

TENDER

FOR

SUPPLY & INSTALLATION OF REAL TIME DIGITAL  
SIMULATOR IN SCHOOL OF COMPUTING & ELECTRICAL  
ENGINEERING, IIT MANDI



**Tender No.: IITMANDI/Admin/PUR-140/2014-15/7346-47**

**Tender date: 04<sup>th</sup> February, 2015**

**Last Date of submission: 25<sup>th</sup> February, 2015**

Indian Institute of Technology, Mandi

Transit Campus: Mandav Hotel, 2<sup>nd</sup> Floor (Near Bus Stand), Mandi – 175001 (H.P)

**Tel.:** 01905-267061 **email:** [sceeoffice@iitmandi.ac.in](mailto:sceeoffice@iitmandi.ac.in)

Indian Institute of Technology Mandi, Mandi invites tender for supply, erection, installation, commissioning, testing, demonstration and training of an Instrument, as per specifications given in the Annexure attached to the Tender form. All offers should be made in English and should be written in both figures and words. Tender forms can be downloaded from the website (<http://iitmandi.ac.in/administration/tenderseoi.html>) of the Institute.

The bidders are requested to read the tender document carefully and ensure compliance with all specifications/instructions herein. Non-compliance with specifications/instructions in this document may disqualify the bidders from the tender exercise. The Director, IIT Mandi, reserves the right to select the item (in single or multiple units) or to reject any quotation wholly or partly without assigning any reason. Incomplete tenders, amendments and additions to tender after opening or late tenders are liable to be ignored and rejected.

**Terms and Conditions:**

1. The technical and financial bids should be quoted separately and put in different sealed envelopes marked “**Technical bid**” or “**Financial bid**” as applicable. These separate bids envelopes are to be put in an outer envelope which should also be sealed.
2. The Vendors who have earlier supplied the equipment to any of the IITs, IISc, IISERs and other Scientific Institute of National Repute may only tender. The details of such institutions and the cost with name of equipment may also be supplied with the bids.
3. The technical and financial bids should be submitted in original. The financial bid should include the cost of main equipment/item and its accessories. If there is any separate cost for installation etc. that should be quoted separately.
4. Each individual sealed envelope as well as the outer envelope should be marked with the following reference on the top left hand corner: “**IITMANDI/Admin/PUR-140/2014-15/7346-47/Item Name.\_\_\_\_dated 04<sup>th</sup> February, 2015**”
5. The printed literature and catalogue/brochure giving full technical details should be included with the technical bid to verify the specifications quoted in the tender. The bidders should submit copies of suitable documents in support of their reputation, credentials and past performance.
6. The rates should be quoted in figures (typed or printed) and cutting should be avoided. The final amount should be in figures as well as in words. If there are cuttings, they should be duly initialed, failing which the bids are liable to be rejected.
7. Any bids received after **1:00 P.M. on 25<sup>th</sup> February, 2015** shall not be considered
8. The Technical Bids will be opened on **25<sup>th</sup> February, 2015 at 03:30 P.M.** The date & time for opening of Financial Bids will be informed later on to the technically qualified bidders.
9. While sending rates, the firm shall give an undertaking to the effect that “*the terms/conditions mentioned in the enquiry letter/Tender Notice against which the rates are being given are acceptable to the firm.*” In case the firms do not give this undertaking, their rates will not be considered.

10. If the supplier/firm is original equipment manufacturer (OEM)/authorized dealer/sole distributor of any item, the certificate to this effect should be attached.
11. The quantity shown against the item is approximate and may vary as per demand of the Institute at the time of placing order.
12. All tender documents should have to be sent through courier, speed post or registered post only. All tender documents received after the specified date and time shall not be considered.

The postal address for submitting the tenders is:

**“Assistant Registrar, Stores and Purchase”  
Indian Institute of Technology Mandi (IIT Mandi),  
Administrative Block (Mandav Hotel,  
Near Bus Stand), Mandi – 175001 (H.P), India”**

13. In the event of any dispute or difference(s) between the vendee Institute (IIT Mandi) and the vendor(s) arising out of non-supply of material or supplies not found according to specifications or any other cause whatsoever relating to the supply or purchase order before or after the supply has been executed, shall be referred to “The Director, IIT Mandi”, Mandi who may decide the matter himself or may appoint arbitrator(s) under the arbitration and conciliation Act,1996. The decision of the arbitrator shall be final and binding on both the parties.
14. The place of arbitration and the language to be used in arbitral proceedings shall be decided by the arbitrator.
15. All disputes shall be subject to Mandi Jurisdiction only.
16. All tenders in which any of the prescribed conditions is not fulfilled or any condition is putforth by the tenderer shall be summarily rejected.
17. The bidders or their authorized representatives may also be present during the opening of the Technical Bid, if they desire so, at their own expenses.

**Note:** Price bids of only those bidders will be opened whose technical bids are found suitable by the committee appointed for the purpose. Date and time of opening of price bids will be decided after technical bids have been evaluated by the committee. Information in this regard will be posted on Institute’s web site / Notice board. In exceptional situation, an authorized committee may negotiate price with the qualified bidder quoting the lowest price before awarding the contract.

18. **Clarifications:**

In case the bidders requires any clarification regarding the tender documents, they are requested to contact our office (e-mail: [sceeooffice@iitmandi.ac.in](mailto:sceeooffice@iitmandi.ac.in) & [arosp@iitmandi.ac.in](mailto:arosp@iitmandi.ac.in) on or before **21/02/2015**).

19. **Tender Cost:**

A Demand draft of **Rs. 1,000/- (Rupees One Thousand only)** towards non-refundable **tender fee, drawn in favour of "The Registrar, IIT Mandi"** payable at Mandi should accompany the Technical bid documents. In the absence of tender cost, the tender will not be accepted.

