CONNECTION ASSESSMENT
& APPROVAL PROCESS

ASSESSMENT SUMMARY

Applicant: *Mississagi Power Trust*

Project: *Wells GS: Unit G1*
Replacement of Exciter

CAA ID No. 2002-EX075

Long Term Forecasts & Assessments Department
Consistent Information Set Department

Date: *22nd October 2002*

ASSESSMENT SUMMARY

MISSISSAGI POWER TRUST

WELLS GS - Replace Exciter on Unit G1

1.0 Introduction

The Mississagi Power Trust is proposing to replace the existing exciter on the 107MVA unit G1 at Wells GS with a new unit.

The new unit is to meet all of the performance requirements specified in the Market Rules.

2.0 Market Rule Requirements

The new exciter has to be capable of meeting the following Market Rules Requirement:

Reference 12 Appendix 4.2

The excitation system has to have a voltage response time no longer than 50ms and a ceiling voltage at least twice the rated field voltage

3.0 Specification

A copy of the specification for the new exciter is attached.

The specific criteria that it is required to meet are as follows:

- Maximum continuous field current rating > 1500A dc.

  This would meet the requirement for the maximum field current to be at least 105% of the rated requirement of 1390A dc corresponding to the maximum rotor current.

- Ceiling Voltage ≥ 800V dc (this corresponds to the capability of the existing exciter)

  While this would exceed the requirement of 550V dc, based on a rated field voltage of 275V dc, it would correspond to the rating of the existing exciter.

- Ceiling Field Current ≥ 1700A for 30 seconds

  This would meet the requirement for the ceiling field voltage to be 150% of the rated field current of 1135A dc (corresponding to the continuous rating of 107MVA at 0.9 power factor and full rated voltage).

- To meet an excitation system response time of 50 milliseconds, the following requirements were specified:
  - The equivalent time constant associated with the terminal voltage feedback to the AVR should not exceed 30 milliseconds.
  - The equivalent time constant associated with the AVR should not exceed 20 milliseconds.
  - The AVR gain should be adjustable up to 300 pu E_{fd}/pu E_t based on IEEE definitions.

4.0 Assessment

Based on the above specification it is expected that the performance of the new exciter will be superior to the existing unit and that it will meet, or exceed, the requirements specified in the Market Rules.

A copy of the Commissioning Report is to be provided to the IMO within 30 days.

5.0 Notification of Approval

Subject to the test results obtained during the commissioning of the new exciter either meeting or exceeding the requirements of the Market Rules it is therefore recommended that a Notification of Approval of the Connection Proposal be issued.

Specification for
Static Excitation System
Station GS

Table of Contents

2A GENERAL

2A1 Definitions and References

For the purpose of this specification the *Buyer* is Ontario Power Generation Inc. The *Vendor* is the primary supplier using this specification to prepare a bid for supply of the excitation system. The term *Specification* will refer to this document and any other addenda, attachments, drawings or tables supplied as part of the Request for Quotation.

For the purposes of this specification, the term excitation system and exciter are used interchangeably to refer to all equipment associated with the supply of field current to the rotor of the generator. Other definitions can be found in the following references.

Every attempt has been made to follow standard industry practices in the preparation of this specification. Where differences do exist between standard practices and this specification, this specification will apply. Where appropriate, Vendors must identify any discrepancies that could lead to a compromise in the performance or reliability of the overall system.

[1] IEEE Std 100, IEEE Standard Dictionary of Electrical and Electronics Terms.

[2] IEEE Std 421.1, IEEE Standard Definitions for Excitation Systems for Synchronous Machines.

2A2 Scope of Work

(a) This document gives details on the following activities related to a digital Static Excitation System (exciter):

- Design.
- Manufacture.
- Testing.
- Supervision of commissioning.

The exciter is to supply direct current (dc) power to the synchronous generator described in Attachment A. Attachment A describes the detailed excitation requirements for the synchronous generator, including the performance standards that must be met to comply with Regulatory requirements.

(b) Work described in this document must be completed to the satisfaction of the Buyer. The Vendor will, without extra cost to the Buyer, supply all extra material and labour not mentioned in this specification that is required to finish the project to the Buyer's satisfaction.

(c) The Buyer shall be responsible for the selection, review and final approval of all limiter and AVR settings. The Buyer will designate a representative to participate in all commissioning and acceptance tests. The Buyer's representative will have the authority to determine whether the work has been completed in accordance with the Specification.

(d) The Buyer will not pay for power system studies in relation to this project as existing settings will be applied to the new excitation equipment.

(e) The price for commissioning acceptance tests must be included in the overall price. Details of the required tests are provided in the body of this specification.

2A3 Laws, Standards, and Codes

All work shall conform to the Laws, Standards, and Codes (LS&C) listed below, that are elsewhere in this document or that apply in general to this work. Should any LS&C be revised, the Vendor and the Buyer will make each other aware of the revision to discuss adoption of the revision.

Should conflict occur between LS&C and this Specification, the most stringent requirements shall govern. In case the conflict can not be resolved this specification shall take precedence over all LS&C with the exception of (a) (1) below:

(a) Canadian Sources

- a) The laws and regulations of Canada, the province of Ontario or local municipalities.
- b) Canadian Standards Association (CSA).
- c) Electrical and Electronic Manufacturers Association of Canada.
- d) Canadian Government Specifications Board (CGSB).

