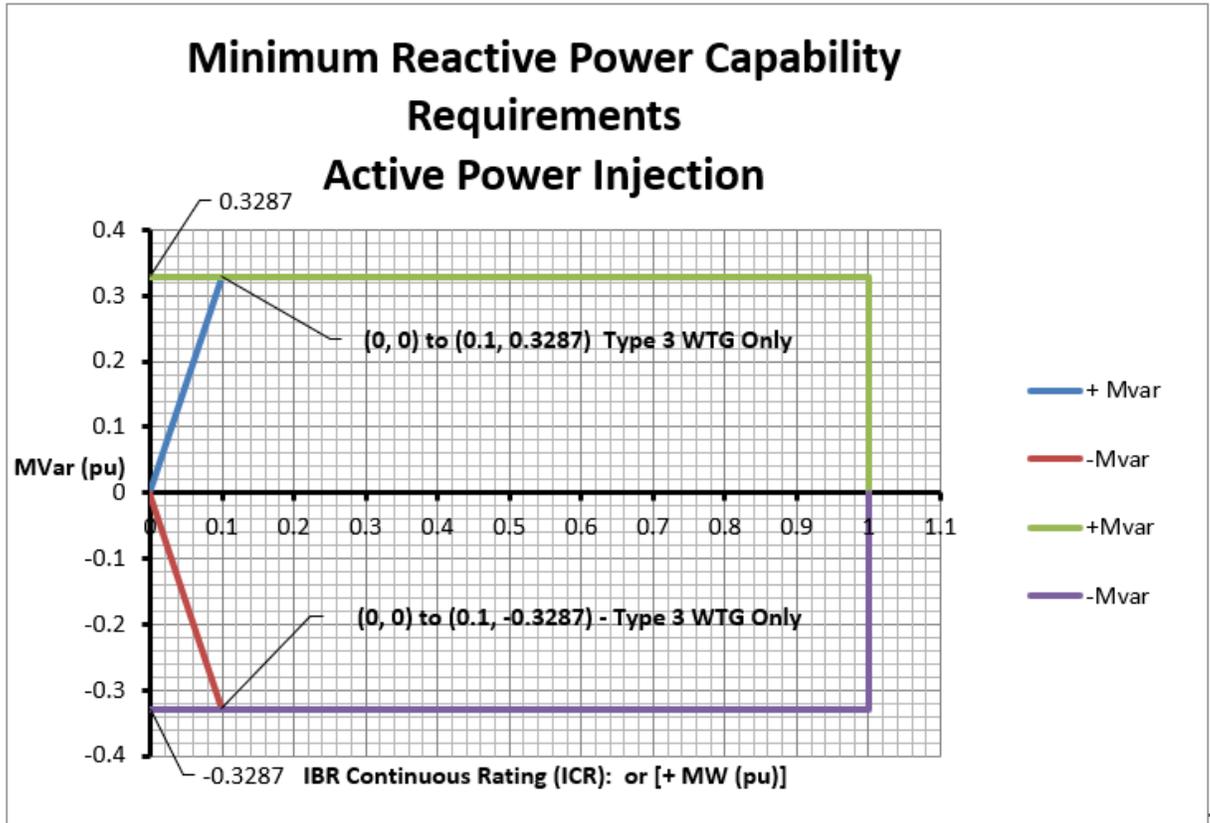


Figure 4 :Minimum Reactive Power Injection Capability Requirements for Inverter Based Resource Generation

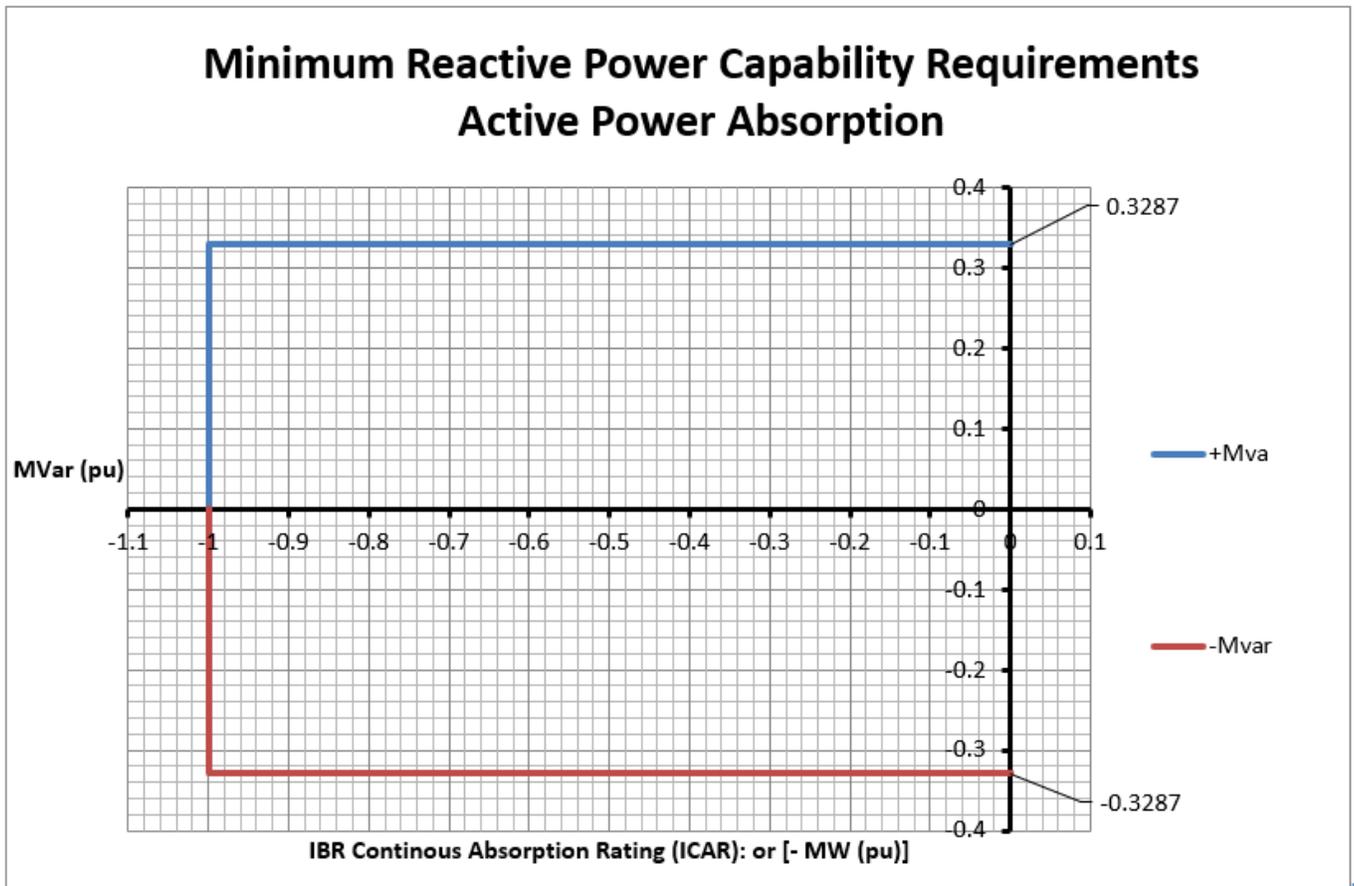


Figure 5 :Minimum Reactive Power Absorption Capability Requirements for Inverter Based Resource Generation

#### 4.16.8. Required Data for Inverter Based Generators

- The Generation Interconnection Facilities' active power output should be able to be controlled between 0 MW and maximum available MW output by SaskPower's AGC system. See APPENDIX D: REQUIRED DATA FOR WIND TURBINE GENERATORS and APPENDIX E: REQUIRED DATA FOR INVERTER BASED RESOURCE GENERATORS for required data information.

### 4.17. Short-Term Off-Frequency Operation Requirements for Conventional & IBR

Generators must have a short-time capability of off-frequency operation and must not trip, for the frequency values illustrated within the Eastern Interconnection of the No Trip Zone in Attachment

1 of NERC PRC-024-2, Figure 6 and Table 10, Off Nominal Frequency Capability Curve, for the Eastern Interconnection.

The PRC-024-2 off Nominal Frequency Capability Curves specify a “No Trip Zone” for protection system (and control system) settings. Outside of the “No Trip Zone” should not be interpreted as a “must trip zone”.

