Technical Specifications of "Quantum Simulator" For Expression of Interest (EoI)

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1. Introduction

Quantum computing is new computing paradigm that has potential to solve critical problems in diverse areas more efficiently than classical computers and High Performance Computing (HPC) systems. High Performance computing is another classical way to address massive computation through efficient parallelization but is not capable to address many problems in a reasonable timeframe. The compute/execute time is exponential as the number of states grow. This is where quantum computers unlock new potentials and their timeframe increases linearly in contrast to exponential in HPC. The first quantum revolution at microscopic level brought major innovations such as transistor, laser, superconducting devices and optical fibers. We are in the era of 2nd quantum revolution where we are migrating from bits to qubits. The quantum superposition enables massive parallel computation with reasonable number of qubits to solve practical problems of interest which may not be possible with most powerful supercomputers available today.

The quantum computing platforms available today are mostly being offered by computing powerhouses on cloud environment which may be suitable for few but not for all research sectors. Thereby few market players have thought of substituting requirement of independent quantum computers with quantum simulators.

Scientific Analysis Group (SAG) is looking for a complete on-premises hardware agnostic environment to enable quantum software developers for experimentation. The Quantum simulator must have a dedicated hardware to understand the impact of qubits on cryptographic algorithms. The quantum simulator is expected to provide quantum programming and simulation platform with right set of optimizers and noise models to emulate execution as a genuine quantum computer would. It must simulate the laws of physics, which is the core of any quantum computing platform. It should enable developers to focus on applications and algorithms in quantum domain without having to wait for independent quantum machine. It should be different from quantum processors in the sense that it doesn't suffer from quantum noise, quantum de-coherence, manufacturing biases and performance bottlenecks. An extensible quantum circuit model with high level quantum hybrid language built on python will be preferred. A set of mathematical libraries and algorithms must be available for kick starting experiments in the desired domain. Programs developed on Quantum Simulator must be adaptable to the physical quantum computers of tomorrow. Developers should have access to high level wrappers to incorporate quantum programs from other frameworks.

Respondents to this document are expected to give suggestions to refine the specifications by addition/deletion/modification of specific parameters (technical/Non-technical).

Specifications are intended to be generic however any proprietary spec if found in this document may be highlighted, with equivalent available. Equivalence must be corroborated with support document(s).

If any specification is better/equivalent in offered product, details should be furnished with supporting OEM Brochure (mentioning Page/Para number).

A comprehensive test methodology (for ATP) and compliance to all specifications should be submitted for qualification and participation in bidding at later stage.

Best price must be quoted with all terms & conditions on Company Letter Head and signed by authorized person. Validity of quotation must be at least 150 days.

2. Software Modules

The Quantum Simulator must have the following **functional software modules**:

Sr. No.	Specifications parameter		Compliance (Yes/No/Better/Equivalent/Remarks)
	PROGRAMMING		
1.	QASM	Quantum Assembler to build quantum Circuits	
2.	QLIB	Quantum libraries to handle different applications in computing domain	
3.	CIRC	To define binary format of quantum Circuits	
4.	Python Support	Python extension to quantum assembler (QASM)	
5.	Quantum Algorithms	Support for algorithms such as • Quantum Approximate Optimization Algorithm(QAOA) • Variational Quantum Eigensolver (VQE) • Variational Quantum Factoring (VQF) • Variational Quantum Classifier(VQC)	
6.	Plug-in(s)	The quantum programming language must be able to integrate plugins in different language. OEM must provide a SDK to integrate the algorithm to the solution.	
7.	Hybrid Support	The system must provide a solution than can mix classical and quantum programming language. It must also support a "universal quantum language" for gate based computing, quantum	

Sr. No.	Specifications parameter		Compliance (Yes/No/Better/Equivalent/ Remarks)
		annealing and analog computing.	
	QUANTUM PROCESSING UNIT (QPU)		
8.	QPU	QPU Emulation support	
	OPTIMIZATION		
9.	Gate Set Optimizer	There should be Abstract gates for optimization	
10.	Circuit Optimizer	There should be support for • Generic Circuit optimizer • Gate set rewriter • Custom Plugin and • Topology constraint solvers	
11.	Mathematical formulation tools	The product should enable experiments using Quadratic Unconstrained Binary Optimization (QUBO)	
	SIMULATION		
12.	Circuit modeling	Different simulation models should be available to model circuits	
13.	Quantum Physical Noise Simulation (Noise modeling)	There should be different models for quantum noise simulation for underlying technologies like trapped ions, superconducting circuits or Semiconducting silicon. The noise models should be as close to reality as possible without reducing the available number of qubits. -Support for Open Source Noiseless Simulator: PyLinalg -Advanced Noiseless Simulators: • Linalg • Feynman • Stabilizers • Matrix Product State	