(b) United States Sources

- a) American National Standards Institute (ANSI). (ASA and USAS are also included.)
  1. ANSI C34.2, Semiconductor Power Rectifiers.
  2. ANSI C37.18, Enclosed Field Discharge Circuit Breaker.
  3. ANSI C57.12.91, Test Code for Dry Type Transformers.
- b) American Society for Testing and Materials (ASTM).
- c) Institute of Electrical and Electronic Engineers (IEEE).
  1. IEEE Std 100-1996, IEEE Standard Dictionary of Electrical and Electronics Terms
  2. IEEE 421.1, Standard Definitions for Excitation Systems for Synchronous Machines.
  3. IEEE Std 421.2-1990, IEEE Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems.
  4. IEEE Std 421.5-1992, IEEE Standard Recommended Practice for Excitation System models for Power System Stability Studies.
  5. IEEE Std 421.3-1997, IEEE Standard for High-Potential Test Requirements for Excitation Systems

d) National Electrical Manufacturers Association (NEMA).

NEMA ST 20 Dry type Transformer

(c) Other Sources

1. International Electrotechnical Commission (IEC).

2A4 Quality Program

The Vendor shall have an **ISO9001** quality program in effect. Upon request of the Purchaser, the Vendor shall submit a complete list of procedures, instructions, standards and guides implemented and maintained by the Vendor ISO9001 program.

2A5 Exciter Overview

The exciter's primary function is to supply field current to satisfy the generator's excitation requirements for both off-line and on-line conditions, under control of one or more regulators or excitation limiters. The exciter shall provide high-speed response and sensitivity. The exciter shall limit excitation to maintain generator terminal conditions within the generator's capabilities.

The excitation system control logic must be digitally-implemented. Analog-electronic designs will not be considered.

The existing excitation transformer (PPT – power potential transformer) will be retained at this location, and the new excitation system must be designed to interface with this transformer. Detailed information on the excitation transformer is included in the Attachments.

The exciter shall be equipped with the following specific features:

a) Thyristor rectifier bridges.

b) Automatic Voltage Regulator (AVR).

c) Power System Stabilizer (PSS).

d) Over-Excitation Limiter (OEL).

e) Manual control.

f) Field flashing

g) Field suppression circuit including discharge resistor.

h) Inputs and outputs capable for connecting the exciter into the station's local and remote protection and control scheme.

i) DC over-voltage protection circuit.

j) Miscellaneous equipment and supplies required for satisfactory operation of the system.

k) Provision for easy isolation and grounding of the field leads to the generator rotor for work protection purposes.

2B CHARACTERISTICS AND PERFORMANCE

2B1 User Interface

The manufacturer of the digital static excitation system shall supply a software user-interface for communicating with the main on-line processing system. The user interface must provide access to the following features:

a) settings for all regulators and limiters

b) limited control of configuration and internal test features

c) display of calculated and measured excitation and generator terminal quantities

d) access to internally recorded data

e) display of detailed diagnostic information

The exciter must be capable of recording calculated and measured quantities for display or down- loading to an external PC during tests. The number of quantities, sampling rate and record duration must be selectable by the user.

The software should use a simple menu-driven or terminal interface, which allows station staff to access information without the need for extensive training in its operation. The software must be capable of operating on any standard IBM-PC compatible laptop computer running one of the following versions of the Microsoft Windows operating systems: 95/98, NT, 2000, XP. If there are restrictions on the type of computers or operating systems this must be explicitly identified in the bid.

In addition to the general requirements listed above, the system must meet the following specific requirements:

a) Settings for regulators and limiters can be changed on-line without disruption to the operation of the excitation system. All settings must be expressed in engineering units (i.e. kV, per-unit or similar units) to avoid confusion and errors. Base values must be clearly identified in the manufacturer's software description and through the on-line display. Display of calculated quantities in similar engineering units is also preferred, but is not mandatory, since the consequences of mis-interpretation are not the same. It must be possible to change settings with the unit in operation, and then store the final settings in non-volatile memory.

b) Configuration changes may require off-line operation of the excitation system. Within reason the software must provide interlocks to ensure that users cannot make changes that would adversely affect the operation of the system while it is providing excitation to the generator.

c) Data gathering by the exciter's recording facility or sequence-of-events recorder must be accessible through the user-interface. The user should be capable of saving this data in a conventional format (e.g. ASCII text, CSV) for display or processing with third party software.

d) The exciter must be capable of sending internally calculated quantities to D/A outputs for measurement on external test equipment.

e) The exciter must have a user-programmable A/D input to allow external test sources to be used during commissioning and routine testing of regulator and stabilizer functions.

f) The exciter must have a user-programmable test function that allows test signals to be introduced at various reference points for the regulators and limiters. As a minimum, the test facility must allow for the addition of adjustable step changes of terminal voltage reference to the AVR summing junction.

g) The manufacturer must provide a detailed software description with a clear explanation of the operation of the software interface. Block diagrams of each regulator (e.g. AVR) and limiter (e.g. OEL) must be provided with reference to the software parameters that are accessible to the end user.

Third party Human Factors Engineering consultants can be used to resolve any conflict in the interpretation of this specification.

2B2 Capabilities

The exciter shall be required to provide:

a) Maximum continuous field current, which is at least 105% of the maximum continuous field current requirement. For this location, the maximum continuous requirement is taken to be equal to the field current corresponding to a 120°C total temperature on the field winding of the machine, and all excitation system components, with the exception of the excitation transformer, must be capable of operating at 1450 Adc continuously.

b) Ceiling field current, which is 150% of rated field current, for a period of 30 seconds. For the purpose of this specification, rated field current is 1135 Adc, corresponding to operation at rated MVA, power factor and terminal voltage. A field forcing level of 1,700 Adc for 30 seconds will be used as the basis of this specification.

The exciter must be capable of providing the maximum continuous field current with one failed bridge.

The exciter will not be required to supply negative field current but it must allow negative field current to flow during conditions of line energization or out of step. Negative field current should not result in exciter damage or inadvertent unit shutdowns.