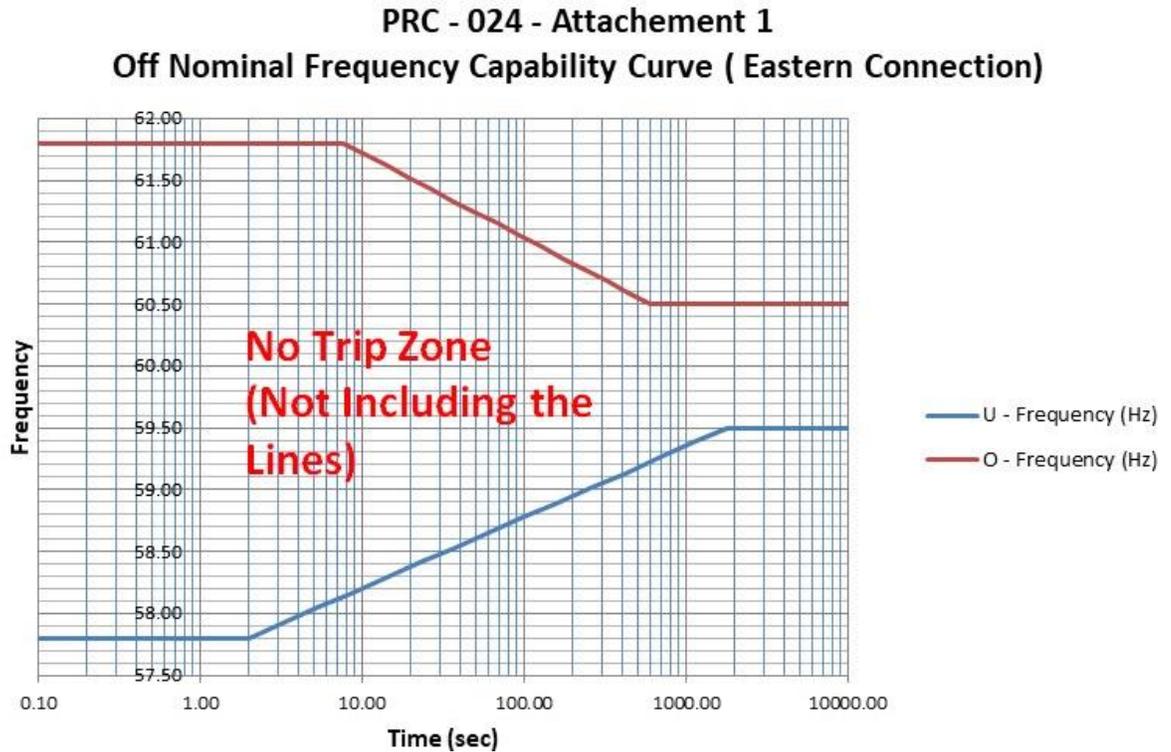
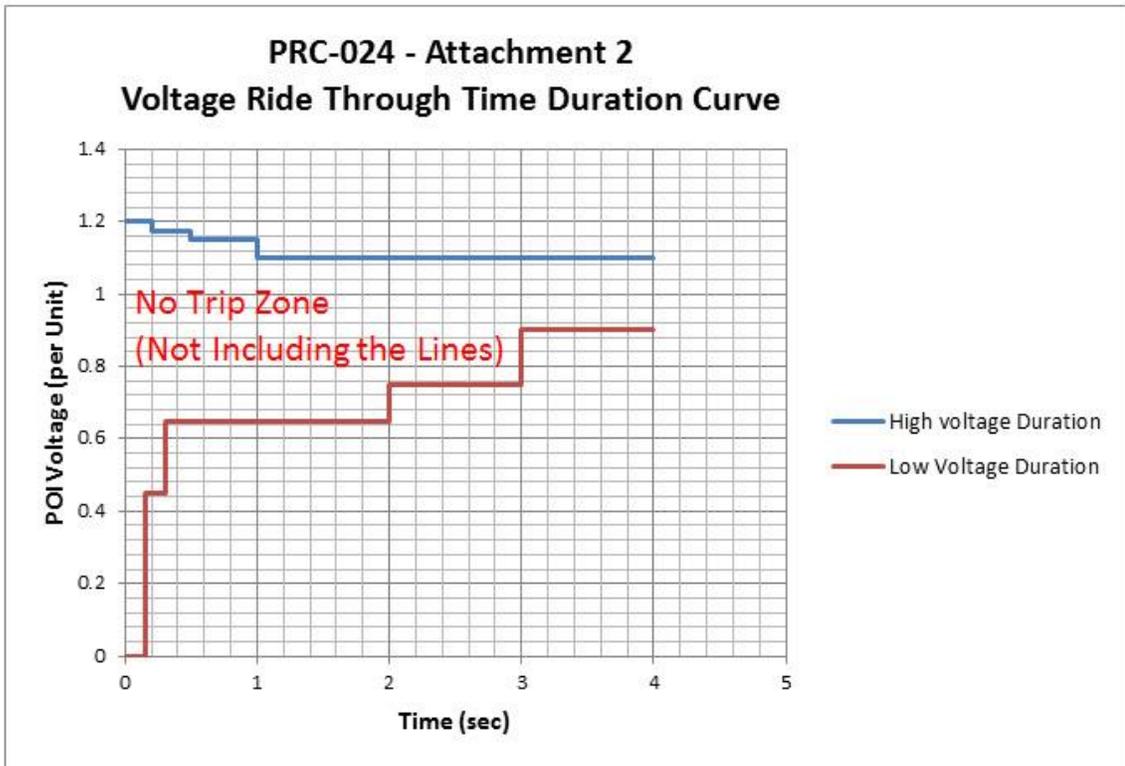


Figure 6 : Off Nominal Frequency Capability Curve





**Figure 7 : Voltage Ride-Through Time Duration Curve**

**Table 11: Voltage Ride-Through Duration Curve Values**

High Voltage Ride Through Duration		Low Voltage Ride Through Duration	
High voltage Duration	Time (s)	Low Voltage Duration	Time (s)
≥ 1.200	Instantaneous	< 0.45	0.15
≥ 1.175	0.2	< 0.65	0.30
≥ 1.150	0.5	< 0.75	2.00
≥ 1.100	1.0	< 0.90	3.00

Momentary cessation of inverter output must not be used within the voltage and frequency ride through curves specified in PRC-024-2. Use of momentary cessation is not considered “ride through” within the “No Trip” zone.

#### **4.19. Power Island/Anti-Islanding and Inadvertent Energization**

- The GIF must not operate as a power island while connected to any isolated parts of STS or SaskPower customers, unless explicitly granted approval by SaskPower to do so. All facilities must have local Anti-Islanding protection.
- The above stated protection must coordinate with other protection on STS. Where SaskPower determines it is necessary, a dedicated communication signal will be sent from STS to trip the generation facilities' main breaker for anti-islanding purposes.
- The Entity must apply technologies in their anti-islanding protection that will not inject signals that will interfere with any other Entity's anti islanding protection.
- The Entity must not energize STS while STS is de-energized, unless required for Black Start capabilities. The Entity must also apply protection to prevent inadvertent energization of the GIF or STS.

#### **4.20. Loss of Synchronism**

Loss of Synchronism protection is required on generation connections and to mitigate pole slipping or out of phase commutating of Inverters that may affect flicker limitations in reference to Section 4.10.2 of this document or as required by SaskPower. This feature must be available and must be enabled if requested by SaskPower.

### **5. TESTING, COMMISSIONING & REPORTING REQUIREMENTS**

The Entity must propose and follow a set of test plans for the equipment. The test plans must include the following: design, production, commissioning, interconnection conformance, acceptance and periodic interconnection testing of the GIF to ensure a safe, reliable operation of individual generating units or as a cluster that is compliant with the requirements of the governmental authorities, applicable reliability standards and compliant with the requirements in this document or any other requirements as stipulated by SaskPower. For some tests, a type test with supporting documentation on an identical system would be considered in place of an actual on-site test.

The Entity must submit an electrical commissioning/test report prior to the commercial operation date.

The Entity must provide SaskPower with the proposed test plan for review prior to testing and must provide SaskPower with reasonable opportunity to witness any or all the tests.

## **5.1. Testing Requirements**

### **5.1.1. Type (or Design) Tests**

Design tests must be performed on the specific interconnection technologies to confirm the technology meets the design specifications. If there are significant multiple items in the technology, a representative quantity may be tested instead of the total. These tests may be performed at the factory, at the installation Site or with independent certified test facilities.

The design tests must include but are not limited to:

#### **5.1.1.1. Response to Abnormal Voltages and Frequencies**

The GIF must not be connected to STS when the frequencies and voltages meet or exceed the limits as indicated in Section 4.17 and Section 4.18 of this document.

#### **5.1.1.2. Synchronization**

Test result demonstrating conformance to the requirements of the three sections, below; 5.1.1.2.1, 5.1.1.2.2, 5.1.1.2.3 must be provided to confirm compliance with Section 4.4 of this document.

SaskPower will accept no responsibility for damage within the GIF, due to out-of-phase reclosing or conditions that cause generators to pull out-of-step (loss of synchronism).

##### **5.1.1.2.1. Synchronous Interconnection Test**

This test must demonstrate that upon the closure of interconnecting device of the Entity, to STS, that the values in Table 12 will not be exceeded. The paralleling device must not close if any of the values in Table 12 are exceeded. Units larger than 5 MVA will require special studies, which may require a significant lead time. Single units or aggregate of units installed and greater than 5 MVA may require different tolerances. For units of this level, please contact SaskPower.

**Table 12: Limiting Value for Paralleling<sup>33</sup>**

Aggregate Rating of Generation Unit (kVA)	Frequency Difference ( $\Delta F$ , Hz)	Voltage Difference ( $\Delta V$ , %)	Phase Difference ( $\Delta \phi$ , °)
0 – 500	$\leq 0.3$	$\leq 10$	$\leq 20$
> 500 – 1,500	$\leq 0.2$	$\leq 5$	$1 \leq 5$
> 1,500 – 20,000	$\leq 0.1$	$\leq 3$	$\leq 10$

**5.1.1.2.2. Induction Generator or Motor Interconnection**

Induction Generators or Induction Motors that may become generating sources must be tested and must meet Table 12 requirements. The values from these tests must be used to determine the maximum start up (in rush) current drawn by the unit or installation to determine the voltage drop for the starting of the generator or aggregate of the combined units or determine the starting order of the units if they are varying in kVA/MVA rating and must not exceed the values in Section 4.4 for voltage fluctuation on paralleling and Section 4.10.2 on Flicker in this document.

**5.1.1.2.3. Inverter Interconnection Integrity**

- The paralleling device, for any inverter-based GIF that produces fundamental voltage prior to closing, must follow the same testing requirement limits for synchronous generation as specified in Table 12.
- Testing must be performed to determine the maximum start up current and thus the maximum expected voltage drop while starting the particular generation installation to ensure it meets the values in Sections 4.4 and 4.10.2, for all types of inverter-based GIF that do not produce a fundamental voltage prior to paralleling.

**5.1.1.3. Interconnection Integrity Test**

Commissioning tests are required for the complete GIF. An interconnection integrity test checks the individual components to confirm proper operation at the desired condition(s).

**5.1.1.3.1. EMI Protection Requirements**

The GIF must be tested according to ANSI C37.90.2 2004 (R2010) & IEEE 1613 2009 (with Class 2 rating) to confirm that the installation complies with Section 4.10.8 of this document.