Sr. No.	Specifications parameter		Compliance (Yes/No/Better/Equivalent/ Remarks)
		• Binary Decision Diagram -Noisy Simulators: • Deterministic • Stochastic	
14.	Quantum inspired algorithms	Simulated Quantum Annealing (SQA) or Simulated Bifurcation Algorithm (SBA) with support for 5000 variables or more	
15.	Simulators	The simulation environment should consist of at least following simulators: • Full state-vector simulation • Path integral formulation simulation • MPS (Matrix Product State) simulation • Clifford-gates-only simulation	
	INTEROPERABILITY		
16.	INTEROP	There should be interoperability connectors with frameworks such as Qiskit (IBM), Cirq (Google), ProjectQ or Forest.	
17.	Scalability	The appliance proposed must be evolutive i.e. moving from 40 Qubit to higher in the future.	
18.	Qubits requirement	The solution must be able to emulate a quantum solution for full state vector simulation of at least 40 qubits for any circuit.	
19.	Test cases	Exploration and building of test cases for quantum	

Sr. No.	Specifications parameter	Compliance (Yes/No/Better/Equivalent/ Remarks)
	algorithms like Shor & Grover's	
20.	The appliance/solution provided must be able to generate serialized and machine quantum code (assembly language) for different hardware and the appliance must be compatible with different QPU.	
21.	The OEM must provide an optimization environment that allows to adapt the different quantum circuits to a particular hardware according to the existing gates on the target hardware. Their solution must also be able to optimize the number of gates according to the gates available on the target hardware, as well as minimize their number using standard best practices.	

3. System Hardware Configuration

While the scientists and engineers are working on improvising quantum hardware from Noisy Intermediate State Quantum (NISQ) to fault tolerant side, the industry is exploring quantum advantage and possible applications. We at SAG are looking for a specific hardware based infrastructure having dimensions of a physical business server with scalable architecture. It should have a large in-memory capacity with a dedicated hardware accelerator. The broad specifications of hardware are as follows:

HARDWARE SPECIFICATIONS			
Sr. No.	Parameter	Specifications	Compliance (Yes/No/Better/Equivalent/ Remarks)
1.	Qubits	40 or more, Full State Vector Qubits	
2.	Form factor	30U or less	
3.	Ethernet Copper ports	Phy ETH Board Unit for 12 * 1Gb/s (RJ45) or more ports	
4.	Ethernet optical ports	12 * 10Gb/s (SFP+) or more ports	
5.	CPU	Xeon Cascade Lake Platinum Processor 24C (16* Xeon 24 Cores) or better	
6.	Memory	At least 24 TB DDR4	
7.	GPU	Nvidia A30 PCIe GPU Cards	

HARDWARE SPECIFICATIONS

8.	Storage	Hardware RAID Controller 16*1.6TB SAS	
9.	Management	Embedded Ethernet management switch	
10.	Power supply	220V 60Hz Preferably with redundant power supply for all servers with plug/sockets as per Indian standards	
11.	Power consumption	Less than 20 KW	
12.	Safety	CE, IEC, UL, CSA + APAC certificates	
13.	Electromagnetic Compatibility	EC, FCC, ICES-0.3, VCCI certificates	
14.	Environment	RoHS II & WEEE directives, REACH regulation	

3.1 Hardware Specifications of Administrator/User Terminals

One (01) administrator and Four (04) User terminals should be made available with system and interconnected in the same network environment so that all terminals can access Quantum Simulator.

The **hardware** is expected to be provided with following (or better) specifications:

Sr. No.	Parameter	Specifications	Compliance (Yes/No/Better/Remarks)
i.	Configurability	All the terminals should be MAC bound to Simulator through Administrator.	
ii.	Role Assignment	The administrator console should have the control to grant and deny permissions for any upgrade and update.	
iii.	Operating system	Latest 64 bit Microsoft Windows Operating System	
iv.	Processor	i7 processor or equivalent	
v.	No. of LAN Port	2 or more	
vi.	RAM	16 GB or more	
vii.	HDD/SSD	1 TB or more	
viii.	Graphic Card	Yes	