2B3 Response Characteristics

2B3.1 Small Signal Response of Exciter on AVR Control

The required characteristics are:

(a) The voltage regulating loop proportional gain shall be adjustable between 25 and 250 per unit field voltage per unit terminal voltage. Per unit field voltage is the field voltage required to produce rated terminal voltage with the generator on the air gap line of the open circuit saturation characteristic and the field winding is 100 degree C.

(b) The equivalent time constant associated with terminal voltage feedback to the AVR must not exceed 30 milliseconds.

The equivalent time constant associated with the AVR itself and the firing circuitry must not exceed 20 milliseconds.

(c) The response to positive and negative error signals should not be significantly different.

(d) The voltage regulator algorithm circuit must have provision for a transient gain reduction transfer function (TGR) or functionally equivalent transfer function. The TGR transfer function will have the following form:

$$H(s) = \frac{1 + T1s}{1 + T2s}$$

where s = Laplace operator
T1 = 0.04 - 2.0 seconds
T2 = linear function of T1 as follows:

T1	T2
0.04	2(T1) - 60(T1)
2.00	2(T1) - 10(T1)

For other values of T1, T2 should have a proportional range. The manufacturer shall provide a method to switch in the TGR transfer function based on internal conditions (e.g. PSS failure) or external discrete logic. Provision of a complete set of alternate AVR settings for this purpose is acceptable.

2B3.2 Large Signal Response of Exciter on AVR Control

The Excitation System Voltage Response Time (ESVRT) shall be less than 25 ms for these conditions:

(a) Regulator loop gain = 200.

(b) 5% drop in terminal voltage.

(c) T1 = 0.

(d) T2 = 0.

The ESVRT is defined by the IEEE as follows:

The time (in seconds) for the excitation voltage to attain 95% of the difference between ceiling voltage and rated load field voltage for a specified sustained drop in terminal voltage (5% in this case).

Between positive and negative ceiling voltages, the generator field voltage shall be a linear function of error voltage. The error voltage is the difference between the reference voltage and the generator terminal voltage feedback signal. The firing circuit must automatically adjust for changing supply voltage such that the exciter output is independent of the excitation transformer secondary voltage when operating between the upper and lower limits.

2B4 Ceiling Voltages

2B4.1 Positive Ceiling Voltage

The exciter no-load ceiling voltage shall be based on a nominal 670 Vac PPT secondary voltage and a reasonable firing circuit delay angle margin. The resulting no-load ceiling shall be at least 850 Vdc. Maintenance of this level of forcing at lower operating voltages is not a requirement.

2B4.2 Negative Ceiling Voltage

The negative ceiling voltage shall be at least 70% of the magnitude of the positive ceiling voltage. The exciter shall be capable of supplying negative ceiling voltage while positive field current is flowing.

2B5 Fault Condition Requirements

2B5.1 Field Voltage

The exciter shall provide a field voltage during any fault at the high voltage side of the unit transformer that is defined as follows:

Vff = Vfc x Vta/Vt

where

Vff	=	field voltage during a fault
Vfc	=	exciter positive ceiling voltage
Vta	=	arithmetic average of three phase to phase voltages during fault (where all phases are greater than 25% of rated value)
Vt	=	rated unit terminal voltage

2B5.2 Operation of Components

Controls, firing circuits and power supplies must operate correctly during the conditions of reduced and/or unbalanced voltages associated with faults.

The exciter should be able to withstand the following duty cycles without damage or loss of life (assuming initial conditions of unit at full load, rated voltage and power factor):

(a) Load Rejection

- 0.0 to 0.6 s - 3 phase fault on line side of unit breaker

- 0.6 s plus - operation at no load and rated voltage

This could occur for a load rejection followed by return to speed no load.

(b) Breaker Failure

- 0.0 to 0.1 s - 3 phase fault on line side of unit breaker

- 0.1 to 0.4 s - exciter operating at ceiling voltage

- 0.4 to 0.5 s - 3 phase fault on line side of unit breaker

- 0.5 s plus - exciter brings the field current up to 1.6 times rated until the fault clears or 30 s passes

This is a worst case situation. It could occur if a line protection trips, recloses and one or more breakers fail to open.

2B5.3 Induced Currents During Fault and Pole-Slip Conditions

The excitation system should withstand, without damage, any faults or abnormal operation of the synchronous machine. Faults on the synchronous machine ac terminals will induce a large positive current into the field (adding to the normal field current) which will have a dc and an ac component at the machine frequency. The peak of the ac component of the induced fault current will be additive for one of the rectifiers and provisions must be made for this overload duty. IEEE C37.18-1996 (ANSI) should be used as a guide for selecting the magnitude and time duration of the induced currents for design purposes.

Besides the positive induced field current under faults, there can be induced currents (subtracting from the normal field current) during pole-slipping events leading to an attempt to reverse the current through the thyristor bridge, leading to a large field overvoltage condition. The exciter field overvoltage protection must be designed to cater to these field overvoltages to protect both the exciter and machine field circuit. The vendor must use conservative design criteria for estimating the pole slip voltage magnitude of the induced voltage based on the generator design specifications provided in the attachment. The calculated pole slip voltage, plus appropriate design margin must be used to size the thyristor Peak Reverse Voltage to prevent breakdown failure. The energy capacity of the protective equipment provided by the vendor must take into account the possibility of pole slipping without primary protective relay operation (i.e. Loss-of-field or Out-of-Step relays).

2B5.4 Field Faults

The exciter must be able to withstand a short circuit across the field without damage or loss of life.

2B6 Overvoltages

The exciter shall be able to withstand various types of overvoltages without damage or loss of life.

2B6.1 Impulse

The exciter shall be able to withstand a full wave (1.2 x 50 ms) impulse having a crest voltage of 95 kV at the high voltage terminals of the exciter transformer. Impulse voltage protections must not shut down the exciter. These requirements are in addition to any standards quoted at other locations within this specification.