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<sup>33</sup> From Table 5 of IEEE 1547-2018

#### **5.1.1.3.2. Surge Withstand**

The GIF must be tested for the requirements for surge withstand in Section 3.2 of this document and IEEE Std. C37.90.1-2012 and IEEE 1613-2009 (with Class 2 rating), or most recent versions.

#### **5.1.1.3.3. Paralleling**

Dielectric testing must be performed across the open contacts of any paralleling device to confirm the device meets the requirements as stipulated in Section 3.5 of this document. The open contacts of the paralleling device must continuously withstand 2.20 pu (220 %) <sup>34</sup> of rated voltage.

#### **5.1.1.4. Unintentional Islanding**

- A test must be performed to confirm the correct operation of any anti islanding protections applied. The quantities monitored, range, and time of operation must be met that removes the GIF from STS in case islanding occurs, as stipulated in Section 4.19 of this document.
- Test and/or simulation must be performed to confirm that there are no interactions between various types of generation and conversion systems, new and older, that will cause any GIF to maintain voltage while connected to any isolated portion of STS, unless requested to do so by SaskPower.

#### **5.1.1.5. Limitation of DC Injection Test**

Inverter-based generation connections must be tested to confirm that the injection of DC current into STS meets the requirements of Section 4.10.7 of this document.

#### **5.1.1.6. Harmonics**

Single frequency and Total Harmonic Distortion measurements may be conducted by SaskPower at the POI, Entity's Site, or other locations on STS to determine whether the Entity's equipment is the source of excessive harmonics. Refer to sections 4.10.5 & 4.10.6.

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<sup>34</sup> Required as per IEEE Std C37.100.1-2018 Section 5.3 Table 1b and IEEE Std. 1547 (Section 4.11.3) and to address system voltage slip seen by the open contacts of the breaker between STS and the GIF.

### **5.1.2. Production Tests**

The GIF with adjustable set points must be tested at a single set point as specified by the manufacturer. The test may be conducted at the factory or at the Site during commissioning. Each GIF must be subject to the requirements of the “Response to Abnormal Voltages and Frequencies” and the “Synchronous Interconnection” test as describe in Section 5.1.1.1 of this document.

### **5.1.3. Commissioning Tests**

The commissioning tests must be performed to verify the integrity of the GIF from the generating source to the POI that the GIF meets the requirements of the standards previously named. Previous stated test requirements are for specific parts of the entire GIF. Any of the type (or design) tests and production tests not previously conducted must be tested during commissioning. All commissioning tests must be based on written and approved test procedures.

#### **5.1.3.1. Ground Integration with STS**

System design verification must be made to ensure that the requirement is met, that the grounding scheme of the GIF must not cause overvoltage that exceeds the ratings of the equipment, connected to STS, as stated in Section 2.5.2 of this document and must not corrupt the ground fault protection coordination on STS.

#### **5.1.3.2. Isolation Device**

System design verification must be performed to confirm that the requirements of Section 3.6 of this document are met.

#### **5.1.3.3. Monitoring**

System design verification must be performed to confirm that the required monitoring design as specified in Section 3.12 of this document is met.

#### **5.1.3.4. STS Faults**

System design verification must be performed to confirm that the GIF will cease to energize STS for faults located within the area or local STS it is connected to.

#### **5.1.3.5. STS Reclosing Coordination**

System design verification or test must be performed to verify that the GIF is disconnected from STS prior to reclosing of STS lines as indicated in Section 2.7 of this document for High-Speed auto reclosing and for slower speed restoration.

#### **5.1.3.6. Reverse-Power, Minimum Power, and Other Anti-Islanding Protection Tests**

Any protection schemes designed to detect unintentional islanding must be tested to ensure these devices detect and operate as per design to disconnect the GIF upon loss of continuity between the GIF and STS (schemes such as but not limited to, reverse power or minimum power, vector jump, over/under frequency, over/under voltage, direct trip receive communications are possible options).

This may be done by injection or creating actual modifying system conditions to meet the triggering condition.

#### **5.1.3.7. Cease to Energize Functional Tests**

The unit breakers along with the various applied anti islanding protection must be tested together to verify that the scheme operates and cease to energize STS, as designed to remove the GIF from STS, within the time required and if an auto restore scheme is used that the time delay meets design parameters.

### **5.1.4. Interconnection Conformance Testing**

The Entity must perform tests for generation equipment Interconnecting generation sources with STS, for reference and guidance in the testing of the GIF, as many items are applicable for connections to the transmission or distribution systems. Where SaskPower requirements are more stringent, the SaskPower testing requirements must prevail. Refer to IEEE Std 1547.1-2020.

### **5.1.5. Performance Testing & Parameter Validation**

Dynamic performance tests and machine or generator parameter measurements include, but are not limited to:

- Governor response tests.
  - AVR and exciter response test.
  - PSS response tests.
  - Machine parameter validation tests.
  - Steady state tests.
  - Capability tests, and
  - Limiter tests.
- Each generator must be tested in accordance with Saskatchewan adopted NERC requirements for Generation owners: MOD 025 2; 026 1; 027-1: PRC 019 1; - 024 2. Testing is also required to verify compliance with these requirements, or other contractual requirements, and to demonstrate acceptable performance.

- The Entity must provide the tested and validated capabilities of the GIF, PSS/E NERC power flow, short circuit, dynamic models and the PSCAD models of their interconnected generation facilities to SaskPower. The models must contain at least the generation source, wind turbine/PV, interconnecting transformer, and any auxiliary equipment. Where the models are proprietary, non-proprietary models may be provided instead. Up to date models compatible with the current and new releases of PSS/E and PSCAD must be provided.
- The Entity must provide SaskPower with the tested parameters of all units 5 MVA and greater and units less than 5 MVA if SaskPower determined it is necessary.
- The Entity must provide SaskPower with the information from periodic re-tests following unit maintenance and following unit modifications as required.

Where SaskPower has similar or more stringent requirements, the SaskPower requirements must prevail.

#### **5.1.6. Acceptance Testing**

Acceptance testing shall be performed on all generators and generating equipment not pre-certified by a nationally recognized testing and certification laboratory as suitable for utility interconnection and in compliance with the applicable codes and standard.

Equipment acceptance tests should include, but are not limited to:

- HV cable insulation testing, transformer, switch gear, and generator.
- testing of the protective relaying system.
- SCADA system.
- VER control systems.
- voltage and power factor regulation systems.
- frequency control system.

The Entity must propose which tests will be required prior to energization of individual VER or groups of VERs' and which tests will be required prior to energization of the GIF.

#### **5.1.7. Periodic Interconnection Tests**

All interconnection related protective functions and associated batteries must be periodically tested at specified intervals from the manufacturer, system integrator or authority which has jurisdiction over the GIF. Periodic test reports or logs for inspection must be maintained and available.

Machine or generator capability tests must be conducted annually for each individual unit within the GIF and the results provided to SaskPower. Following receipt of the test data, SaskPower will

review the data for informational modeling purposes. SaskPower may request additional tests or the repeat of tests. In addition to the above requirements, it is anticipated that the proposed test plan will include the following or similar tests as in Table 13:

**Table 13: Test Plan Quantities**

Test	Quantities
1. Start-up Test	Run through start up sequence: <ul style="list-style-type: none"> <li>• Demonstrate that the power gradient is within the maximum allowable power ramp rate.</li> <li>• Monitor voltages on collector system and at the low and high voltage terminals of the GIF's main substation step up transformer connected to STS (POI) to confirm compliance within specifications.</li> </ul>
2. Full Output Reduction Test	Simulate shutdown of the GIF at full output: <ul style="list-style-type: none"> <li>• Demonstrate power gradient during shutdown does not exceed the maximum allowable power ramp rate, notwithstanding emergency or protection limits.</li> </ul>
3. Voltage Regulation Test	Demonstrate the ability to regulate voltage at the machine terminals and at the low and high voltage terminals of the GIF's main substation step up transformer connected to STS (at the POI) as required by the specification.
4. Power Factor Regulation Test	Demonstrate the ability to regulate power factor at the machine terminals and at the low and high voltage terminals of the GIF's main substation step up transformer connected to STS (at the POI) as required by the specification.
5. Frequency Control Test	Demonstrate the ability to control the output of the GIF in response to an over-frequency and under-frequency condition (droop). Type tests, with supporting documentation, on identical systems would be considered in place of an actual Site test.  Demonstrate the ability to provide an emulated inertial response for under-frequency condition (applicable for wind generation facilities).  Type tests, with supporting documentation, on identical systems would be considered in place of an actual Site test.
6. Low Voltage Ride-Through Test	Demonstrate the ability of the GIF's turbines or other generating technologies can stay connected through low voltage conditions as required by the specification. Type tests, with supporting documentation, on identical systems would be considered in place of an actual Site test.
7. Frequency Ride-Through Test	Demonstrate the off-frequency operation of the GIF as required by the specification. Type tests, with supporting documentation, on identical systems would be considered in

	place of an actual Site test.
8. Power Oscillation Test	Monitor the GIF output during normal operation to confirm the absence of oscillations in the 1 Hz to 2 Hz range.
9. Flicker/Harmonics Test	Record the GIF's output during normal operation and analyze for flicker and for harmonic content.

## 5.2. Test Result Responsibilities

Annual capability test reports received from the Entity are for informational purposes only. SaskPower accepts no responsibilities nor accepts liability associated with the installation of the DER/VER, due to the receipt of any test reports provided to SaskPower by the Entity.

## 5.3. Reporting Requirements

The Entity must perform and provide annual reports of the appropriate tests and the proper test processes for the type and rating of generation source being tested for the items listed under the following subheadings of this section. Additional testing may be necessary at the discretion of SaskPower. The Entity is also responsible for providing SaskPower with the associated engineering reports.