20. **Earnest Money Deposit (EMD):**

A refundable amount of **Rs.4 Lakh** earnest money deposit (EMD) in the shape of DD from a scheduled bank in India (**valid for a minimum period of 3 months from the date of submission of tender**) should accompany the bid documents. The DD drawn in favour of "The Registrar, IIT Mandi" payable at Mandi should accompany the bid documents. The EMD should be kept in a separate sealed envelope, should be marked clearly and put in the outer envelope that contains the technical and financial bid envelopes. The bidders should enclose a pre-receipted bill for the EMD to enable us to return the EMD of unsuccessful bidders. Failure to deposit **Earnest Money** will lead to rejection of tender. The bidders should submit separate EMD.

21. **Pre – Qualification Criteria:**

- a. Bidders should be the manufacturer / authorized dealer. Letter of Authorization from original equipment manufacturer (OEM) on the same and specific to the tender should be enclosed.
- b. The Vendors who have earlier supplied the equipment to any of the IITs, IISc, IISERs and other Scientific Institute of National Repute may only tender. The details of such institutions and the cost with name of equipment may also be supplied with the bids.
- c. An undertaking from the OEM is required stating that they would facilitate the bidder on a regular basis with technology/product updates and extend support for the warranty as well.
- d. OEM should be internationally reputed Branded Company.
- e. Non-compliance of tender terms, non-submission of required documents, lack of clarity of the specifications, contradiction between bidder specification and supporting documents etc. may lead to rejection of the bid.
- f. **Furnishing of wrong/ambiguous information in the compliance statement may lead to rejection of bid and further black listing of the bidder, if prima-facie it appears that the information in the compliance statement was given with a malafide/fraudulent intent.**

22. **Prices:**

- a. The Prices quoted should be inclusive of all taxes or duties, packing, forwarding, freight, insurance, delivery and commissioning etc. at destination site (IIT Mandi, Mandi). IIT Mandi is registered with DSIR, Govt. of India and is exempted from Custom / Excise Duty. Exemption Certificate to this effect will be issued by IIT Mandi. **Hence, Customs/Excise Duty exempted price should be quoted.** The rates shall be firm and final. Nothing extra shall be paid on any account. **In the price bid/financial bid, the**

**vendor should clearly mention the final price breakup i.e. ex-work price/FCA price, FOB price, CIP/CIF price & FOR IIT Mandi, Kamand Campus price, as applicable in their bid.**

- b. In case of imported equipment(s)/item(s), the agency commission, if any, payable in Indian rupees should be mentioned separately. For imported equipment, the Letter of Credit will be opened for the amount excluding agency commission in Indian Rupees. The firm should clearly mention the address of foreign bank in the financial bid.

**23. Validity:**

The bid should be valid for acceptance up to a period of 180 Days. The Bidders should be ready to extend the validity, if required without any additional financial implications.

**24. Delivery:**

The Equipment should be delivered and installed within the period as specified in the purchase order and be ready for use within 24 weeks of the issue of purchase order unless otherwise prescribed. If the bidder fails to deliver and place any or all the Equipments or perform the service by the specified date, penalty at the rate of 1% per week of the total order value subject to the maximum of 10% of total order value will be deducted.

**25. Training:**

Bidders need to provide adequate training to the nominated persons of IIT Mandi at their cost. IIT Mandi will not bear any training expenditure.

**26. Warranty Declaration:**

Bidders must give the comprehensive on-site warranty as required from the date of successful installation of Equipment against any manufacturing defects and also give the warranty declaration that *“everything to be supplied by us hereunder shall be free from all defects and faults in material, workmanship and shall be of the highest quality and material of the type ordered, shall be in full conformity with the specification and shall be complete enough to carry out the experiments, as specified in the tender document.*

Any deviation in the material, and the specifications from the accepted terms may liable to be rejected and the bidders need to supply all the goods in the specified form to the satisfaction / specifications specified in the order / contract and demonstrate at their own cost.

- 27. Performance Bank Guarantee:** A performance bank guarantee from a scheduled bank in India for an amount equal to 10% of the price for duration of two months beyond the expiry of warranty period will be taken from the supplier or Indian agent.

- 28. Terms of Payment:** Payment will generally be made only after delivery and satisfactory installation, testing, commissioning etc. **This must be specified in the tender/quotation.**

- In case of imported supplies, payment (excluding Indian agency commission, if any) will be made through irrecoverable Letter of Credit in two installments. 80 % of the money will be released on submission of shipping of documents. Remaining 20 % will be released after successful installation of the instrument and submission of a performance bank guarantee

for 10% of the order value from a nationalized bank, valid for 2 months beyond the expiry of the warranty.

29. **Tender expenses and documents:** All costs incurred by the bidder in the preparation of the tender shall be at the entire expense of the bidder.
30. **Tender Evaluation Criteria:** The technical bids will be opened and evaluated by a duly constituted committee. After evaluation of the technical bid, the financial bid for only those offers which have qualified in the evaluation of technical bid will be opened.
31. **Return of EMD:**
  - The earnest money of unsuccessful bidders will be returned to them without any interest within 30 working days after awarding the contract.
  - The earnest money of the successful bidder will be returned to them without any interest within 30 Days after supply of material.
32. **Manual and documentation:** All the manuals necessary for operating and servicing the equipment (including details of electronic circuits) will have to be provided along with the instrument.
33. Bidders should go through the tender terms, conditions and specifications carefully and fill in the attached compliance statement accurately and unambiguously. They should ensure that all the required documents are furnished along with the bid.