2B6.2 Switching Surges

Switching surges will be present in all 60 Hz voltages. These surges may reach 2.5 times normal and may last several cycles. These requirements are in addition to any standards quoted at other locations within this specification.

2B6.3 Dynamic Overvoltages

Tripping remote end breakers on a transmission line can cause dynamic overvoltages. These overvoltages may appear on the generator terminals at values of 1.5 times normal.

They may last three seconds. These requirements are in addition to any standards quoted at other locations within this specification.

2B7 Variation in Unit Terminal Voltage

The exciter should be able to operate continuously over a range of variation in unit terminal voltage of 80% to 110% of nominal.

2B8 Regulators and Limiters

2B8.1 AVR Function

The AVR must have a voltage adjustment range of 80% to 110% of rated terminal voltage. The adjustment of setpoint must be linear throughout this range. The rate of setpoint adjustment must be adjustable.

The generator terminal voltage must be regulated with ±0.5% of rated over the entire operating range. Temperature drift must not exceed this regulation level for slow changes in ambient temperature from 15° C to 40° C.
A discrete contact output identifying the AVR status must be provided. This contact must identify the internal AVR status and not the Operator’s selection.

2B8.2 V/Hz Limiter Function

A function is required to reduce generator terminal voltage in proportion to frequency to control possible over-flux conditions. This limiter must operate whether the AVR or manual control is in service. The per-unit ratio setting is to be adjustable from 1.05 to 1.2 at 60 Hz.

2B8.3 Overexcitation Limit and Protection

An overexcitation limiter function in the form of a field current limiter is required to detect and prevent the unit from exceeding the lesser of the generator rotor’s over-excited operating capability and the exciter’s current capability. The limiter/protection features must protect the excitation system against damage due to extended field forcing or dc bus short circuits. The limit shall be adjustable to permit matching the limit and protection characteristics to the generator rotor characteristic, and consist of the following separately adjustable settings:

a) Adjustable time delay during which no field current limiting takes place (e.g. 100ms) to allow for induced field currents during fault-on periods.

b) An instantaneous field current limit setting that takes effect as soon as the initial time delay is exceeded.

c) A timed field current limit characteristic in the form of an I^2t characteristic, or equivalent, that can be tailored to the generator field winding limited–time capability.

d) A rotor heating memory to prevent rotor overheating under conditions of repetitive field forcing.

e) Field current limiters configured as proportional regulators must have a method of limiting regulation error to less than 2% of the selected limit startpoint.

f) Any over-excitation protection functions should be co-ordinated such that they will only operate if the limiter fails to limit field current within a reasonable amount of time.

The manufacturer as an option can provide different field current limiter settings for off-line and on-line conditions.

2B8.4 Power System Stabilizer

a) Configuration

The power system stabilizer must be of the dual-input design (reference: type PSS2A, "IEEE Recommended Practice for Excitation System Models for Power System Stability Studies, " IEEE Std 421.5-1992).

The acceptable input signals are electrical power and compensated frequency (see details later in this section).

b) Settings

The digital design must accommodate the following range of settings:

- The high-pass filters must allow for time constants of up to 20 seconds (T_{W1}, T_{W2}, T_{W3}, T_{W4})
- The "mechanical-power" filter must provide attenuation of at least 40 dB at 10 Hz and must be of the "ramp-tracking" configuration to minimize terminal voltage excursions during mechanical power variations. Specifically the stabilizer output change must not exceed 1% of terminal voltage reference with a stabilizer gain of 10 pu $E_{t\text{-}ref}$/pu speed, for mechanical power ramp rates of 0.1 pu/second. (T_8, T_9, N, M selected to meet above criteria).
- The stabilizer gain (K_{S1}) must be adjustable between 0 pu $E_{t\text{-}ref}$/pu speed and 50 pu $E_{t\text{-}ref}$/pu speed.
- Up to three adjustable phase lead transfer function blocks must be provided. The settings must allow for a wide range of phase compensation settings. A normal range of adjustment for the phase lead time constants is:

  T_{LEAD} = 0.01 to 6.0 seconds
  T_{LAG} = 0.02 to 6.0 seconds
- Stabilizer signal output limits are required. A normal range of adjustment for the limits is:

  V_{STMAX} = 0.0 to 0.3 pu
  V_{STMIN} = 0.0 to -0.25 pu

All settings must be adjustable while the unit is running.

c) Input Signals

The stabilizer input signals are electrical active power and compensated frequency (i.e. derived signal proportional to rotor speed). The active power signal is normally derived from an instantaneous watt transducer or comparable digital algorithm. The speed signal is normally derived from a measurement or calculation of compensated terminal frequency. The accuracy of the two measurements must be within 1% of full range. The effective time constant associated with the power and compensated frequency measurements must be no greater than 20 ms, and there must be less than 10 ms difference between the two input channels.

For the compensated frequency input, the manufacturer must supply an arrangement whereby the terminal voltage is summed with a quadrature component of terminal current. Three-phase inputs must be used for this purpose. This arrangement must allow for compensation up to 3.0 pu on the impedance base of the generator. This compensation shall be continuously adjustable over the entire range. A direct measurement of un-compensated terminal frequency is not adequate for this application.

d) Status Indication

A discrete contact output identifying the PSS status must be provided. This status point must identify if the PSS is off when it should be on. For example if the excitation system identifies an internal failure requiring the PSS function to be turned off, then the indication should only be provided if the unit is operating above the turn-on power level for the PSS.

2B8.5 Reactance Compensation

A function is required to provide an adjustable compensation characteristic to allow the AVR to regulate voltage at a point other than the generator's low-voltage terminals. This control could be configured for either reactive droop compensation or to compensate for unit transformer impedance and must allow for compensation of up to 15% on the generator's impedance base.

