



INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
MATERIALS MANAGEMENT DIVISION
Powai, Mumbai 400076

Purchase Requisition No. 1000011808 (SRM/RFX No. 6100000185)

Technical specification of Real Time HIL Microgrid Testbed

I. Eligibility Criteria for Vendor's

1. Vendor should have experience in developing real-time HIL facilities for the Electrical Industries and preferably for power system and power electronic applications. The vendor must have supplied systems to academic institutions which have been used in various electrical R&D projects. Previous supply order details should be provided with technical bid.
2. Vendor should demonstrate all features to the user as part of TEC (Technical Evaluation Committee).
3. IIT Bombay has developed various MATLAB Simulink models for electrical systems. Further, various control and system models will be developed during the use of the test facility. The HIL system should have provision to port these models.
4. Vendor should provide details of their project team hierarchy with qualification and experience for in-house test facilities, infrastructure and past experience in carrying out similar tasks.
5. Vendor should provide training, and familiarize IIT Bombay researchers for operation of the test facility.
6. Vendor provided solution must be based on Commercial off-the-shelf (COTS) hardware. It must be scalable and flexible allowing easy integration with new controllers.
7. Vendors must be OEMs or their authorised representatives.
8. Single vendor should supply the complete hardware and software as per the given specification.
9. Bidders should submit all supporting documents for the above mentioned eligibility along with tender.

II. General Specification

The requirement is for the use of state-of-the-art Hardware-in-Loop Simulation Systems (HILS Systems) for testing and integrating various electrical systems, such as, the integrated renewable energy, energy storage, DER's and other smart grid systems, using functional dynamic models with the actual hardware in order to develop and study solutions suitable for the next generation electrical systems

This tender document is about procurement of a HiLS system which will be integrated with various controllers. Recognizing that the HIL simulator is needed for the long-term, with multiple projects and programme objectives, Supplier should provide modular hardware architecture as mentioned below:

- Scalable Processing – multi-core/multi-processor/ (Field Programming Gate Array) FPGA configurations to meet real-time model computation requirements. A basic single core configuration can be used for simple models and expanded to multiple cores as computational needs increase with the use of more complex models for higher simulation fidelity.
- Expandable I/O and Signal Conditioning– the I/O chassis should support multiple FPGA I/O modules as well as third-party boards. Supplier should provide several modules of I/Os, any change or increase in I/O requirements should be accommodated by replacing/adding modules and cards at any point of time. Since projects will be running for multiple years, scope of adding or removing the I/O module should be available.
- Commercial Real Time Operating System (RTOS) used should support wide range of software tools to run in real time environment. This capability will be critical for our projects which will be using the in house developed Simulink Models, Certified C Code, FORTRAN and third party tools like, DigSILENT PowerFactory, PSS/E, CYME, AMESim, Dymola etc...
- Test automation should support tools like Python, LabView TestStand, Altia, PROVETech etc. This will help IIT Bombay to achieve complete testing of hardware for the various conditions.
- Vendor should supply an OPEN but fully integrated solution, HIL system should have high degree of FLEXIBILITY to meet a variety of testing objectives.

III. Detailed specifications

Detailed requirement of the real time HIL microgrid testbed system are given below:

HiLS-System Level

The system-level requirements that are to be satisfied by the HiLS System are given below:

- Systems offered should be primarily designed for hard real-time high fidelity simulation of electrical systems. The purpose is to aid in the design, development of prototypes of controllers and monitoring systems, suitable for implementation in actual electrical systems.
- Industry production standard hardware platforms based on PC technologies (with multi-core, multi-processor motherboards, PCIe/VME/PXI and Gigabit Ethernet communication capabilities) with emphasis on open architecture for ensuring interoperability with products of industry-leading manufacturers of similar systems.
- Multi-node or multi-core distributed architecture with I/O capabilities with direct linkage to I/O modules or systems to ensure reduction of model-I/O communication overheads and latencies in closed loop operation.
- Real-time communication through external communication links amid all the nodes for deterministic exchange of parameters amongst models or through shared memory in case of

execution of models in multi- core system with appropriate clock synchronization through master slave mechanism.

- Software framework for assignment of models to various nodes/cores and distribution of executable software models to respective nodes/cores for simultaneous execution and control of specific I/O, in hard real-time, through the use of an RTOS, in frame-synchronised manner, at simulation time steps as fast as 20 us, in order to achieve high fidelity with respect to the performance of the actual systems.
- Real time computation of complete electro-mechanical systems up to an assured time-step of 20 microseconds. Multi-rate/Multi-time step simulation should be possible. With FPGA based simulation for Power Electronics simulation time step should be as low as 150ns.
- Re-configurable FPGA based simulation model creation, debugging and execution capabilities with on-board discrete I/Os required to ensure time-steps as small as 150ns and direct control of interfaces to external hardware.
- Test script generation, execution and intrusive/non-intrusive debugging in manual, interactive mode as well as in automatic mode.
- Selection of signals and parameters for display and plotting at run-time
- Test results display as well as recording/logging in on-line mode in hard disk storage

Specification details for Hardware and Software

S	S. No	Description	Qty
1.		<p style="text-align: center;"><u>Real Time HIL Microgrid HIL Testbed Technical Specifications</u></p> <p>(1) Real Time Emulator(s)</p> <p>(a) Main processor: FPGA with 3 X 8 cores Co-processors: ARM with 3 X 2 CPU</p> <ul style="list-style-type: none"> • FPGA based (FPGAs as main processor) with pre-defined multi-core configurations enabling short compilation time and low latency, small time-step, simulation of power electronics and dynamic power systems. • Dedicated FPGA cores (solvers) for switching devices, machines, signal generators, LUTs, etc. • CPU Co-processors for simulation in signal domain. 	01 System