Sd/-  
**Assistant Registrar**  
**Stores & Purchase**

## BID PARTICULARS

1. Name of the Supplier :

2. Address of the Supplier :

3. Availability of demonstration of equipment : Yes / No

4. Tender cost enclosed: : Yes/No if yes

D.D. No. \_\_\_\_\_ Bank \_\_\_\_\_ Amount \_\_\_\_\_

5. EMD enclosed : Yes / No if Yes

D.D. No. \_\_\_\_\_ Bank \_\_\_\_\_

6. Name and address of the Officer/contact person to whom all references shall be made regarding this tender enquiry.

Name :

Address :

Telephone No. :

Fax No. :

Mobile No :

e-Mail :

Web

## Annexure 1

Ref:-ENQUIRYNO:- **IITMANDI/Admin/PUR- 140/2014-15/Real Time Digital Simulator**

S.No.	Name of Equipment
01	<p><b><u>Real Time Digital Simulator</u></b>            The Real Time Simulator must be a Digital system (RTDS) able to perform electromagnetic transient simulations electric power system (frequency range DC to several kHz) continuously in real time. The external hardware to be included in the simulation loop can be a commercial device such as protective relay, FACTS &amp; HVDC controller, generator controller (exciter, stabilizer, etc.), machine drive controller, etc., or any in-house prototype controller. In addition, the simulator will also be used for general power system studies and power system training as well as Power Hardware In-the-Loop (PHIL) testing.</p> <p>RTDS must be able to simulate the following:</p> <ul style="list-style-type: none"> <li>• Power System Analysis with Hydro and Thermal Generation with Renewable (Wind and Solar)</li> <li>• General AC and DC system Operations</li> <li>• Interaction of AC and DC systems</li> <li>• Integrated Protection and Control systems</li> <li>• Control system for synchronous machines, drives, converters, HVDC, SVC</li> <li>• FACTS and custom power devices</li> <li>• Protective relay schemes with analog connections as well as digital communication</li> <li>• Synchrophasor and Wide Area Monitor and Protection</li> <li>• Advanced academic research and training</li> </ul> <p><b><u>RTDS Hardware</u></b>            The simulator must be <i>modular</i> in design to allow future expansion and upgrading of the system.</p> <p>The basic <i>module</i> of the simulator must perform three functions:</p> <ol style="list-style-type: none"> <li>1) Computation (i.e. solution) of the power and control system algorithms</li> <li>2) Ethernet communication to allow control of the simulator via a standard Microsoft Windows based computer workstation</li> <li>3) Dedicated, high speed communication to allow expansion of the simulator using additional <i>modules</i></li> </ol> <p><b><u>Computational Units</u></b>            The power and control system computation within each <i>module</i> shall be performed by processors (CPU) housed on multiple printed circuit cards. The processor cards shall not be dedicated to simulating specific models and the function of each processor contained in a module shall be completely defined by primary graphical user interface (GUI) software of the simulator.</p> <p>To prevent adverse effects caused by communication restrictions, it shall be possible to connect high accuracy, 16-bit digital to analogue and analogue to digital converters, plus digital input and output, directly to the computational units.</p> <p><b><u>Multi-user Access</u></b>            The basic simulator module shall have ability to connect directly to a 10/100BaseT or higher speed Ethernet Local Area Network (LAN) so that it can be accessed remotely by a large group of users.</p> <p>It shall also be possible via the simulator software and the Ethernet</p>



communication to control, monitor and interact with simulations during execution. This is a key aspect of the simulator, allowing the user to “operate” the simulated power system in a manner similar to that of a real power system (i.e. the simulator operator must have continuous communication with and control of the simulator during real time simulations).

#### **Global Time Synchronization**

It shall be possible for the simulation timestep to be synchronized to a 1 Pulse Per Second (1PPS), IEEE 1588 or IRIG-B time reference signal provided by an external device (i.e. GPS clock). Synchronization of the simulation timestep to an external time reference is necessary for Phasor Measurement Unit (PMU) benchmark testing and it is advantageous for IEC 61850-9-2 sampled value output. The simulation of a constant phase angle shall not drift whatsoever over time with respect to the external GPS reference signal and shall exhibit a jitter not larger than 1 microsecond. Utilizing this GPS capability, multiple modules running two or more independent simulations shall be able to start and operate in synchronism. One of the applications this feature is end-to-end testing of protection/control systems consisting of physically remote schemes.

#### **Expandability**

It shall be possible to expand the simulator by adding more *modules* to the system. Dedicated communication shall be used between simulator modules so that the simulation timestep is not affected in a negative way. Additionally, if multiple *modules* are used in the simulator, a precision optical communication channel shall be used to ensure absolute synchronization of computation in all modules.

To facilitate future expansion for larger scale real time simulations, it shall be possible to extend the simulator capacity to accommodate a minimum of one thousand three-phase buses (equivalent to approximately three thousand single-phase nodes) along with a number of transmission lines, transformers, composite loads, and generators existing in a typical transmission grid.

#### **Input / Output Capabilities**

The simulator shall provide the following minimum input/output capabilities:

- 1) Analogue Output (high resolution / optically isolated) - a minimum of 12, 16-bit analogue output channels shall be available on the simulator to facilitate connection to external devices. These outputs shall meet the following minimum specifications:
  - usable dynamic range ~ 400:1 (based on 100kHz BW limited signal & 28db SNR)
  - output voltage and current range +/- 10 Volts & 5 milli Amps max. resolution 305 micro VoltsFor standard simulations operating with timesteps in the range of 50 microseconds, the analogue output signal shall be oversampled at a rate of 1 microsecond.  
The analogue output shall be equipped with a “watch dog” circuit to ensure the output voltage is set to zero within 1 millisecond of a simulation being stopped. The zeroing of the d/a output shall be within 1 millisecond regardless of how the simulation is terminated, either intentional or accidental.
- 2) Analogue Input (high resolution / optically isolated) - a minimum of 12, 16-bit analogue input channels shall be available on the simulator to facilitate importing analogue signals from external sources. These inputs shall meet the following specifications:
  - usable dynamic range ~ 400:1 (based on 100kHz BW limited signal & 28db SNR)
  - input voltage range +/- 10 Volts resolution 305 micro Volts
- 3) Digital Input (optically isolated) - a minimum of 64 optically isolated digital input channels shall be available to allow the connection of multiple external devices to the system. At least 60 of the 64 digital inputs shall be

capable of providing a digital input timestamp with an accuracy of 250 nanoseconds or better.