2B8.6 Under Excitation Limiter

An under-excitation limiter is not required as an option at this location.

2B8.7 Manual Control

A manual control of exciter output is required in the event that the AVR control has failed for some reason. The Manual control may also be used during commissioning checks or troubleshooting. The Manual control may be implemented as a field voltage regulator (FVR) or field current regulator (FCR). In either case, the regulator must be capable of maintaining a constant output when the supply voltage from the excitation transformer is changing.

The manual regulator shall include an adjuster, which shall provide adjustment of excitation voltage or current from 0% to 110% of rated excitation current or voltage. Adjustment steps should be no more than 0.5% of rated unit voltage while the unit is at no load in the range of 80% to 110% of rated unit voltage. Setpoint adjustments must be linear, and the rate of change must be adjustable.

Adjustable limiting functions shall be provided to stop the adjuster at extreme limits and to issue both local and remote signals. Provision shall be made for smooth transfer from automatic to manual control and from manual to automatic control. The design of the follow-up logic shall ensure that the manual regulator does not follow the AVR too quickly, resulting in large terminal quantity changes during transfers initiated by AVR failures. An immediate reset input shall be provided in order to avoid over voltages caused by reactive load rejections when operating in manual mode.

2B8.8 PT Failure Monitor

A PT failure monitor must be provided to automatically transfer control from AVR to MANUAL when a drop in the PT feedback signal, corresponding to the loss of a single phase input (e.g. fuse failure). The monitor must use a signal from the excitation transformer secondary as the comparison voltage source. A loss of this source must be alarmed. The signal conditioning of the two sources (PT and excitation transformer) must be virtually identical, such that transfers are not initiated during power system transients that result in sudden voltage changes.

The transfers initiated by the PT Fuse Failure Monitor must take place in less than 100 ms and result in minimal increases in generator terminal voltage. The target is to maintain the voltage rise below 2% of rated voltage for PT failure with the generator operating on open circuit.

2B8.9 VAR/PF Control

A VAR or power factor control is not required as an option at this location.

2B8.10 Field Temperature Monitoring

The exciter must provide an estimate of the field temperature based on the average resistance method. The calculation must use suitably filtered versions of the exciter output voltage and current, and include a provision for programming of a fixed voltage drop component (e.g. brush voltage drop) for the purposes of calibration.

The calculated field temperature must be available for display in units of °C, and for use in setting an alarm based on the calculated temperature exceeding a user-adjustable limit.

2B9 Supply Voltages Details

2B9.1 Power Transformer Input

The main source of ac power will be from the excitation transformer connected across the generator terminals. The nominal secondary voltage is listed in Attachment B.

2B9.2 DC Supply

The station battery will be available and can be considered to be uninterruptable. The battery nominal voltage is 125 V dc, with an operating window from 105 V dc to 140 V dc. The battery voltage level may stay at these extremes for up to 48 hours at a time.

2B9.3 Alternate Current (ac) Supply

The following ac supply voltages will be available for exciter auxiliaries and testing only:

a) 120/208 Vac, single and three phase, 60 Hz - for low power requirements.

b) 600 Vac, three phase, 60 Hz, 575 +/-5% nominal - for high power requirements.

These ac supplies are subject to interruptions lasting one or more seconds and must not be relied upon for normal operation of the excitation system.

2B9.4 Electronic Power Supplies

The power supplies used for the main excitation functions (e.g. AVR, firing circuits, annunciation) must be fed from dual sources and be capable of operating from a single source without interruption. The recommended sources are the station battery supply and the ac excitation transformer secondary (stepped down to a suitable voltage level). The loss of either of these supplies must be alarmed.

2B10 Environment

The exciter will have to operate in the following environment:

a) Maximum average ambient temperature of 40 °C.

b) Humidity ranging from 0% to 95%, non-condensing.

c) Inside the powerhouse in an environment is normally dry and free from atmospheric contamination.

2C DESIGN AND CONSTRUCTION

2C1 General Overview

The exciter shall have the following components:

a) Excitation cubicles c/w thyristor rectifier bridges & related components.

b) Digital control including AVR and related regulators/limiters.

c) Multi-pole dc field breaker complete with auxiliary contacts to insert field discharge resistor into circuit.

d) Field discharge resistor

e) Field flashing contactor and associated resistor

f) Protections.

g) Control circuits.

h) Instrumentation and indication.

i) Annunciation.

j) Calibrated shunt to provide measurement point for total exciter output current. A shunt shall be provided even if a DCCT is used to measure field current for the excitation limiting and control functions.

k) Disconnect switches within the excitation cubicle for each external power supply (e.g. 125 V dc, 120 V ac, etc.).

l) A full set of three-phase voltage and current test switches (compatible with Westinghouse FT style) are to be supplied at the entry point to the excitation system from the generator PT and CT circuits.

m) Any exposed terminals, bus work, or other energized component that can be accessed with one or more of the cabinet doors open must be properly labelled. Plexiglass, or equivalent transparent, non-conductive barriers must be mounted wherever workers could come into contact with energized components during the course of normal maintenance or troubleshooting activities (e.g. measuring testpoints, inspecting hardware, operating breakers or disconnect switches, replacing fan filters,…). Barriers must be designed so that maintenance activities can take place without the need for removal of the barriers.

All equipment shall be tested in accordance with NEMA SG5-1975.

2C2 Equipment, Materials and Services Provided by the Buyer

a) All connections necessary to interface the exciter to the existing equipment with the exception of any items explicitly identified in the specification. This will include cables from the existing excitation transformer into the excitation bridge inputs, and cables for connection of the bridge output to the brushgear of the generator field winding.

b) Generator current transformer(s) with the characteristics listed in the supplementary specification.

c) Generator voltage transformers with the characteristics listed in the supplementary specification.

d) Speed switch contacts for use with start/stop circuits.

e) All concrete foundation and necessary grouting materials.

f) Placement of the exciter into position.