### The electrical commissioning report should include, but not be limited to:

- i. Generator – all documentation regarding specifics of factory testing, model #s, etc.; insulation resistance; DC winding resistance; high potential.
- ii. Transformer – all documentation regarding specifics of factory testing, model #s, etc.; insulation resistance; DC winding resistance; turns ratio; CT Saturation.
- iii. Power cables – insulation resistance, high potential (or agreed-to equivalent).
- iv. Circuit Breaker – insulation resistance; contact resistance; functional checks.
- v. Electrical Protection System – functional checks of the protective relaying system.
- vi. SCADA system and turbine control systems – functionality checks.
- vii. Voltage and power factor regulation systems – functionality checks.
- viii. Frequency control system – functionality checks.
- ix. All other GIF commissioning and functionality checks.

### 5.3.1. Provision for Future Changes

The Entity is responsible for making required changes to the GIF in response to meet new or revised standards or due to system changes. These changes will be performed only with the knowledge and agreement with SaskPower to ensure no adverse effects result. Some examples of potential requirements for GIF changes include the addition of a PSS or other control feature

or changes to a PSS, AVR, or governor settings or limiters. These may be required by future system conditions or changes to accommodate new or revised standards.

When advised by SaskPower, the Entity must make requested changes to the GIF.

## 6. TERMS AND DEFINITIONS

AGC	Automatic Generator Control
ANSI	American National Standards Institute or any successor organization or assigns.
APEGS	Association of Professional Engineers and Geoscientists of Saskatchewan
AVR	Automatic Voltage Regulator
BUCC	Back Up Control Centre
Black Start	Is the capability to restart and generate power independently from any external sources or facilities.
Bulk Electric System or BES	(See NERC Glossary of Terms)
CF	Compliance Factor - is a ratio of the accumulated clock-minute compliance parameters for the most recent preceding calendar months, divided by the square of the target frequency bound. $\epsilon_{1_i}$ for the Eastern Interconnection. $CF = \frac{CF_{12 \text{ month}}}{(\epsilon_{1_i})^2} - (\text{NERC BAL-001-2})$
COG	Coefficient of Grounding $\frac{V_{p-g(max.)}}{(V_{p-p})} \times 100\%$ Where: $V_{p-g} - (max)$ is the highest unfaulted phase RMS voltage for a fault involving ground on the other phase(s). $V_{p-p}$ – is the phase-to-phase RMS voltage under no fault condition.
COMTRADE	Common Format for Transient Data Exchange
Conventional Sources	Synchronous Generators connected directly to STS
Consulting Engineer	A registered Professional Engineer who has obtained a permission to consult licence in the discipline the Engineer is consulting in where he/she will perform the work. (The Engineering and Geoscience Professions Act and in the Engineering and Geoscience Professions Regulatory Bylaws - APEGS)
CSA	Canadian Standards Association or any successor organization or assigns.
Distributed Energy Resources (DER)	A Distributed Energy Resource (DER) is any resource on the distribution system that produces electricity and is not otherwise included in the formal NERC definition of the Bulk Electric System (BES).

Distributed Resource (DR)	Same as DER.
Direct Transfer Trip (DTT)	Direct Transfer Trip (over communications channels)
Dual Diverse	Composed of two different vendors/manufacturers or different platforms of devices that are of equal capabilities to perform the functions required.
D.R.M.S.	$D.R.M.S. = \sqrt{\frac{1}{N} \sum_{i=1}^N [\Delta f(t_i)]^2}$
$\epsilon_{11}$ (D.R.M.S.)	Constant derived from the targeted frequency bound. It is also defined as the Discrete Root Mean Square (D.R.M.S. <sup>35</sup> ) of the targeted frequency error for the interconnection (NERC BAL-001-2).
Effectively Grounded System	<p>IEEE Std C62.92.1-2016 defines effective grounding as follows:</p> <p>A system or portion of a system can be said to be Effectively Grounded when grounded through a sufficiently low impedance (inherent or intentional added, or both) so that the Coefficient of Grounding (COG) does not exceed 80%.</p>
Entity	Owner(s) of a Generation Interconnection Facility.
Far North Grid System	The 66kV, 115 kV and 138 kV transmission and generation system connecting Island Falls generating station, just below the 55th parallel on the east side of Saskatchewan to the Charlotte River, Waterloo and Wellington hydro generating stations just below the 60th parallel on the northeast side of Saskatchewan and connected through Manitoba Hydro to the rest of Saskatchewan.
Fault Clearing Time	The time from the fault inception until the fault is interrupted. The Fault Clearing Time consists of several components such as fault measurement, communications, auxiliary relay operation, breaker tripping, and arc extinction.
GCC	Grid Control Centre (SaskPower)
GIA	Generation Interconnection Agreement
Generation Interconnection Facility (GIF)	Generating equipment and/or facilities located at the Site on the Entity's side of the POI that interconnects to STS, including, but not limited to, the substation (complete with the interconnecting transformer), and all associated equipment. The GIF may be a single or aggregated

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<sup>35</sup> The discrete-time, cumulative root mean square value of a signal  $\Delta f(t_i)$  is defined as:  $\epsilon_{11} = D.R.M.S. = \sqrt{\frac{1}{N} \sum_{i=1}^N [\Delta f(t_i)]^2}$  The D.R.M.S value gives a measure of the average cumulative frequency deviation a sliding 365 day window.

	generation source and includes an existing load interconnection with added generation.
Harmonics	Sinusoidal voltages and currents at frequencies that are integral multiples of the fundamental power frequency (60 Hz)
High-Speed	<p>High-Speed is typically defined as follows:</p> <ul style="list-style-type: none"> <li>- for Protective Relays: <math>\leq 16.67</math> ms.</li> <li>- for Reclosing 3 Phase: <math>\leq 500</math> ms.</li> <li>- for Reclosing 1 Phase: <math>\leq 750</math> ms.</li> <li>- for Communications: <math>\leq 16.67</math> ms.</li> <li>- for Inverter response: <math>\leq 16.67</math> ms.</li> </ul> <p>However, SaskPower must be contacted to confirm actual values.</p>
IBR	Inverter Based Resources
ICAR	IBR Continuous Absorption Rating (- MW)
ICR	IBR Continuous Rating (+ MW)
Independent Power Producer	Investor-owned facilities dedicated exclusively to the generation of electrical energy.
Interconnected Operations Services or IOS	A service (exclusive of basic energy and transmission services) that is required to support the reliable operation of interconnected Bulk Electric Systems as defined by NERC standard (Draft) policy 10.
Inverters: System Commutating Inverter	This is source that requires to be connected to a power system to produce a current output
Inverters: Voltage Source Inverter	This is a self-commutating source that does not require connection to the Power System to produce current output. Only needs a voltage source like a battery bank.
Inverters: Current Source Inverter	This is a line commutating source that requires connection to the Power System to produce current output. Only needs a current source such as a phase-controlled rectifier supplying the inverter in series with a relatively large inductor.
Line Dead Time	Time interval between the removal of the supply and restoration of supply.
Load Customer	An existing or new SaskPower customer, which: (1) is electrically connected to the SaskPower electrical system; (2) is recipient of electrical service of primarily active power from SaskPower; (3) is connected behind the SaskPower revenue metering at the POI.
Maintenance Interface	The dead-end insulators on the substation.

Maximum Practical Gain	The maximum gain available from the Power System Stabilizer based on the limitation of the system and equipment.
Momentary Interconnection	Momentary Interconnection is defined as: An electrical connection between the GIF and STS through a high voltage circuit breaker. The time duration is from the closing of the breaker contacts to the opening of the breaker contacts of the interconnecting circuit breaker. The duration this occurs is < 100 ms.
MVA	Mega Volt Amperes
NEMA	National Electrical Manufacturers Association or any successor organization or assigned.
NERC	North American Electric Reliability Corporation or any successor organization or assigns.
No Trip Zone	Region within which Generation Sources Must Not Trip. Applies to System Voltages or System Frequency variations.
Non-Conventional Sources	Wind Turbine Generation, Battery Storage, Inverter, and other non-Synchronous generation
Operating Interface	High voltage isolation switch
PCC	Point of Common Coupling (IEEE Term)
POI	Point of Interconnection (SaskPower Term – Same meaning as PCC). The location where the Entity's GIF connects to the SaskPower Transmission System. (The Dead-End insulators on the Entity's substation)
PPA	Power Purchase Agreement
Professional Engineer	A person who is registered and recognized by the APEGS council as a Professional Engineer and has successfully completed at least a four-year bachelor level university program of study in engineering recognized by the APEGS council. (The Engineering and Geoscience Professions Act and the Engineering and Geoscience Professions Regulatory Bylaws – APEGS)
PSS	Power System Stabilizer
Qualified	A person who has the appropriate education, working experience and expertise to understand all the intricacies, consequences and the processes to design and apply the technology.
Requester (Same as Entity)	Owner(s) of a Generation Interconnection Facility.
RMS	Root Mean Square

RTU	Remote Terminal Unit
(STS)	SaskPower Transmission System (means the same as BES in this document)
SCADA	Supervisory Control and Data Acquisition
Self-Generation	Customer-owned generation used to supply load at the Entity's Site. This may include energy produced from on-site co-generation facilities.
SERA	Saskatchewan Electric Reliability Authority
Site	An existing or planned location at which the GIF is situated or may be situated.
Solid Ground Connection (Electrical)	No intentionally added impedance in the connection
SOP	SaskPower's "Standard Operating Practises" that may be amended by SaskPower from time to time
Southern Grid System	For this document, this is the rest of the SaskPower System that is not part of the Far North System.
Total Harmonic Distortion (THD)	A measurement of the harmonic distortion present. It is defined as a ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
Transmission System	Interconnected group of electric transmission lines and associated equipment for the movement or transfer of electric energy in bulk between points of supply and points of delivery.
UTC	Coordinated Universal Time
Variable Energy Resources (VER)	<p>A Variable Energy Resource is a device to produce electricity that is characterized by an energy source that:</p> <p>(1) is renewable; (2) cannot be stored by the facility owner or operator; and (3) has variability that is beyond the control of the facility owner or operator. This includes, for example, wind, solar, thermal, and photovoltaic, and hydrokinetic generating facilities.</p> <p>Also, may be a DER.</p>
Wind Turbine Generator Types	<p>Type 1: Fixed Speed Squirrel Cage Induction Generator</p> <p>Type 2: Semi Variable Speed Wound Rotor Induction Generator</p> <p>Type 3: Doubly Fed Induction Generator, Wound Rotor</p> <p>Type 4: Back-Back Voltage Source Inverter</p> <p>Type 5: Synchronous Generator Torque/Speed Converter</p>

## 7. APPENDIX A: PROTECTION – TECHNICAL INFORMATION REQUIREMENTS

The Entity must provide the technical information on the protective relaying devices that they propose to use to SaskPower prior to procurement and at least one year in advance of the in-service date to ensure that the devices are compatible with the system requirements and with the protective relaying schemes used by SaskPower.