- 4) Digital Output (optically isolated) - a minimum of 64 optically isolated digital output channels shall be available to allow the connection of multiple external devices to the system.
- 5) 250 Vdc Digital Output Interface - a minimum of 16 dry contact outputs shall be available to allow the connection status signals, etc. to external devices at station level voltages (i.e. up to 250 Vdc).
- 6) One OMICRON CMS 156 Amplifiers set
- 7) One PC including Intel Quad Core , 8 GB ram, 300 GB hard disk , two (2) 24inch flat panel screen display or similar.
- 8) Printer HP Designjet 510, 24 inch

### **Simulator Capacity and Simulation Timestep**

Depending on the purpose of the study being conducted, the simulator should be capable of modeling systems of various sizes, application, and levels of detail and timestep resolutions. The capacity is specified on a per *module* basis as the description of *module* given in the Hardware section. Such modularity of the simulator capacity is very important in our mode of use and should not be overlooked by satisfying overall capacity and not the modular capacity. For example, **NxM Buses** means N modules with each module capable of simulating at least M buses in an independent simulation and at least NxM buses when all N modules are used in one large simulation. It should be possible to have any number of modules (up to N) in one simulation and the capacity shall be linearly proportional to the number of modules. The size of the power system that can be modeled should meet the following minimum requirement in a typical power system and power electronic network context for hardware in the loop (controller and power HIL) real-time simulation.

- 1) Detailed large scale systems with up to **1x120 three-phase buses** and **1x20 synchronous generators** with their detailed controls such as exciters, governors, etc. represented in a fully *dynamic model* to accurately represent slow dynamics of rotor swings, fault currents, frequency deviations, etc. and operating with a timestep in the range of 50  $\mu$ s.
- 2) Fast transient simulations that include up to **1x60 three-phase buses**, HVDC, FACTS devices, generators, motors, transformers, transmission lines, loads, harmonic filters, faults, etc. running with a timestep in the range of 30-50  $\mu$ s. The number of buses mentioned here are the observable and controllable grid buses such as substation bus and load bus that are connected by transmission lines and transformers. Embedded buses internal to a device/system/model such as branch buses of filter banks, fault bus inside machines/transformers, non-interface nodes of a converter/drive and embedded breakers are not included in this count. Please keep in mind that purpose of number of buses here is to determine the size of the power system network and not necessarily the complexity of the devices being modeled. Hence, only interface bus to the network should be counted here. The simulator shall be capable of representing the power systems and others similar in nature in real time with a digital timestep in the range of 40-60 microseconds. Please consider this as a guideline as the number of buses being counted here.
- 3) Entire networks with up to **1x30 nodes** constructed with a simulation timestep in the range of 1 – 4  $\mu$ s to include power electronic systems within power system network including drives.
- 4) The simulator should be able to run real-time HIL simulation studies using combinations of all the capabilities mentioned above whereby very detailed FACTS models running at 1 - 4  $\mu$ s can be represented together with slower dynamics of the power system network running with time steps in the order of 30-50  $\mu$ s for conducting a range of applications

summarized in subsequent sections below.

- 5) The *power system simulator* should provide a facility to interface prototype controllers (student projects developed using D-Space, Nation Instruments (NI) or Texas Instruments (TI) Boards) or commercial power system devices such as relays, PMUs, drives, FACTS controller, etc. to the power system modeled in the simulator. For this purpose, the simulator should have both analog and digital inputs and outputs. Following is a minimum number requested. Please see the I/O performance specification separately.
  - i. **1x12 analog outputs**, high precision (16 bits), optically isolated, modular
  - ii. **1x12 analog inputs**, high precision (16 bits), optically isolated, modular
  - iii. **1x64 digital inputs**, optically isolated, modular
  - iv. **1x64 digital outputs**, optically isolated, modular
- 6) The simulator shall have overall capability for protocol based communications (GOOSE, PMU, DNP3, etc.) described elsewhere in the document. PMU and GOOSE protocols should be included in the scope. All other available protocols should be listed as options
- 7) The simulator shall be capable of representing, in real time with a digital timestep in the range of 40-60 microseconds.

#### **Numerical Stability**

The simulator shall be capable of simulating the systems continuously in real time for a *minimum* duration of twelve (12) hours. The operator shall manually apply faults at random times during the test to ensure the numerical stability and continuous operation of the system.

#### **Power Electronic Simulation**

AC-DC grid simulation with different variety of generators including wind and photovoltaic and complex loads.

#### **Line Commutated Power Electronic Converters**

The simulator shall be capable of representing line commutated power electronic converter (i.e. HVDC, SVC, TCSC) with an effective firing accuracy of 1 microseconds or better. The accuracy shall be maintained at all times and regardless of whether the firing pulses are generated internally by a simulated controller or externally by a physical controller. Furthermore it is required that these converters be solved as embedded parts of the main network solution and not as isolated subsystems. This is important to ensure maximum numerical stability and the proper representation of harmonics. These models shall also allow the representation of internal faults.

#### **Voltage Source Converter (VSC) Based Power Electronic Schemes**

VSC based power electronic schemes typically operate with higher frequency switching, particularly when driven by Pulse Width Modulation (PWM) control. Depending on the power level and application, PWM frequencies typically range from approximately 1 – 10 kHz and the dynamics of these schemes cannot be accurately represented using a timestep in the range of 50-70 microseconds. Therefore the simulator shall have the ability to represent the VSC schemes as special subnetworks that operate with timesteps in the range of 1-4 microseconds.

It shall be possible to connect the subnetworks containing the VSC schemes to the main simulation through a numerical interface so that the interaction of the VSC with a large scale network can be represented and studied.

The subnetworks containing VSC's shall be freely configurable and able to include a minimum of 30 nodes and 36 switching devices (an IGBT – Back Diode pair shall count only as one device). The subnetworks containing the VSC's are required to represent switching for PWM frequencies in the order of 1-1.5 kHz for 3-level converters and <10 kHz for 2-level converters.