2C3 Exciter Supply Transformer (PPT)

The existing dry-type excitation transformer described in the attachment will be retained for use at this location.

The exciter will accept digital inputs for indication of the following conditions:

a) excitation transformer over-temperature alarm

b) excitation transformer over-current (50/51) operation

2C4 Cubicles

The exciter components shall be housed in an assembly of 3 mm sheet steel, indoor type cubicles. The cubicles shall have the following features:

a) Drip proof.

b) Dust tight (in cubicles not convection cooled).

c) Steel channel sills.

d) Hinged doors.

e) Service access.

The cubicles will be subject to the Buyer's approval for arrangement, construction and finishing.

2C5 Rectifier and Power Components

2C5.1 Capabilities

The rectifier shall have the following design:

a) Shall be fully controlled (six thyristors per bridge) to supply both positive and negative output DC voltage. Negative field current is not a requirement.

b) Sufficient number of fully rated parallel thyristor bridges to meet the output current capability requirements specified in an earlier section. The system shall be furnished with one (1) redundant rectifier bridge.

c) Upon failure of one (1) thyristor bridge assembly the load shall be distributed between the remaining bridges without overloading the system during operation at the continuous rated field current requirement.

d) The load of a failed thyristor bridge must be transferred smoothly to the other thyristor bridges.

e) Failure in a thyristor bridge assembly shall be alarmed at the local display panel and provided as an external discrete alarm point for remote indication. The exciter shall provide local indication of the failed bridge as well as the failed leg(s). This indication can be provided digitally through the front-panel display and/or through direct indication on the bridge (e.g. a visible target or LED on each thyristor leg). If indication is provided on the bridges directly, they shall be visible during normal operating conditions (i.e. not requiring opening of any cubicle doors). All bridges and legs shall be clearly labelled for ease of identification during troubleshooting or routine maintenance.

f) Each thyristor bridge assembly shall be properly protected against voltage surges and have semiconductor fuses installed in each leg.

g) There shall be no commonly used parts between the thyristor converters connected in parallel. A fault in one thyristor converter shall not affect the operation of the remaining healthy converters.

h) There shall be devices to insure equal loading of thyristors and equal current contribution between the thyristor converters operating in parallel.

i) Devices to assist commutation and reduce current surges.

j) On load thyristor or bridge disconnection is not required.

2C5.2 Cooling

Bids featuring natural cooling will be given preference over bids relying on forced cooling. If substantial price differences exist, Vendors should identify the cost of the forced cooling option in the main proposal, and offer a convection-cooled design as an option. Requirements for a forced air cooling system are:

a) 100% reserve capacity fans that run either continuously or transfer into service for low pressure or flow. Automatic detection and annunciation of fan failure and /or filter blockage shall be provided using differential pressure switches. Lover-based mercury switches are not acceptable for this function.

b) All controls required to give automatic operation.

c) Latching contactors for the fan motors.

d) Fan motors that are 600 Vac nominal.

Fan filters that:

a) Have a large cross sectional area.

b) Provide a low-pressure drop.

c) Are easily accessed and replaced.

d) Are readily available in Canada.

e) Air inlets and outlets on opposite sides of the cubicles to prevent recirculation.

f) Inlet air must not be drawn from near the floor.

2C5.3 Components

The rectifier equipment shall include:

a) Thyristors with heat sinks.

b) Firing circuits, which give smooth and fine control over the entire range of operation.

c) dc bus bars which are closed coupled to the field contactor.

2C6 Generator Field Equipment

2C6.1 Field Contactor

If DC field circuit breaker is not used the field contactor requires the following:

a) Mechanical latching and trip free mechanism.

b) Two pole construction with an auxiliary preclosing contact.

c) The ability to electrically isolate the generator field.

d) An overlapping contact to be used with a discharge resistor.

e) Design, manufacturing and testing in accordance with IEC 158-1 and ANSI C37.16 and C37.18 or the latest revision.

2C6.2 Discharge Resistor

A field discharge resistor is required to rapidly de-excite the field when the field contactor opens. It shall be adequately ventilated and located so as not to overheat adjacent equipment.

2C6.3 Field Flashing Circuit

A field flashing circuit is required to allow the unit to be black started. The requirements are:

a) Electrically operated contactors.

b) A series resistor to limit the current drawn from the battery.

c) A circuit to block currents from flowing into the battery.

d) A circuit that automatically transfers load from the battery to the rectifier as the unit voltage builds up.

2C7 Protections

The exciter must protect itself and the generator field. The protections must be able to work in conjunction with the unit protection scheme. All protections are subject to the Buyer's approval. Protections provided as part of the excitation system must not compromise the capability of the generator by reducing the ability to operate anywhere with the machine capabilities.

2C7.1 Protection Schemes

A protection may perform one of the following tasks:

a) Alarm only.

b) Alarm and perform control functions.

c) Perform control functions only.

d) Alarm and shut down the unit.

The protection scheme must include the following protections:

Alarm only:

a) Field ground detector covering 100% of the field. It must monitor on the generator side of the field contactor.

b) Rectifier failure (minor).

c) Excitation transformer high temperature.

d) Loss of second voltage source used in PT fuse failure (derived from excitation transformer secondary voltage)

e) Loss of one source input to the main power supply.

f) Calculated average field temperature exceeds user-selected limit

Alarm and control:

a) Transfer to backup fan for low pressure or flow (forced air cooling only)

b) PT fuse failure transfer

c) Optional transfer to backup or alternate AVR settings on loss of PSS above the power turn-on level.