The Entity must provide the engineering design documents, settings, protection single line drawings, and engineering application design documents to SaskPower at least six months ahead of the in-service date to ensure acceptable protection application and coordination between the Entity and SaskPower facilities.

Item	Information
Protection Scheme Device Number:	
Manufacture:	
Relay Model:	
A complete submission letter with a document list of information included in package:	
Overall description of how the protection system proposed will operate:	
Settings: (component settings such as: trigger levels, time setting values, etc.)	
Supply Relevant Data Sheets for each Protective Device:	
Disconnect Details: (manufacturer, model, nameplate, and associated certifications)	
Current Transformer Technical Information	
Potential Transformer Technical Information	
Auxiliary Current Transformer Information: (If used)	
Protective Relaying Single-Line:	
Engineering Application Summary of the Protective Relaying Design & Philosophy:	
Breaker Details: (Manufacturer, model, and nameplate)	
Detailed description of the operation of the GIF load distribution that is connected to STS:	

For additional requirement please contact the SP&AM department for details.

## 8. APPENDIX B: FINAL GENERATOR CONNECTION DATA REQUIREMENTS

The Entity must submit detailed information as required to model the transient, dynamic, and steady state behavior of the generator in system integration studies. The Entity is responsible for ensuring that the data submitted provides an adequate mathematical representation of the GIF's electric behavior.

Such information must include the following: See Links Below to the OASIS sites and the Form to be filled and submitted. (This form may change from time to time, the Entity is responsible to obtain the most recent form from SaskPower prior to submission.)

Insert link from Oasis: [OATI OASIS](#)

Interconnection\_Service\_Request\_-\_Generation\_-\_General\_-\_ver1s.docx (live.com)

Document link:

[https://www.oasis.oati.com/woa/docs/SPC/SPCdocs/Interconnection\\_Service\\_Request\\_-\\_Generation\\_-\\_General\\_-\\_ver1s.docx](https://www.oasis.oati.com/woa/docs/SPC/SPCdocs/Interconnection_Service_Request_-_Generation_-_General_-_ver1s.docx)

## 9. APPENDIX C: OPERATING AGREEMENT

In addition to negotiating and signing any agreements required by SaskPower (which may include a Power Purchase Agreement and/or Interconnection Agreement), the Entity will be required to negotiate and sign an Operating Agreement covering Standard Operating Practices (SOP). Specific items to be addressed within the Operating Agreement will include but are not limited to the following:

- Definition of maintenance and Operating Interface devices.
- Lock-out procedures of the GIF.
- Communication procedures for normal contact and emergency contact.
- Alarm and fault reporting procedures.
- Protection settings, including procedures for making changes and verification of changes.
- Voltage scheduling and control.
- Restoration procedures (synchronization).
- Initial synchronization.
- Initial synchronization following maintenance.
- Synchronization following disconnection due to:
  - Fault on STS,
  - Fault within the GIF,
  - Request from SaskPower Grid Control Operations (GCO)

## 10. APPENDIX D: REQUIRED DATA FOR WIND TURBINE GENERATORS

Item	Unit of Measure	Extent	Action
<b>Wind Site</b>			
Turbines in Stop		Per wind Site	Read
Turbines in Emergency stop		Per wind site	Read
Turbines without communication		Per wind Site	Read
Current Set point Ramp rate (feedback)	[MW/sec]	Per wind site	Read
Current Set point Power curtailment (feedback)	[MW]	Per wind Site	Read
Current ramp rate control mode on/off (feedback)	On/off	Per wind Site	Read
Set Ramp rate	[MW/sec]	Per wind Site	Write
Set Power curtailment	[MW]	Per wind Site	Write
Set Ramp rate control mode on/off	On/off	Per wind Site	Write
Max MW Available (sum of total possible output from all available generators)	[MW]	Per wind Site	Read
<b>Automatic generation Control (AGC)</b>			
Facilities' active power output should be able to be controlled between 0 MW and maximum available MW output by SaskPower's <b>AGC system</b> . Here are the data points required for an AGC system.	AGC Setpoint <sup>36</sup>	MW	Per Site
	AGC Setpoint Feedback	MW	Per Site
	AGC Control Mode <sup>37</sup>	Auto/Manual	Per Site
<b>Frequency Response</b>			
FFR <sup>38</sup> Headroom	MW	Per Site	Write
FFR Headroom Feedback	MW	Per Site	Read
PFR <sup>39</sup> Headroom	MW	Per Site	Write
PFR Headroom Feedback	MW	Per Site	Read

<sup>36</sup> MW value that SaskPower's AGC sends to the generating unit

<sup>37</sup> Auto would mean that SaskPower's AGC system is allowed to control the site output based on provided MW Setpoint.

<sup>38</sup> Fast Frequency Response (FFR)

<sup>39</sup> Primary Frequency Response (PFR)

Item	Unit of Measure	Extent	Action
<b>Turbines</b>			
Power	[kW]	Per turbine	Read
Reactive power	[kVAr]	Per turbine	Read
Wind speed	[m/s]	Per turbine	Read
Wind direction	[degrees]	Per turbine	Read
Temperature (within any 5 Km radius)	[C]	Per applicable turbine	Read
Turbine Availability (which turbines are available to generate, even if they are not currently generating)		Per turbine	Read
<b>Met mast</b>			
Wind speed hub height	[m/s]	Per met tower	Read
Wind direction hub height	[degree]	Per met tower	Read
Wind Speed at 50% of the hub height	[m/s]	Per met tower	Read
Wind direction at 50% of the hub height	[degree]	Per met tower	Read
Air pressure (at 2 to 3m elevation)	[Mbar]	Per met tower	Read
Temperature (at 2 to 3m elevation)	[C]	Per met tower	Read
Relative Humidity at 2 to 3m	%	Per met tower	Read
Precipitation	[mm]	Per met tower	Read
Air density	[kg/m <sup>3</sup> ]	Per met tower	Read
<b>GIF's Main Substation</b>			
Active production	[MW]		Read
Reactive production	[MVA <sub>r</sub> ]		Read
Switches, breakers	status	Per device	Read
Total MVA <sub>r</sub> support provided	[MVA <sub>r</sub> ]		Read
Dynamic MVA <sub>r</sub> support provided	[MVA <sub>r</sub> ]		Read
Total MVA <sub>r</sub> support available	[MVA <sub>r</sub> ]		Read

Scanning update time of the SaskPower RTU by the SaskPower master stations can be once in 10 s or less.

Expected refresh time of GIF's values must be no less than once in 5 s or less.

It is expected that the GIF's aggregate SCADA is capable of two-step update of SaskPower controlled values, if required (Step 1: set via set point, Step 2: execute).

## 11. APPENDIX E: REQUIRED DATA FOR INVERTER BASED RESOURCE GENERATORS

Item	Unit of Measure	Extent	Action	
<b>IBR Site</b>				
Max MW Available <sup>40</sup> (sum of total possible output from all available generators)	[MW]	Per Site	Read	
Set Power curtailment	[MW]	Per Site	Write	
Current Set point Power curtailment (feedback)	[MW]	Per Site	Read	
Set Ramp rate control mode on/off	On/off	Per Site	Write	
Current ramp rate control mode on/off (feedback)	On/off	Per Site	Read	
Set Ramp rate	[MW/min]	Per Site	Write	
Current Set Point Ramp Rate <sup>41</sup> (feedback)	MW/min	Per Site	Read	
Solar Tracking	degrees/sec.	Per Site	Read	
Power	[kW]	Per unit	Read	
Reactive power	[kVAr]	Per unit	Read	
Wind speed (Any efficiency relationship?)	[m/s]	Per unit	Read	
Wind direction (Any efficiency relationship?)	[degrees]	Per turbine	Read	
Temperature (within any 5 Km radius)	[°C]	Per applicable turbine	Read	
PV Bank Availability (which PV banks are available to generate, even if they are not currently generating)		Per unit	Read	
<b>Automatic Generation Control (AGC)</b>				
Facilities' active power output should be able to be controlled between 0 MW and maximum available MW output by SaskPower's <b>AGC system</b> . Here are the data points required for an AGC system.	AGC Setpoint <sup>42</sup>	MW	Per Site	Write
	AGC Setpoint Feedback	MW	Per Site	Read
	AGC Control Mode <sup>43</sup>	Auto/Manual	Per Site	Read

<sup>40</sup> This is the highest instantaneous MW value that the plant can generate irrespective of the setpoint, curtailments or FFR and PFR headroom. This will change based on plant conditions like equipment out of service, temperature, irradiance, etc.

<sup>41</sup> Unit of measure for this data point will be MW/min instead of %/min.