The subnetworks containing the VSC's shall also be able to represent Multi-Module Converters (MMC or also known as cascaded H-bridges). For the full-

bridge configurations a minimum of 40 levels must be represented per leg and a minimum of 48 levels per leg for half-bridge configurations. It shall further be possible to expand the MMC valve representation using FPGA based models to a minimum of 500 submodules per valve (i.e. 1500 submodules for a STATCOM configuration and 3000 submodules for an HVDC terminal). It must be possible to connect each valve to the external control via no more than two duplex optical fibres. The fibre optic connections will carry the firing pulse information from the controller to the valve model and the capacitor voltages, valve current, etc. from the valve to the controller using an industry standard protocol (e.g. Aurora serial protocol).

The VSC converter models shall be capable of testing the firing pulse controllers (i.e. averaging models are not acceptable) for 2- and 3-level bridges as well as MMC. Therefore the simulators analogue output and digital input hardware must be respectively capable to send out and read new values every subnetwork timestep (i.e. in the range of 1-4 microseconds).

In addition to the VSC components, it shall also be possible to include the following elements in the subnetworks; transformers, transmission lines, cables, permanent magnet synchronous machines, double fed induction machines, breakers, filters, etc., and it shall be possible to freely interconnect any of these to form the circuit.

It shall also be possible to interconnect the subnetworks via traveling wave transmission line or cable models. Travel times as low as the subnetwork timestep (i.e. 1-4 microseconds) shall be allowed.

#### **Applications**

The simulator should be equipped with up-to-date software and hardware to facilitate real-time HIL simulation of *electrical and power electronic networks* including but not limited to the following applications. The simulator should include complete range of digital and analog input and output capabilities for HIL simulation.

##### 1. Power Electronics

- HVDC – conventional and VSC based schemes
  - System design
  - Closed-loop control system design and verification testing
  - AC system impact studies
  - VSC based schemes with 2- and 3-level converts as well as Modular Multi-level Converters (MMC)
- FACTS – SVC, TCSC, STATCOM, UPFC, SSSC, etc.
  - System design
  - Closed-loop control system design and verification testing
  - AC system impact studies
  - VSC based schemes with 2- and 3-level converts as well as Modular Multi-level Converters (MMC)
- Motor drives
  - Closed-loop control system design and verification testing
  - Configurable converter models and topologies
- General Power Electronic Circuits

##### 2. Protection System Testing

- Internal faults for transmission lines, transformers, synchronous machines, etc.
- Detailed CT, PT and CVT models including saturation, hysteresis, etc.
- IEC 61850 Capability with the following minimum number of channels
  - IEC 61850 GOOSE Publish and Subscribe
    - 64 binary input (subscribe) from up to 8 different IED's
    - 64 binary output (publish)
    - 8 analogue input

- 8 analogue output
  - Typical response time of 3 ms or better
  - IEC 61850-9-2 Sample Value Output
    - 80 or 256 samples per cycle for 50/60 Hz
    - Time synchronization / timestamp from 1PPS or IEEE 1588
  - Testing Wide Area Protection and Control Based on PMU Data
    - External Time Reference Synchronization
      - Required to provide consistent and reliable phase reference
      - Synchronization to GPS clock via 1PPS or IEEE 1588
    - IEEE C37.118 PMU communication protocol
3. Smart Grid
- Study and integration of renewable sources
    - Wind power with various configurations including Double Fed Induction Generator (DFIG) and Permanent Magnet Synchronous Machine (PMSM)
    - Solar
    - Fuel cell
    - Flywheel
    - Battery storage
    - Vehicle to grid
    - Configurable converter models and topologies
  - Investigation of new operating strategies and protection
  - Investigation of coordination of new communication protocols (e.g. IEC 61850)
  - Microgrid and distributed generation (DG) studies
4. AC system studies
- System security and transient stability investigations
  - Electromagnetic transient studies
  - Wide area protection and control development and testing
  - Black start
  - Islanding and anti-islanding
5. Academics
- Masters and PhD projects
  - Hands-on exposure to physical protection and control equipment in a realistic power system environment
  - Demonstration of real-time dynamic responses (such as machine swings) to students to re-enforce class room theory
6. Marine electrical systems
- Conventional ship simulations
  - All electric ship simulations
    - AC schemes
    - DC schemes
    - Hybrid schemes
    - Pulse loads
7. **Power Hardware In the Loop (PHIL)**
- Power amplifiers, if included in the scope above, should be supplied as a separate equipment and not built into the simulator cabinet. However, the simulator must have the I/O capabilities for stable interface with power amplifier.
  - Microgrid research
  - Analysis of dynamic load behavior such as air conditioners
  - Analysis of physical DG such as PV and Fuel Cell systems
  - Power equipment testing
    - Mechanical
    - Electrical
8. *Prototype Controller & Development Testing*: Prototype controllers may be

developed in-house by researchers using off-the-shelf real-time hardware platforms such as D-Space, National Instruments, Texas Instruments, Mathworks xPC Target Turnkey and FPGA for a variety of applications. Each of these controllers will be programmed using *programming environment* recommended by or provided with the controller platform hardware including such programming environments as MATLAB© to enrich student experience with the variety of tools. The power system simulator *GUI* is not expected to support these third party *software programming environments*. However, the prototype controller is expected to interface to the simulator through hardware analogue/digital Input/output (I/O) interface of the simulator in most instances. Hence, please treat simulator GUI features/capabilities independent of the GUI facilities of prototype controller development environment. This distinction has been done deliberately to provide flexibility and verity to range of tools available to the students.