Control only:

a) Transient voltage surge protections for:

- AC and DC buses.
- Each thyristor circuit.

b) Field over-voltage protection to limit positive and negative over-voltages due to loss of unit synchronism. A path for the positive and negative induced currents shall be provided.

c) Fusing for thyristors to protect for the situation of a shorted thyristor.

Alarm and trip:

a) Field contactor opens inadvertently with generator on-line.

b) Rectifier failure (major).

c) Total fan failure.

d) Transformer over temperature.

e) Transformer timed and instantaneous over-current in all phases.

2C7.2 Protection Equipment Requirements

The Vendor must document the function, method of operation and recommended settings for any protection included as part of the excitation system. The protection wiring diagrams should be included as part of the overall excitation system documentation.

The hardware requirements are:

a) Relay inputs and outputs, that are to interface with Hydro circuits, shall be wired to terminal blocks to allow for convenient cable terminations.

b) Relay contacts to be rated for 125 Vdc, 0.2 A., noninductive.

c) Relays readily available in Canada should be used.

d) Relays should be clearly labelled in accordance with ANSI C37.2 1970.

e) Different potentials should not be mixed on the contacts of any relay.

f) Relay contacts used with 48 Vdc and below should be chosen to avoid contact contamination.

g) Draw out construction.

h) Flush or semi-flush mount.

i) The exciter shall have a main, latching trip relay equipped with at least five normally open contacts. This relay will be used to initiate generator shutdown.

Auxiliary relays should be:

a) Flush mounted if mounted outside.

b) Surface mounted if mounted inside.

c) Located conveniently for maintenance.

Equipment used at 600 volts and greater should be shrouded to minimize the possibility of contact.

With the exception of power supply monitoring relays, there should be no continuously energized relays.

Hardwired control circuits shall not have fuses with the exception of the field contactor trip/close circuits.

Current transformer circuits should not be easily open circuited. Current links shall be provided.

2C8 Controls

Controls and control circuits are required to allow operators to use the facilities of the exciter. Controls for local operation and inputs for remote operation are required. The controls and control circuits must allow the following operations:

a) Automatic start/stop of the exciter.

b) Close/trip of the field contactor.

c) Raise/lower of the active regulator set point (AVR or MANUAL).

d) Regulator/manual transfer and Channel transfer (redundant systems only).

e) Fan lead/lag selection (forced air cooling only).

The control circuits may be either hardwired relay logic or software logic. If the software method is used the Vendor must supply any software required to modify and document the program and to monitor its operation while the unit is on-line for commissioning and troubleshooting activities.

2C9 Instrumentation and Indication

Local meters and lamps must be built into the exciter. Metering outputs and indication outputs are required for remote use. The hardware requirements are the same as those listed for protection and control circuits, as applicable.

2C9.1 Instrumentation

The required local instrumentation includes:

a) Field voltage, current and temperature

b) Current per Thyristor bridge.

c) Exciter transformer temperature.

Analog voltage or mA current loop outputs for remote instrumentation must be available for all quantities. The Vendor should interface to the excitation transformer thermocouple or RTD output for temperature datalogging. The Vendor shall provide metering specifications to the Buyer.

2C9.2 Indications

The required local indications include:

a) AVR/MANUAL mode.

b) Field contactor position.

c) Active regulator lower limit, raise limit and preset.

d) Excitation limiter engaged

Outputs for remote indications are also to be included.

2C10 Annunciation

Visual annunciation is to be included with the exciter to indicate all trips and alarms. No loss of information should result from a power supply failure. Each trip and alarm point should also include two normally open, electrically separated contacts wired to terminal blocks. These contacts shall be rated for 125 V dc, 0.2 A. noninductive.

2C11 Test Facilities

All circuits shall be designed with safe, readily accessible test points.

If software control logic is used, the manufacturer must specify the minimum requirements for external interface equipment and provide all external interface cables.

The test supply switch shall be interlocked with the normal supply switch to insure the two supplies are not paralleled.

2C12 Noise and Interference Immunity

All equipment shall comply with:

a) IEC 61000-4-12 oscillatory transient

b) IEC 61000-4-3 radiated field susceptibility

c) IEC 61000-4-2 electrostatic discharge

d) IEC 61000-4-4 electrical fast transient

Equipment that has been tested to North America (i.e. IEEE standards) will also be considered. The Vendor is responsible for identifying the test standard that has been applied and its relationship to the test standards identified above.

2C13 Paint

In general, two coats of primer and one coat of approved paint shall be applied to the equipment before shipment. The paint finish shall be ASA No. 61 light grey.

2C14 Documentation

Five copies of the service and maintenance manual(s) must be provided at the time of delivery. All documentation must be supplied in the English language. This manual set must contain as a minimum:

a) All documentation required for understanding equipment operation and performing routine or corrective maintenance shall be provided.

b) The manual shall cover all details of maintenance, fault tracing and required test equipment.

c) If software control logic is used, documentation must include all maintenance software in a format compatible with the external interface equipment described earlier. Restrictions in making copies of this software must be stated in the initial quotation so that appropriate numbers of copies can be ordered.

d) The Buyer requires all software and associated facilities to configure, operate, commission, test and troubleshoot the excitation system. Any software that is normally provided by the Vendor as an option item, shall be specifically identified by the Vendor and the costs included as part of the main bid. If special interface is necessary to connect a PC to the excitation system (e.g. optical coupler, PCMCIA card, etc.) then the price for three of each of these items shall be included in the bid.

e) OEM Manufacturer's manuals and bulletins.

f) As a minimum, the manufacturer shall supply in suitable turnover package (preferably on CD) for each unit the following drawings:

1) A schematic one-line diagram of the excitation system.
2) AC and DC elementary wiring diagrams for all control, protective relaying and power equipment.
3) Connection wiring diagrams for all cubicles.
4) Inter-cubicle and cabling connection wiring diagrams.
5) Customer External Connection Diagram (Electronic Media in AUTOCAD format).
6) Block Diagrams of the various subsystems.
7) Schematic diagrams of the various electronic modules.
8) Assembly diagrams and detailed parts lists for all modules and chassis.
9) Ladder diagrams for programmable logic if software control logic is used.