<sup>42</sup> MW value that SaskPower's AGC sends to the generating unit

<sup>43</sup> Auto would mean that SaskPower's AGC system is allowed to control the site output based on provided MW

Item	Unit of Measure	Extent	Action
<b>Frequency response</b>			
FFR <sup>44</sup> Headroom	MW	Per Site	Write
FFR Headroom Feedback	MW	Per Site	Read
PRF <sup>45</sup> Headroom	MW	Per Site	Write
PRF Headroom Feedback	MW	Per Site	Read
<b>PV Site</b>			
Solar Irradiance	[w/m <sup>2</sup> ]	Per met tower	Read
Solar Altitude (Angle from earth horizon)	[degrees]	Per met tower	Read
Solar Azimuth (Angle from a reference angle – Normally True North.)	[degrees]	Per PV bank	Read
Solar Incidence Angle (from NORMAL to bank surface)	[degrees]	Per PV bank	Read
Air pressure (at PV bank)	[Mbar]	Per met tower	Read
Temperature (at PV bank)	[C]	Per met tower	Read
Battery Bank Charge Level	MW (DC)	Per PV bank	Read
Battery Bank Charge/Discharge Rate	+/- MW/s	Per PV bank	Read
Relative Humidity at 2 to 3m	%	Per met tower	Read
Precipitation	[mm]	Per met tower	Read
<b>GIF's Main Substation</b>			
Active production	[MW]	Per PV bank	Read
Reactive production	[MVA <sub>r</sub> ]	Per PV bank	Read
Switches, breakers	status	Per device	Read
Total (MVA <sub>r</sub> )support provided	[MVA <sub>r</sub> ]	Per PV bank	Read
Dynamic (MVA <sub>r</sub> )support provided	[MVA <sub>r</sub> ]	Per PV bank	Read
Total (MVA <sub>r</sub> )support available	[MVA <sub>r</sub> ]	Per PV bank	Read

Scanning update time of the SaskPower RTU by the SaskPower master stations can be once in 10 seconds or less.

Expected refresh time of GIF's values must be no less than once in 5 seconds or less.

It is expected that the GIF's aggregate SCADA is capable of two-step update of SaskPower controlled values, if required (step 1: set via set point, step 2: execute).

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Setpoint.

<sup>44</sup> Fast Frequency Response (FFR)

<sup>45</sup> Primary Frequency Response (PFR)

## 12. APPENDIX F: CONFIRMATION OF COMPLIANCE AGREEMENT/AGREEMENT FORM

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
1.	3.1	Provide SaskPower the proposed GIF's protection single line	<input type="checkbox"/>	<input type="checkbox"/>	
2.	3.2.1	GIF designed for overvoltage withstand capabilities as in Table 3	<input type="checkbox"/>	<input type="checkbox"/>	
3.	3.2.1.1	Equipment electrically impulses as in Table 4	<input type="checkbox"/>	<input type="checkbox"/>	
4.	3.2.1.2	Equipment withstands several cycles of switching surge and voltage withstand of 3 times nominal voltage	<input type="checkbox"/>	<input type="checkbox"/>	
5.	3.2.1.3	Withstand dynamic over-voltages resulting from full load rejection of the generation	<input type="checkbox"/>	<input type="checkbox"/>	
6.	3.3	Must participate with SaskPower to perform Interconnection Studies	<input type="checkbox"/>	<input type="checkbox"/>	
7.	3.4.1	The transformer configuration must present an Effectively Grounded system and block Triplen harmonics from the GIF to STS	<input type="checkbox"/>	<input type="checkbox"/>	
8.	3.4.2	On-load tap changer installed to assist in matching operating voltages	<input type="checkbox"/>	<input type="checkbox"/>	
9.	3.5	High voltage breaker included and withstands over voltages of 120% and 220% as specified	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
10.	3.5 cont'd	Coordinates wit STS protection	<input type="checkbox"/>	<input type="checkbox"/>	
11.	3.5 cont'd	Protection system will be designed as specified to complete tripping, even if upstream STS protection trips first.	<input type="checkbox"/>	<input type="checkbox"/>	
12.	3.6	Visible high voltage disconnect Switch meets requirements as stated	<input type="checkbox"/>	<input type="checkbox"/>	
13.	3.7	Must work with SaskPower on anti-Islanding scheme and meet requirements as stated	<input type="checkbox"/>	<input type="checkbox"/>	
14.	3.8	Must design and implement the requirements to prevent SaskPower from auto-reclosing to the GIF	<input type="checkbox"/>	<input type="checkbox"/>	
15.	3.9	Entity must design their protection systems to meet requirements at interconnection location	<input type="checkbox"/>	<input type="checkbox"/>	
16.	3.9.1	Design the protection system to meet or exceed the speed requirements as stated	<input type="checkbox"/>	<input type="checkbox"/>	
17.	3.9.2	Meet requirement for internal faults	<input type="checkbox"/>	<input type="checkbox"/>	
18.	3.9.3	Collaborate with SaskPower to coordinate and meet the requirements for external faults and apply Dual Diverse protection schemes	<input type="checkbox"/>	<input type="checkbox"/>	
19.	3.9.4	Must design the GIF to meet requirements for stated abnormal conditions	<input type="checkbox"/>	<input type="checkbox"/>	
20.	3.9.5	Collaborate with SaskPower to implement necessary RAS	<input type="checkbox"/>	<input type="checkbox"/>	
21.	3.9.6	Accept responsibility for installation and implement a breaker failure scheme to meet stated requirements	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
22.	3.9.7	Must work with SaskPower to ensure coordination and transfer of required equipment and design information within the time frame stipulated. Information provided to Saskpower at least six months prior to in-service date.	<input type="checkbox"/>	<input type="checkbox"/>	
23.	3.9.8	Agrees to initial testing and commissioning and during regular maintenance as specified in NERC PRC-005-1.1b and provide SaskPower at least 30 days lead time notification to allow SaskPower to witness tests	<input type="checkbox"/>	<input type="checkbox"/>	
24.	3.9.9	Certifies that all protection components meet the identified standard and in bibliography in section 13.	<input type="checkbox"/>	<input type="checkbox"/>	
25.	3.10	Agrees to design to, and confirms that any interconnection to the STS that qualifies as “Momentary”, is automated and must be parallel to STS for < 100 ms	<input type="checkbox"/>	<input type="checkbox"/>	
26.	3.11	Entity must provide an environmentally controlled, physical space with enough room for the SaskPower communications terminal equipment	<input type="checkbox"/>	<input type="checkbox"/>	
27.	3.11 (cont’d)	A non-interruptible power supply must be provided to meet any or all the SaskPower equipment listed in section 3.11	<input type="checkbox"/>	<input type="checkbox"/>	
28.	3.11 (cont’d)	This environmentally controlled physical space must be available and accessible to SaskPower 24/7	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
29.	3.11 (cont'd)	Operational voice to SaskPower GCC must be provided for single unit or aggregated units of $\geq 5$ MVA	<input type="checkbox"/>	<input type="checkbox"/>	
30.	3.12	Entity must provide sufficient physical space for a SaskPower remote terminal unit (RTU), and must be contiguous with the space for the communications equipment of section 3.11 for the intended purposes and provide the information as stated in section 3.12	<input type="checkbox"/>	<input type="checkbox"/>	
31.	3.12 (cont'd)	The Entity must provide a dynamic disturbance recorder (DDR) to meet the requirements as stated in section 3.12. (See Figure 2, for example)	<input type="checkbox"/>	<input type="checkbox"/>	
32.	3.13	The Entity must install revenue metering and must meet the requirements as stated in section 3.13, including the environmentally controlled building	<input type="checkbox"/>	<input type="checkbox"/>	
33.	3.14	The Entity agrees that any changes to the GIF will meet revised standards or SaskPower requests	<input type="checkbox"/>	<input type="checkbox"/>	
34.	3.15	The Entity must install and operate an aggregate GIF SCADA system, which will allow the monitoring and control of individual or the aggregate total by the SaskPower GCC to provide the parameters to meet the requirements in this interconnection document	<input type="checkbox"/>	<input type="checkbox"/>	
35.	3.15 (cont'd)	Must provide and accept information via the SaskPower RTU installed at the GIF.	<input type="checkbox"/>	<input type="checkbox"/>	
36.	3.15 (cont'd)	Must connect into the SaskPower SCADA system via installed SaskPower RTU			