## **SOFTWARE**

### **Graphical User Interface**

All aspects of the simulator operation, from construction of simulation cases, to operation of the simulator, to post analysis of results must be controlled by a single Graphical User Interface (GUI). The GUI shall consist of modules for the following functions:

- 1) Circuit Construction - a module to allow the construction of simulation circuits. It shall be possible to use predefined modules from a library of components to assemble new simulation cases. It shall be possible to construct the diagram in either three-line or single-line diagram format and it shall be possible to toggle between the two different views of the same circuit.
- 2) Transmission Line and Cable Constants – a module to calculate the traveling wave and pi-section parameters for transmission lines and cables. It shall be possible to input the physical parameters of transmission lines and cables to calculate the parameters. Alternatively for overhead transmission lines it shall be possible to input positive and zero sequence data for 3 and 6 conductor transmission lines to calculate the parameters.
- 3) Simulator Operation – a module for operation of the simulator and the retrieval of simulation results. This module shall allow simulation cases to be started and stopped, operation of the power system (i.e. changing of set-points and breaker operations), fault applications, monitoring of system status (e.g. RMS voltages and currents), and the retrieval of details simulation results (similar to a fault recorder).
- 4) Storing of Results - it shall be possible to save simulation results directly from the GUI in ASCII, jpg, emf (vector format), pdf or COMTRADE format.
- 5) Post analysis of simulation results

### **Batch Mode Operation**

Software shall be provided to allow the user to program a series of simulations to run automatically (i.e. batch mode). The batch mode software shall be capable of nested looping (e.g. if, for and while) to allow adaptive algorithms to be used during automatic operation. The batch mode software shall also be capable of recording key results in ASCII format and selectively printing or storing simulation results.

The batch mode software shall have the ability to embed text and simulation results (in jpg or emf format) directly into Microsoft® Word™ documents.

The batch mode software will be used to conduct automated relay testing where many hundreds or thousands of cases may be simulated during a day.

### **Power System Models**

A minimum of the following power system models shall be available for the

simulator:

- 1) Traveling wave and pi-section multi-phase (max. 12 conductors), coupled transmission line and cable models. It shall be possible to embed breakers in each end of the transmission line models with a maximum of 6 conductors. The nodes introduced by the breakers shall be solved by the transmission line model and shall not count as part of those solved by the main network solution. Additionally a phase domain frequency dependent model shall also be available to represent a minimum of 6 coupled conductors.
- 2) Transformers with 2 or 3 windings and autotransformers with an optional tertiary winding, including saturation and hysteresis, online tap changer and internal fault representation
- 3) Synchronous machines (standard and permanent magnet). The synchronous machine models must be solved as part of the main network and are not allowed to be numerically interfaced to the network solution. The synchronous machine model shall optionally allow the unit transformer to be embedded as part of the model so the transformer secondary nodes do not reduce the number available in the network solution (i.e. only the transformer primary nodes need be counted as solved by the network solution). Additionally a phase domain synchronous machine model must be available with a true stator-ground fault. The phase domain machine must also be solved as part of the main network and in not permitted to be interfaced or decoupled from the network solution.
- 4) Inductions machines (squirrel cage and double fed)
- 5) Voltage sources with definable equivalent impedances, source magnitude, frequency and phase
- 6) Passive Resistive, Inductive and Capacitive components (including various filter configurations)
- 7) Circuit breakers & fault switches
- 8) Bus arrestors
- 9) Series capacitors with ZnO arrestors and bypass switches
- 10) Thyristor Controlled Series Capacitors (TCSC)
- 11) HVDC valve groups for transmission and back-to-back schemes. The HVDC valve groups shall include 6-pulse and 12-pulse configurations. The 12-pulse configurations shall be fed from a 3-winding transformer with an option to include a 4<sup>th</sup> winding for the freely configurable connection of filters and or reactive power compensation. The valve group models shall support internal valve faults and shall be solved as part of the main network solution. It is not acceptable that the valve groups are numerically decoupled from the network solution or interfaced. The switches representing thyristor valves must be embedded in the main network solution and NOT solved as independent subsystems.
- 12) Filter bank model to allow multiple banks of up to 12 switchable filters to be added to simulations without reducing the number of switches or nodes available in the main network solution
- 13) Static VAR Compensators (SVC) including TCR and TSC branches. The switches representing thyristor valves must be embedded in the main network solution and NOT solved as independent subsystems.
- 14) Instrument transformers including current transformers (CT), inductive voltage transformers (PT), and capacitive voltage transformers (CVT) with full support for saturation and hysteresis loop modeling
- 15) Voltage Source Converters: STATCOM, UPFC, SSSC, VSC-based HVDC, DFIG wind generation
- 16) COMTRADE and ASCII Playback. It shall be possible to playback COMTRADE, or ASCII, data files as large as 4 GB.

#### **Control System Models**

A minimum of the following control system components shall be available for

the simulator in the control system module:

- User-Input - Slider, switch, button, dial, etc.
- Constants – integer, floating point, PI
- Data conversion- deg-rad, rad-deg, int-float, float-int
- Math functions – gain, exp, log, ln,  $e^x$ ,  $x^y$ , sqrt, inverse, abs, sum, multiply, divide, max, min, etc.
- Complex math functions – multiply, divide, add, subtract, etc.
- Trigonometric functions – sin, arcsin, cos, arcos, tan, arctan, arctan2
- Standard control blocks - deadband, pulse generator, edge detector, time, counter, ramp, ramp limits, limiters, phase-locked loop (PLL), flip-flops, fourier transform, integrator, lead-lag, wash-out, lookup table, non-linear gains, etc.
- Logic functions – and, or, nor, bit shift functions, bit -> word, if-then-else, etc.
- Sequencer functions – wait, apply fault, close breaker, ...
- Meters – real and reactive power, RMS (single- and three-phase), angle difference, frequency
- Signal processing – sample & hold, down sampler, moving average, FIR, DFT, ABC-DQ0, DQ0-ABC, ABC- $\alpha\beta$ ,  $\alpha\beta$ -ABC, vector rotator, etc.
- Generator controls – exciters (IEEE Type 1 to 5, AC1 to 4, ST1 to 3, X1, X2, 2A, SCRX, DC2, IVO, etc.), governors (IEEE Type 1-3, IVO, European BBGOV1, Gas turbine, steam turbine, hydro turbine, etc.), power system stabilizers (PSS2A, IEEEEST, IEE2ST)
- Relay models – line distance protection (mho & quad), transformer, differential, generator, overcurrent, etc.
- Phasor Measurement Unit (PMU) – model which will operate in a manner similar to PMU devices typically found in power systems to allow the development of wide area protection and control based on PMU data.