All drawings shall be submitted to the Buyer for approval. Any drawing deficiencies shall be the Vendor’s responsibility and any rectification of such deficiencies shall be done at the Vendor’s cost.

2C15 Training

The manufacturer shall provide a separate quote identifying the costs for supplying technical training for up to three of the Buyer’s staff. This training will include: overview of excitation system operation, functional design of system, recommended maintenance and testing of system, troubleshooting and repair.

2D TESTS

The Vendor shall state test details in the tender. The Vendor shall perform all tests necessary to insure the exciter will perform as specified before it is shipped. The tests shall be witnessed and accepted by the Buyer’s representative. It is recommended that all tests be completed at least one month prior to delivery of the excitation to site. The Buyer reserves the right to waive the witnessing of the tests.

2D1 Factory Tests

2D1.1 Rectifier

a) Short circuit heat run (48 hour duration)

b) Voltage and current sharing between each thyristors and bridges.

c) High potential per IEEE Std 421.3-1995.

d) Open circuit.

e) Reverse voltage for thyristors.

f) Power input and load loss.

g) Positive and negative ceiling voltage.

h) Converter cooling, fans, motors (forced cooling only)

i) Temperature rise, ambient air temperature, and temperature distribution in converter cubicles.

2D1.2 Control, Firing, and Protection Circuits

a) Test of alarm circuits, trip circuits, relays, switches, etc.

b) Test of field flashing circuit and its related controls and indications.

2D1.3 Voltage Regulator

a) Manual and auto control range setting.

b) Auto-manual changeover.

c) Alarms and protection checks.

d) Over-excitation limiter.

e) High voltage tests.

g) PT fuse failure function.

2D1.4 Field Contactor/ DC Field Circuit Breaker

a) Resistance of operating coils.

b) Electrical operation of contactor over a range of dc voltage 105 to 140 volts.

c) Check contactor will not close against a trip impulse.

d) Trip timing tests.

e) Manual operation of contactor.

f) High voltage tests on field contactors.

g) Check operation of auxiliary contacts and control relays.

2D1.5 Electronic Tests

Transient immunity and radiated interference testing of electronic control equipment shall be carried out in the Vendor's premises prior to shipping in accordance with the specifications quoted earlier. Documented type tests performed on identical equipment may be accepted at the Buyer’s discretion.

2D1.6 Power System Stabilizer (PSS) Tests

The proper function of the PSS is critical to the operation of the overall excitation system. Only PSS' that comply with the requirements documented in this specification will be considered. If the PSS unit has been previously accepted by the Buyer or designated representative, then type tests or factory acceptance tests may not be required. For all other units, part of the factory acceptance tests shall include verification of the PSS implementation. This shall involve applying simulated inputs to the exciter and measuring the response of the PSS at various points through out the algorithm. The general intent of these tests is to ensure that the manufacturer's PSS shall meet the performance of the existing PSS under all conditions, and allow implementation of the same settings currently applied to the units.

A detailed test plan shall be supplied by the Buyer to the successful Vendor.

2D1.7 Commissioning Tests

The cost for the participation of the Vendor's staff in the performance of the commissioning tests must be included in the main bid. The vendor must submit a detailed commissioning plan for the excitation system to include as a minimum the following steps:

a) operation of each rectifier bridge and all associated control logic

b) current sharing of bridges

c) operation of all start-stop and field flashing circuitry

d) redundant power supply transfer

e) functional checks of all interfacing between station control and annunciation and exciter

f) functional test of range adjusters and associated annunciation

g) functional checks of protection logic including interfacing to station protection logic

h) functional test of field ground detector and adjustment of sensitivity

i) functional test of average field winding temperature calculation and calibration of selected settings

j) operation of fan transfer logic (forced-cooling only)

2D1.8 Acceptance Tests

The cost for the participation of the Vendor's staff in the performance of the acceptance tests must be included in the main bid. The Vendor should budget for up to one week of time for their commissioning staff, concurrent with the commissioning activities. The Buyer will submit a detailed acceptance test plan for the excitation system as required to meet local and regulator compliance performance requirements. These tests will include as a minimum.

a) Monitoring and adjustment of field flashing and other start-up parameters

b) Off-line and on-line AVR and MANUAL control response testing including measurement of large signal performance (i.e. field forcing)

c) Dynamic testing of Over-excitation limiter

d) Excitation system response time measurement

e) PT fuse failure transfer

f) PSS tuning and dynamic testing

2D2 Warranty and Parts

2D2.1 Spare Parts

The Vendor will provide a list of recommended spare parts, recommended quantities and associated prices. The price list should identify any price advantage of ordering spare parts as part of the original order as opposed to ordering spare parts separately at a later date.

As a minimum all replacement parts shall be available for a period of ten (10) years from the production date of the last excitation system of the same model by the Vendor. The Vendor must notify the Buyer at least one year prior to the discontinuation of supply for any spare parts for the system.

2D2.2 Warranty

The Vendor shall warranty all equipment against defects in design, material, and workmanship, for a period of one (1) year after installation and final acceptance. The Vendor shall warrantee that the excitation performance shall meet all specified requirements providing that it is maintained by the Buyer according to the Vendor's recommended maintenance practices.

The Vendor shall provide a separate price for additional warranty coverage on a yearly basis to a maximum of 5 years from the completion of acceptance tests on the unit.