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
37.	3.15 cont'd	The Entity's Wind Turbine, PV cell bank, met towers etc., must be equipped with controller/intelligent electronic device (IED) must connect their aggregated SCADA system	<input type="checkbox"/>	<input type="checkbox"/>	
38.	3.15 cont'd	The controller/IED, must be capable to continue monitoring and store up to one week of information in the event of communications network failure.	<input type="checkbox"/>	<input type="checkbox"/>	
39.	3.15 cont'd	An uninterruptable power supply must be provided the meets the operation requirement stated previously in section 3.15	<input type="checkbox"/>	<input type="checkbox"/>	
40.	3.15 cont'd	Must provide remote view-only requirements replicating on-site GIF SCADA screen, if requested by SaskPower	<input type="checkbox"/>	<input type="checkbox"/>	
41.	3.15 cont'd	The Entity's SCADA system must be capable to accept a curtailment or an increase signal from GCC	<input type="checkbox"/>	<input type="checkbox"/>	
42.	3.15 cont'd	Must be capable to curtail down to 0 MW within the time frame determined by the ramp-rate from the SCADA system controller	<input type="checkbox"/>	<input type="checkbox"/>	
43.	3.15 (cont'd)	Confirmation of status and ramp rate must be sent back to GCC via SCADA	<input type="checkbox"/>	<input type="checkbox"/>	
44.	3.15 (cont'd)	Must be capable of positive and negative ramp rates for start-up and shut-down as stated	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
45.	3.15 (cont'd)	GCC must have the capability to disable the ramp rate control remotely and the information must be provided back to GCC	<input type="checkbox"/>	<input type="checkbox"/>	
46.	3.15 (cont'd)	The GIF's control must be capable to accept a control signal from SaskPower's GCC via the local SaskPower RTU to provide a positive or negative ramp rate in %/minute	<input type="checkbox"/>	<input type="checkbox"/>	
47.	3.15 (cont'd)	The positive ramp rate must not be exceeded during and controlled start-up and the negative ramp rate must not be exceeded during any controlled shut-down, when accessed from GCC	<input type="checkbox"/>	<input type="checkbox"/>	
48.	3.15 (cont'd)	Emergency shutdown must not be controlled by the negative ramp control and used only for emergencies	<input type="checkbox"/>	<input type="checkbox"/>	
49.	3.15 (cont'd)	Must be able to regulate the voltage at the POI based upon the information provided from GCC	<input type="checkbox"/>	<input type="checkbox"/>	
50.	3.15 (cont'd)	The status of all motorized switches and breaker supplied to the SaskPower RTU	<input type="checkbox"/>	<input type="checkbox"/>	
51.	3.15 (cont'd)	The MW, MVAR, MVA and PF, must be supplied to the SaskPower RTU	<input type="checkbox"/>	<input type="checkbox"/>	
52.	3.15 (cont'd)	All available voltages must be supplied to the SaskPower RTU	<input type="checkbox"/>	<input type="checkbox"/>	
53.	3.15 (cont'd)	Must have information as listed in APPENDIX D: REQUIRED DATA FOR WIND TURBINE GENERATORS	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
54.	3.15.1	Must provide details on Entity's communications network/equipment	<input type="checkbox"/>	<input type="checkbox"/>	
55.	3.15.1 (cont'd)	Must provide certification of network integrity/ maximum attenuation for their communications system(s)	<input type="checkbox"/>	<input type="checkbox"/>	
56.	3.15.1 (cont'd)	Must encrypt all wireless as stated	<input type="checkbox"/>	<input type="checkbox"/>	
57.	3.15.1 (cont'd)	Must identify the wireless communications systems, and encryption technology used	<input type="checkbox"/>	<input type="checkbox"/>	
58.	3.15.1 (cont'd)	Must provide the operational cyber security protection system as stated	<input type="checkbox"/>	<input type="checkbox"/>	
59.	3.15.1 (cont'd)	Cyber security systems must be design and operated per industry best practises	<input type="checkbox"/>	<input type="checkbox"/>	
60.	3.15.1 (cont'd)	Must meet NERC CIP standards	<input type="checkbox"/>	<input type="checkbox"/>	
61.	3.15.2	Must provide to SaskPower with data for SaskPower to prepare an electrical forecast, for the GIF	<input type="checkbox"/>	<input type="checkbox"/>	
62.	3.15.2 (cont'd)	Must gather and provide to SaskPower RTU weather and substation data to SaskPower RTU in near real-time or intervals as stated	<input type="checkbox"/>	<input type="checkbox"/>	
63.	3.15.2 (cont'd)	Must install and maintain permanent MET towers to record wind and solar data as specified	<input type="checkbox"/>	<input type="checkbox"/>	
64.	3.15.2 (cont'd)	The number of installed MET towers must be as state	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
65.	3.15.2 (cont'd)	The locations and quantities of the MET towers must be determined by SaskPower as specified.	<input type="checkbox"/>	<input type="checkbox"/>	
66.	3.15.2 (cont'd)	The Entity must accept responsibility for on-going maintenance, as well as moving of the MET towers if required.	<input type="checkbox"/>	<input type="checkbox"/>	
67.	3.15.2 (cont'd)	The Entity must allow SaskPower access to the MET towers, for inspection and verifications, purposes.	<input type="checkbox"/>	<input type="checkbox"/>	
68.	3.15.2 (cont'd)	The Entity must maintain enough measuring equipment to reasonably collect the necessary information and determine capabilities, as stated.	<input type="checkbox"/>	<input type="checkbox"/>	
69.	3.15.2 (cont'd)	Must provide the expected derates, for next two weeks of their facilities, in terms of on an hour-by-hour basis, as stated.	<input type="checkbox"/>	<input type="checkbox"/>	
70.	4	Changes to the GIF must meet new standards	<input type="checkbox"/>	<input type="checkbox"/>	
71.	4 (cont'd)	Generation must be capable to deliver rated active power at power factors between + 0.9 and -0.95 measured on LV side of transformer connected to STS whether a GSU step-up transformer or a collector transformer	<input type="checkbox"/>	<input type="checkbox"/>	
72.	4 (cont'd)	The GIF must be capable to maintain the voltage set-point specified by SaskPower's GCC within the continuous operating voltage levels of Table 3 with	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
		the reactive power capabilities and as per the mode(s) of operation identified in the facility studies			
73.	4 (cont'd)	Synchronous generators must comply with the stipulated harmonized IEEE/IEC standards listed	<input type="checkbox"/>	<input type="checkbox"/>	
74.	4.1.1	The GIF excitation system must be capable of delivering, continuously from 0% to 110% of rated field current at the rated ambient temperature, for the conditions stated in section 4.1.1	<input type="checkbox"/>	<input type="checkbox"/>	
75.	4.1.2	Excitation system must be capable of providing a ceiling current to the field of $\geq 1.6$ times rated field current for 30 seconds	<input type="checkbox"/>	<input type="checkbox"/>	
76.	4.1.2 (cont'd)	Solid state excitation system must provide the above capability with one parallel bridge removed for units > 10 MVA	<input type="checkbox"/>	<input type="checkbox"/>	
77.	4.1.3	Synchronous generator excitation systems must be capable of providing the requirements as stated in section 4.1.3	<input type="checkbox"/>	<input type="checkbox"/>	
78.	4.1.4	Will follow the initial ceiling voltage and field current values stated in section 4.1.4. Until system integration studies define final values	<input type="checkbox"/>	<input type="checkbox"/>	
79.	4.1.5	Must meet the High Initial Response (HIR) as stated in section 4.1.5, under Large Signal Response	<input type="checkbox"/>	<input type="checkbox"/>	
80.	4.1.6	Must meet the requirements of section 4.1.6, for the Small Signal Response	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
81.	4.1.7	Must meet the voltage regulation capability required in section 4.1.7	<input type="checkbox"/>	<input type="checkbox"/>	
82.	4.1.8	Must meet the reactive power capability requirements as specified in section 4.1.8 for conventional synchronous generation and for inverter converter systems such as but not limited to IBR and types 3 and 4 wind turbine generation systems	<input type="checkbox"/>	<input type="checkbox"/>	
83.	4.1.9	Power system stabilizer (PSS) must be provided with all synchronous generation systems and must meet the requirements of section 4.1.9	<input type="checkbox"/>	<input type="checkbox"/>	
84.	4.1.10	The excitation system must not trip and must continue to operate during faults on the HV side and must behave as stipulated in section 4.1.10.	<input type="checkbox"/>	<input type="checkbox"/>	
85.	4.2	Must meet the operating voltage requirements as stated in section 4.2	<input type="checkbox"/>	<input type="checkbox"/>	
86.	4.3	Must provide SaskPower the requested information on the maximum authorized power, as stated in section 4.3, based on the considerations listed	<input type="checkbox"/>	<input type="checkbox"/>	
87.	4.4.1	Must meet the voltage fluctuations limits as the POI as linked to sections 4.4.1 & 4.10	<input type="checkbox"/>	<input type="checkbox"/>	
88.	4.4.2	Must be equipped with dual or functionally alternate automatic synchronization equipment and stated in section 4.4.2	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
89.	4.4.3	Must only synchronize to STS when the generation voltage regulator is available for operation and follow operation procedure as advised by SaskPower	<input type="checkbox"/>	<input type="checkbox"/>	
90.	4.5	Must provide an interface on the governor or equivalent control that accepts an increase or decrease load signal from the SaskPower RTU for AGC control	<input type="checkbox"/>	<input type="checkbox"/>	
91.	4.6	Must determine design, specify, and install for requirements as stated in section 4.6	<input type="checkbox"/>	<input type="checkbox"/>	
92.	4.7	Upon SaskPower's requirements, the Entity must install Black Start with capabilities to be controlled via communications between SaskPower and the GIF	<input type="checkbox"/>	<input type="checkbox"/>	
93.	4.8	Must participate and design the GIF to meet the spinning and non-spinning reserve requirements as part of the generation systems	<input type="checkbox"/>	<input type="checkbox"/>	
94.	4.9	The GIF must be designed to withstand a full load reject scenario	<input type="checkbox"/>	<input type="checkbox"/>	
95.	4.10	Operation of the GIF must not deteriorate the power quality on STS	<input type="checkbox"/>	<input type="checkbox"/>	
96.	4.10.1	The Entity must determine and advise SaskPower on the minimum short circuit ratio (SCR) and the X/R ratio at the GIF and confirm that the GIF will meet the power quality requirements for quantities described in section 4.10.1			