#### **User Defined Models**

It shall be possible for the user to create power and control system models for the simulator to run in real time together with standard models provided by the supplier. The facility provided shall allow custom icon graphics and input menus to be created for the new component. Furthermore the facility shall allow high level programming (for example C code) of the real time simulation algorithm and include all necessary compilers.

#### **Load Flow Initialization**

The software shall include a load flow calculation which can be used to initialize the simulation components before the real time electromagnetic transient simulation is begun.

#### **PSS/E Compatibility**

It shall be possible for the simulator to import and convert PSS/E data for simulation in real time. Once converted, the PSS/E system must also be available in picture format for modification.

#### **PSCAD Compatibility**

It shall be possible for the simulator to import and convert PSCAD network data for simulation in real time.

#### **Software Modules**

The simulator should include all the software modules currently available for power system and power electronics simulation including but not limited to the following modules. Clearly identify modules not available as well as those that are *available but not included*.

- Graphical circuit drawing module
- Interactive run control module
- Transmission line and cable constants solver module
- Post processing module for reporting & curve calculations of saved output
- User defined component builder module with C compiler



- Power flow solver and network initialization
- Power flow importer for network initialization and re-initialization for multi-scenario studies
- Transient stability data importer such as PSS/E and BPA programs
- Frequency Dependent Network Equivalent calculation and interface module
- Transient Fault Recorder (TFR)
- Batch scripting recorder and editor

**Software Licensing**

The software shall be provided with a site license so that it is possible to install the simulator software on any number of desktop or laptop computers. The proposal should include University wide site license for the entire suite of software and hardware with unlimited number of licenses/seats. Simulator supplied should include the cost of *new and independent* software licenses for all the modules without any assumption of existing licenses at the University. If any necessary software is not included or has a restriction on number of seats (as opposed to unlimited site license), please itemize the additional cost for license/seat.

**Communication protocols**

The simulator will be utilized to model modern Smart Grid and Distributed Generation scenarios and as such must be able to provide high level Ethernet based communication as a minimum via the protocols described below. While all these protocols should be available (and demonstrated if needed) as add-on, only a subset or none may be ordered with the simulator purchase.

**IEC 61850 GOOSE Messaging**

The simulator shall be capable of providing IEC 61850 GOOSE formatted messages for binary signals (e.g. trip and breaker status). A minimum of 64 digital inputs and 64 digital outputs shall be provided using the IEC protocol to as many as 8 different IED’s. It shall be possible to manipulate the quality bits, “test” bit and “needs commissioning” bit of the GOOSE messages to test the response of the external protection and control devices.

To ensure compliance with the standard and to ensure multi-vendor interoperability, the IEC 61850 implementation shall be certified by an independent UCA International Users Group recognized test lab (e.g. KEMA).

**IEC 61850-9-2 Sampled Value Messaging**

The simulator shall be capable of providing a minimum of two IEC 61850-9-2 sampled value data streams (i.e. two sets of 4 x voltage and 4 x current channels) to protection and control equipment. The sampled values shall be provided at 80 or 256 samples per cycle for a single data stream. It shall be possible to manipulate the quality bits of the sampled value messages to test the response of the external protection and control devices.

It shall also be possible to subscribe to a minimum of one IEC 61850-9-2 sampled values data stream at 80 or 256 sample per cycle as input to a simulation.

**C37.118 PMU Data Stream Output**

The simulator shall be capable of simulating and providing data stream output for a minimum of eight (8) Phasor Measurement Units (PMU’s) with individually assignable frame-rates of up to 240 frames per second.

**SCADA Interface**

The simulator shall be capable of acting as a slave unit for communication with SCADA equipment using the DNP 3.0 or IEC 60870-5-104 protocol. The system shall communicate with one DNP/ IEC 60870-5-104 master and accommodate the following minimum communication capacity:

- Binary simulation status (i.e. breaker position) 1024 (scan rate 1000 Hz)
- Binary simulation control (i.e. breaker commands) 512 (scan rate 1000 Hz)

- Analogue status (i.e. output from simulator) 500 (scan rate 4 Hz)
- Analogue control (i.e. input to simulator) 100 (scan rate 4 Hz)

### **AVAILABILITY AND MAINTAINABILITY**

The real time simulator will be a combination of both hardware and software, but for the purpose of the specification it shall be considered one entity. Furthermore to ensure fast and comprehensive support, the entire simulator shall be designed and manufactured by one supplier.

It shall be possible for the customer to remove and replace individual printed circuit cards (CPU processor boards as well as individual type of I/O boards) in order to guarantee maintainability and a high level of availability. Hence, it is desirable if the CPUs/cores are divided into multiple processor boards. Each type of I/O (analogue input, analogue output, digital input and digital output) shall be on separate boards for the same purpose. Furthermore, the manufacturer shall offer a maintenance program to extend the hardware warranty and provide software updates. The manufacturer must further guarantee to provide maintenance, including replacement components, for the system for a minimum of 05 years.

### **Installation and Training**

The proposal should include on-site installation and one week training conducted by experienced engineers and should accommodate up to 15 participants (staff, faculty and students). The training should encompass all hardware and software modules including third party modules supplied as part of the simulator. If this cost is not included with the supply, please itemize the additional cost or clearly state non-availability of the service and the reason for the same.

### **Application Notes and Examples**

As part of the installation and training the vendor should install all the application notes and ready-made example cases available. All example applications developed by the vendor during the extended maintenance period (up to 05 years) should be made available to the Institute as part of the maintenance program without any exclusions or additional charge.