(b) Configurations Capability:

- Controller HIL real-time simulation with up to 24 switching converter models (3ph) with simulation time-step down to 500ns.
- Simulation of up to 120 averaged converter models (3ph) with detailed control loops with simulation time-step down to 500ns.
- Simulation of microgrids and distribution power system of at least 450 busses (3ph) with 10 μ s simulation time-step.
- Real time simulation of power electronics converters with switching frequency of up to 200 KHz
- Rapid development of control loops (RCP)
- System must be able to interface with physical devices, and should comprise:
 - At least 180 Analog outputs fully selectable with +/- 10V range, 1 MSPS update rate, 16bit resolution and 1% accuracy.
 - At least 90 Analog inputs fully selectable with +/- 10V range, 1 MSPS update rate, 16bit resolution and 1% accuracy.
 - At least 180 Digital outputs with at least 36 channels capable for PWM modulation with 7ns resolution, +/-24V ESD protection.
 - At least 180 Digital inputs with 20ns sampling resolution on all channels, +/-24V ESD protection
 - Ports for communication over standard communication protocols, including Ethernet/IP, Modbus, IEC61850 Goose and CAN.
 - Connectivity: USB.
 - Input Power supply is 230 Volt, 50Hz.

(c) Simulator should support multiple configuration without making any physical changes into simulator.

(d) Lifelong, Free Firmware update should made available for all supported configurations by Simulator.

(e) Should support switching frequency up to 200 kHz.

(f) System should be able to operate as one large-scale simulator described above or to be disassembled in smaller independent units (3 units).

(g) Should be capable for multiple device cascading if required in future.

(2) Modelling Software with Real-time Interface:

- Permanent software license for modeling as well as Real-time Interface with lifetime free upgrades and unlimited number of software users.
- Unlimited number of installations with offline simulation capabilities for all members of IIT Bombay community.
- Toolbox package with Graphical User Interface (GUI). Building various interactive simulation interfaces with a drag-and-drop library of graphical widgets, measurement elements, action items, etc.

- Modeling environment for plant as well as Signal Processing with embedded library of components with inbuilt, i) Converter toolbox ii) Microgrid toolbox, iii) Power System Toolbox, iv) Signal processing toolbox v) Test Suite, and vi) Communication toolbox having IEC61850, UL 1741, CAN Bus protocol, Ethernet, DNP3, MOD Bus protocol etc.
- All the Switching components in library must have Internal or external both control option during modeling for Hardware-in-the-Loop simulation.
- Ability to run Plant simulation without controller if required.
- High resolution built-in real time signal monitoring oscilloscope with at least 16 channels.
- All supported solvers (based on different applications) should be made available with modelling software.
- Scripting Environment should be based on python. In-built API should be made available for automation as well as for communicating with other software's like PSSE, PSCAD etc. for co-simulation.
- Option for interface with Controller code generated from any simulation software like MATLAB, Simulink, LabView, PSIM etc.

(3) HIL Connect Universal Interface:

- Plug-and-play connectivity with Emulator
- Size: 19", 6U
- 32 AO channels
- 16 x high voltage, ± 183.3 V
- 16 x high current, ± 2 A
- 16 AI channels
- 16 x current, ± 40 mA
- 16 x voltage, ± 10 V
- 32 D IO channels

(4) Woodward EasyGen 3500 genset controller:

- Hardware in the loop system compatible
- Plug-and-play connectivity with Emulator
- True RMS voltage and current sensing (gen, bus and mains)
- CAN network communication/control to engine ECU
- Modbus RTU (slave) communication for SCADA and external control

(5) HIL Connect Protective relays (ABB REF615 / SEL 751 relays):

- Plug-and-play connectivity with Emulator
- Hardware in the loop system compatible
- Protective functions: overvoltage, overcurrent, undervoltage, undercurrent

(6) HIL TI Microgrid Interface Card:

	<ul style="list-style-type: none"> Design, test and verify parallel converter systems, or entire microgrids using the microgrid DSP interface(s) with at least 6 TI DSP controllers and Emulators in single or cluster configuration. <p>(7) HIL TI Interface Card:</p> <ul style="list-style-type: none"> Plug in a TI controller card and start controlling your power converter via a pin-to-pin compatible HIL connection. Compatible with: Delfino F28335 and F28377; Piccolo F2803x and F2806x control cards. <p>(8) Breakout Board:</p> <ul style="list-style-type: none"> Connectivity 96 x Analog IO snap-in terminals, 96 x Digital IO snap-in terminals, 192 x Measurement points, 4 x Analog output BNC connectors, 2 x HIL Connectors (DIN 41612 Female), 2 x DIN 41612 Male Connectors. <p>(9) Cabinet (Rack):</p> <ul style="list-style-type: none"> Size: 19" 	
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Services:

- Installation/Commissioning/Training at IITB

Warranty: Five years from the date of delivery to IIT Bombay

Scalability

- Supplied system should be scalable for the future requirement. System be able to add IO's by adding chassis
- Supplied systems should support required communication protocol which are used in drives application
- Should be able to add software license at point of time to increase the computation power
- System supplied should be with COTS technology