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
97.	4.10.2	Entity must ensure that the GIF will not cause excessive voltage fluctuation, as stated in section 4.10.2 and IEEE Std 519-2014 as indicated in footnote 23	<input type="checkbox"/>	<input type="checkbox"/>	
98.	4.10.3	Voltage distortion values, for all types of generation technologies must meet harmonized IEEE and IEC, as indicated in section 4.10.3 as stipulated in footnote 24	<input type="checkbox"/>	<input type="checkbox"/>	
99.	4.10.4	Must limit commutative notching and Total Harmonic Distortion (THD) to values described in section 2.4 and to values listed in IEEE Std 519-2014, as indicated in section 4.10.4	<input type="checkbox"/>	<input type="checkbox"/>	
100.	4.10.5	Harmonics injection into STS at the POI is not permitted and must comply with the values in Table 9 in section 4.10.5	<input type="checkbox"/>	<input type="checkbox"/>	
101.	4.10.5 (cont'd)	The currents must not exceed the harmonic current factor (HCF) of 0.05 and neither the negative-sequence or zero-sequence currents exceed 5% of the positive sequence component	<input type="checkbox"/>	<input type="checkbox"/>	
102.	4.10.6	The GIF must not inject Interharmonics into STS, as stated in section 4.10.6	<input type="checkbox"/>	<input type="checkbox"/>	
103.	4.10.7	The GIF must not inject dc current > 0.5 % into STS	<input type="checkbox"/>	<input type="checkbox"/>	
104.	4.10.8	The GIF must be designed to withstand EMI, HEMP & HPM and as a result will not cause any mis-operations	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
105.	4.10.9	Must be designed to withstand the GIC currents expected	<input type="checkbox"/>	<input type="checkbox"/>	
106.	4.11	Must design the GIF to meet the requirements in section 4.11, for the fault current contributions and durations	<input type="checkbox"/>	<input type="checkbox"/>	
107.	4.12	Must design the GIF to withstand the unbalance voltage and unbalanced currents for durations as stated in sections 2.2 & 4.12	<input type="checkbox"/>	<input type="checkbox"/>	
108.	4.12 (cont'd)	All 3-phase synchronous and induction generators connected to STS without intervening power electronics must be capable to withstand the negative sequence currents as specified in IEEE C50.12-2005 (R2010) and IEEE C50.13-2014	<input type="checkbox"/>	<input type="checkbox"/>	
109.	4.13	The Entity must assess and mitigate the various resonance and self-excitation conditions listed in section 4.13	<input type="checkbox"/>	<input type="checkbox"/>	
110.	4.14	The Entity must assess and identify the back-up power requirements for their facilities when power is not available from the system and ensure the facilities provide adequate back-up power to meet their requirements	<input type="checkbox"/>	<input type="checkbox"/>	
111.	4.15	The Entity must ensure coordination of their GIF protection with STS protection and provide SaskPower with the relay selection, settings, and any	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
		future setting changes to SaskPower with sufficient lead time as stated in section 3.9.7			
112.	4.16	Inverter Based Resource (IBR) Requirements	<input type="checkbox"/>	<input type="checkbox"/>	
113.	4.16.1	The GIF must be capable of providing the inertial and frequency response as defined in section 4.16.1	<input type="checkbox"/>	<input type="checkbox"/>	
114.	4.16.2	The GIF must be capable to provide the frequency control capabilities as stipulated in section 4.16.2	<input type="checkbox"/>	<input type="checkbox"/>	
115.	4.16.3	The GIF must be capable of providing FFR	<input type="checkbox"/>	<input type="checkbox"/>	
116.	4.16.4	The GIF must be capable of providing PFR	<input type="checkbox"/>	<input type="checkbox"/>	
117.	4.16.5	The GIF must be capable of providing automatic generation control (AGC) to SaskPower, as in section 4.16.5.	<input type="checkbox"/>	<input type="checkbox"/>	
118.	4.16.6	The GIF must be capable to Inject Negative Sequence Current as in section 4.16.6 at the POI.	<input type="checkbox"/>	<input type="checkbox"/>	
119.	4.16.7	The GIF must be capable to meet the requirements for Design and Operation of the Facilities for the Continuous and Dynamic Reactive Power Capabilities in section 4.16.7 .	<input type="checkbox"/>	<input type="checkbox"/>	
120.	4.17.2.5	The GIF Inverter Base Resource generator active power output must be capable of being controlled between 0 MW and maximum available MW output.	<input type="checkbox"/>	<input type="checkbox"/>	
121.	4.17.2.6	The GIF must be capable to meet the requirements in this section.	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
122.	4.17	The GIF must have the capability to operate within off nominal "NO TRIP", region of Figure 6 and Table 10 in section 4.17	<input type="checkbox"/>	<input type="checkbox"/>	
123.	4.18	The GIF must have the capability to operate within the No Trip voltage regions as indicated in Figure 7 and Table 11 of section 4.18	<input type="checkbox"/>	<input type="checkbox"/>	
124.	4.19	Must meet the requirement listed in section 4.19 concerning power islanding, inadvertent energization, anti-islanding, protection, and coordination	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
125.	4.20	Must meet loss of synchronization protection requirements as stated in section 4.20	<input type="checkbox"/>	<input type="checkbox"/>	
0.	5.0	Testing and Commissioning & Report Requirements			
128.	5.1.1	Propose, submit, and perform tests and follow a set of test plans, that meets requirements of section 5 to SaskPower.	<input type="checkbox"/>	<input type="checkbox"/>	
129.	5.1.1.1	Design Tests must be performed to confirm the GIF will not connect to STS for abnormal voltages and currents as stated under this sub section of section 5.1.1.1	<input type="checkbox"/>	<input type="checkbox"/>	
130.	5.1.1.1 (cont'd)	Must cease to energize STS for frequencies and voltages that meets or exceeds the values in sections 4.17 and 4.18.	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
131.	5.1.1.2	Must meet the Synchronization Tests requirements as stated in sections 5.1.1.2.1, 5.1.1.2.2, & 5.1.1.2.3 for Synchronous Interconnection; Induction Generator and Motor Interconnection; & Inverter Interconnection Integrity.	<input type="checkbox"/>	<input type="checkbox"/>	
132.	5.1.1.3	Must meet the Interconnection Integrity Test Tests as stated in sections 5.1.1.3.1, 5.1.1.3.2, & 5.1.1.3.3 for EMI Protection; Surge Withstand; & Paralleling.	<input type="checkbox"/>	<input type="checkbox"/>	
133.	5.1.1.4	Must meet the anti-islanding test and/or simulation requirements of Section 5.1.1.4.	<input type="checkbox"/>	<input type="checkbox"/>	
134.	5.1.1.5	The DC Injection Test must meet the requirements of section 4.10.7.	<input type="checkbox"/>	<input type="checkbox"/>	
135.	5.1.1.6	Must provide SaskPower the opportunity to perform measurements of the amounts of individual and the Total Harmonic Distortion (THD), at various locations at the GIF to determine if the facilities meet the harmonic limitations as stated in section 4.10.5 & 4.10.6.	<input type="checkbox"/>	<input type="checkbox"/>	
136.	5.1.2	Must test the single set points specified by the manufacturer to confirm the response to abnormal voltages and frequencies, as described in section 5.1.1.1.	<input type="checkbox"/>	<input type="checkbox"/>	
137.	5.1.3	Commissioning test must be performed to verify the integrity of the complete interconnection from the	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
		generating source to the POI, as under the subsections below.			
138.	5.1.3.1	Must verify by test that the grounding of the GIF will not cause over voltages to exceed equipment ratings as specified in section 2.5.2.	<input type="checkbox"/>	<input type="checkbox"/>	
139.	5.1.3.2	Must verify by test to confirm that the requirements of section 3.6, are meet.	<input type="checkbox"/>	<input type="checkbox"/>	
140.	5.1.3.3	Must confirm by test that the monitoring design meets the requirements of section 3.12.	<input type="checkbox"/>	<input type="checkbox"/>	
141.	5.1.3.4	Must verify by test that the GIF will cease to energize STS upon occurrence of a fault detection on the STS or local area.	<input type="checkbox"/>	<input type="checkbox"/>	
142.	5.1.3.5	Must verify that the GIF will successfully disconnect from STS before high-speed auto-reclosure occurs on STS, where the GIF is connected, as stated in section 2.7.	<input type="checkbox"/>	<input type="checkbox"/>	
143.	5.1.3.6	Must verify by test all applicable unintentional islanding protection schemes operate as intended, as specified in section 5.1.3.6.	<input type="checkbox"/>	<input type="checkbox"/>	
144.	5.1.3.7	Must verify by test that the appropriate breakers are tripped through the appropriate protection or unintentional islanding schemes and are within the time requirements required by the appropriate protection schemes.	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
145.	5.1.4	Review any specific SaskPower specified conformance test requirements for the testing of the GIF. Refer to IEEE Std 1547.1-2020.	<input type="checkbox"/>	<input type="checkbox"/>	
146.	5.1.4 (cont'd)	Must perform dynamic performance tests as described in section 5.1.5 in accordance with the listed NERC standards and provide SaskPower with the test results, PSS/E and PSCAD information as specified in this section.	<input type="checkbox"/>	<input type="checkbox"/>	
147.	5.1.5	Must provide SaskPower with information acquired from any future retests performed at the GIF.	<input type="checkbox"/>	<input type="checkbox"/>	
148.	5.1.6	Acceptance testing must be performed on all generators and generating equipment, as specified in section 5.1.6, prior to connecting onto STS.	<input type="checkbox"/>	<input type="checkbox"/>	
149.	5.1.7	Periodic Interconnection Tests must be preformed to on related protective functions and batteries as specified intervals and according to section 5.1.7	<input type="checkbox"/>	<input type="checkbox"/>	
150.	5.2	Conduct annual GIF capability tests and provide information to SaskPower as stated in section 5.1.7. See Table 13 for test to be performed.	<input type="checkbox"/>	<input type="checkbox"/>	
151.	5.2 (cont'd)	Acknowledge that the information provided to SaskPower is for informational purposes and SaskPower accepts responsibility or liability from the receipt of the information.	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
152.	5.3	Must provide SaskPower with test reports performed as stated in section 5.3, and for as least the 9 items listed.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
153.	5.3.1	The Entity agrees to being responsible and make appropriate changes to their facilities to new or revised standards or due to system changes, in coordination with SaskPower. Such items as PSS, AVR governor settings or limiter for reasons as stated in section 5.3.1.	<input type="checkbox"/>	<input type="checkbox"/>	
154.	Appendix A	Must provide the information on listed protection items	<input type="checkbox"/>	<input type="checkbox"/>	
155.	Appendix B	Must provide the Generation connection information. See Links to OATI OASIS for forms to fill and submit to SaskPower.	<input type="checkbox"/>	<input type="checkbox"/>	
	Appendix C	Confirm Appendix C Review Agreement Requirements	<input type="checkbox"/>	<input type="checkbox"/>	
156.	Appendix D	Provide Required Information for Wind Turbine Generators	<input type="checkbox"/>	<input type="checkbox"/>	

	Section/ Subsection	Requirement	Reviewed /Comply/ Agreed	Not Comply/ Not Agreed	Comment:
0.					
158.	Appendix E	Provide Required Information for Inverter Base Resource Generators	<input type="checkbox"/>	<input type="checkbox"/>	
159.	Appendix F	Confirmation of Compliance Agreement Form	<input type="checkbox"/>	<input type="checkbox"/>	

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