### **Technical Support**

The simulator should include unlimited technical support on hardware and software for at least 05 years. The technical support should cover all the software and hardware supplied as part of the simulator irrespective of whether the software or hardware was manufactured by the simulator vendor or purchased from third parties. If this cost is not included with the supply, please itemize the additional cost or clearly state non-availability of the service and the reason for the same. The simulator vendor shall demonstrate their expertise for supporting third party software and hardware, now and in the future.

### **Software Maintenance and Upgrade**

The simulator should include unrestricted upgrade (all releases including major and minor releases) and maintenance (patches and fixes) for at least 05 years. The upgrade and maintenance should cover all the software modules supplied as part of the simulator whether the software module was manufactured by the simulator vendor or purchased from third parties. Please identify third party software/modules and provide details (such as transferable contracts from original manufacturer) to support vendor's ability to offer maintenance, upgrade coverage and guarantee compatibility for the requested period. The Institute shall request contact information of existing client sites to verify the history of satisfactory execution of such extended maintenance on vendor developed and third party products. If this cost is not included with the supply, please state non-availability of the service and the reason for the same.

### **Hardware Warranty**

The proposal should include a “repair or replace hardware warranty” that covers parts and labor for at least 05 years with zero deductible. The warranty should cover all the hardware supplied as part of the simulator whether the hardware was manufactured by the simulator vendor or purchased from third parties including off-the-shelf processor boards, power supplies, I/O modules, etc. Please identify all third party hardware boards and provide details (such as transferable contracts from original manufacturer) to support simulator vendor’s ability to offer the warranty coverage for the requested period. The Institute shall request contact information of existing client sites to verify the history of satisfactory execution of such extended maintenance on vendor developed and third party products. If this cost is not included with the supply, please state non-availability of the service and the reason for the same.

### **Hardware Upgrades and Compatibility**

The vendor should provide a clear and demonstrated path for a cost effective hardware upgrade with full backward compatibility. From upgrade cost point, please describe any hardware exchange program offered by the vendor to offset the cost of hardware upgrade including percentage discount offered on exchange and any annual enrolment fee for the *exchange discount program*. In the case of third party components including off-the-shelf processor boards, I/O modules, etc. included with the simulator, please describe in sufficient detail, including any limitation, as to how upgrade with full backward compatibility is assured. Considering 10 year life of the simulator, this aspect is very important to assess the total cost of operation. The compatibility is also important for effective collaboration with other institutions and sponsors that may have a different version of hardware and/or software. If this cost is not included with the supply, please state non-availability of the service and the reason for the same.

### **On-site Demonstration and Hands-on Evaluation**

The Institute reserves the right to request hands-on demonstration of simulator and all the capabilities and features requested. The institute may require that the demonstration simulator unit to be left behind for a short period (up to a month) to experience and further evaluate the simulator firsthand. This may be requested of all the pre-qualified vendors after the evaluation of technical proposal. This may be considered as a required part of the final technical evaluation/qualification process. The demonstration unit should be equipped with the latest versions of all the hardware and software features requested in this specification, even though they are optional. However, the simulator hardware (not the software) could be a scaled down (portable) version of the proposed simulator with limits only on the size of the network being modeled. The demonstration unit/setup should have at least one module of each I/O type proposed with hardware facilities (including a sample external HIL controller) to demonstrate the real-time HIL capabilities. The vendor is responsible to deliver, install and remove the simulator at their own cost and provide at least one day training for up to 3 people at the Institute. Prompt technical support during the evaluation period is expected of the vendor to help complete the technical evaluation on time. The Institute will be under no obligation to purchase the simulator from any vendor after the evaluation or to reimburse the expenses incurred by the vendor. Clearly indicate if this option is not available/acceptable or if any conditions are attached including any associated cost.

### **QUALIFICATION**

In order to qualify as a potential supplier and demonstrate a well-established product, the manufacturer must provide references for at least fifteen similar installations, in the field of electrical power systems, delivered to end customers within the last two years. The list should include at least three installations in India. The reference installation shall have the same technology (hardware generation and software) to be valuable as a reference.

**Compliance statement for the tender  
specifications  
INDIAN INSTITUTE OF TECHNOLOGY MANDI  
HIMACHAL PRADESH-175001**

Ref:-ENQUIRY NO:- IITMANDI/Admin/PUR-140/2014-15/ **Real Time Digital Simulator**

**Instructions**

1. You have to fill in all columns and ensure that you furnish all the required information accurately and unambiguously.
2. If our specification contains any values, you have to provide your values against the column in the same unit as we have specified.
3. Deviation in values, materials etc. from our specification may be explained in the remarks column

S. NO	Check list of documents/ Undertakings ?	YES/NO	Remarks (Give explanation if answer is No)
1	Is Tender fees attached?		
2	Is EMD attached? (if applicable)		
3	Is the bidder original equipment manufacturer (OEM)/authorised dealer?		
4	If authorised dealer, recent dated certificate to this effect from OEM, attached or not?		
5	Undertaking from OEM regarding technical support & extended warranty period		
6	Validity of 180 days or not?		
7	Undertaking from bidder regarding acceptance of tender terms & conditions		
8	Whether list of reputed users (along with telephone numbers of contact persons) for the past three years specific to the instrument attached.		
9	Whether special educational discount for Indian Institute of Technology (IIT) Mandi (H.P) given.		
10	Whether two weeks training of operator and research students without any charges offered.		
11	<b>Does the instrument complies with all the specifications as per Annexure 1. Attach a separate sheet showing compliance with the specifications and explanations thereto if the equipments varies from the requested specifications.</b>		
12	Whether free Installation, Commissioning and Application Training offered.		
13	Whether Three years comprehensive onsite extended warranty offered.		
14	Whether Annual maintenance after expiry of comprehensive onsite warranty quoted separately as optional.		