4. Industrial cabinets/Rack with power supply

S.No.	Specifications	Compliance (Yes/No/Better/ Remarks
1.	**RACK UNIT** System should be mounted on standard Rack with requisite cooling arrangement. Rack should be provided with 2 Nos. Intelligent Zero U Rack mounted 32A Three Phase PDU with minimum 20 Nos. IEC C 13 and 9 Nos. IEC C 19 outlets. PDU should be VDE & UL or equivalent Indian Standards Certified. Rack PDU should have Hydraulic Magnetic Breakers, local LCD Back lit Display which can display Volts, Amps, kVA, kW and should have port to connect minimum 1 number temperature or temperature & humidity sensor Rack Mounted **Electrical system** should be provided in N+N configuration with incomer of 125A, 4P with TM trip, Energy Meter with CT for incomer. Panel shall be with Cu busbar and manufactured as per IS Standard. Outgoing breakers as required for UPS, Inrow cooling. UPS output DB required for outgoing MCB's and atleast 2 Spare MCB's for future expansion. **Electrical Cabling:** All the cablings shall be done using Cu Flexible / Armoured (in case of outdoor cable) FRLS Cables as per relevant IS Standard. Rack should be provided with minimum 1 No. temperature, humidity combo sensor	
2.	**UPS** Rack Mounted 40 kVA UPS should be provided along with Battery bank, interlink cabling, battery breakers. Overall efficiency of UPS system in double conversion mode should be > 95 % Each UPS should be designed to unity power factor at output kVA=kW UPS system should be provided with embedded dust filter and conformal coating PCBA	

S.No.	Specifications	Compliance (Yes/No/Better/ Remarks
	UPS system should support common battery bank to improve overall availability for Back up time	
	Each UPS should be provided with minimum 10 minutes back up at full load of 40 kW UPS system should be in N mode	
3.	**Cooling Arrangement** Standard Horizontal air-cooling unit with sufficient Sensible cooling capacity to ensure smooth operation during peak summer of northern region must be ensured. The cooling unit should be provided with Refrigerant which is environment friendly and variable speed fans which can vary from 30 % to 100 % based on Heat load. To achieve this, high efficiency Compressor with water leak rope sensor is desired.	

5. Inspection Requirements

Sr. No.	Specifications	Compliance (Yes/No/Better/Remarks
1.	**Site Acceptance Testing (SAT)** shall be performed at the premises chosen by buyer after receiving the delivery of the fully integrated system. The SAT will take place within 15 days after integration of complete system. Payment will be released only after satisfactory testing and acceptance.	

6. Installation and Commissioning

Installation, integration, commissioning and subsequent inspection/testing (ATP) at buyer site will be sole responsibility of the supplier.

Compliance (Yes/No/Remarks):

7. Technical Documentation (English language only)

The supplier shall provide hard/soft copy of detailed operational manual of the system covering Quantum program writing, simulation and execution.

Sr. No.	Parameter	Compliance (Yes/No/Remarks)
1.	Operating, maintenance and other manuals shall be provided for all the Hardware and Software components.	
2.	Soft and Hard copy of all documents and installation procedures shall be delivered with the solution.	
3.	FAT test cases and reports should be provided at the time of delivery.	
4.	The supplier shall describe in details and provide documents indicating how system maintenance should be implemented.	

8. Training

The Bidder shall include an offer for Instructor-led weeklong on-site training for 10 (Ten) engineers/technicians. The training shall cover the operation and maintenance aspects of the system and various sub-systems. It must cover hands-on sessions for the acquaintance of all attendees for quantum program writing and simulations. The details of training shall be clearly enumerated as follows:

i.   Training content   : (Should be provided with response and will be mutually finalized after necessary addition/deletion)
ii. Number of trainees   :
iii. Duration   :

On-site training shall be conducted on the installed equipment at buyer site. Training shall be of a standard, required to ensure that staff successfully completing the training shall have complete operational knowledge of the system. Training Material (both hard and soft copy) shall be provided by the Contractor not later than two (2) weeks before the start of the course. The language of instruction shall be English.

Compliance (Yes/No/Remarks):

9. Self-Test & Diagnostic Features

Sr. No.	Parameter	Compliance (Yes/No/Remarks)
1.	POST- Power On Self-Test	
2.	Alarms, display, history, logs etc.	
3.	Fault diagnosis points/references	

10. Technical Support during Warranty/AMC

Sr. No.	Parameter	Compliance (Yes/No)
TECHNICAL SUPPORT		
1.	The supplier shall provide a qualified locally employed, technical support engineer, with the capabilities of troubleshooting hardware and software problems, replacing hardware, installing/upgrading software applications/operating systems, monitoring system performance, and extracting statistics.	
2.	The system is expected to work 24x7 under normal conditions with cooling system provided by the supplier. The locally based technical support engineer shall be available for consultation from Monday through Friday from 8:00AM until 5:00PM. Technician should be accessible via email and telephone to give prompt solution of the problem reported.	
3.	The supplier shall provide qualified project management resources to manage the project schedule and keep track the required activities and events to complete the installation, configuration, integration and acceptance of the implementation in a timely manner.	
4.	The supplier shall ensure the availability of sufficient spare equipment of all hardware components to replace faulty ones within a week.	
5.	The supplier shall ensure that any hardware failure recovery is possible by repair/servicing.	
6.	Bidders to submit details of technical support which will be available locally during the warranty/AMC period.	
7.	Full and complete labelling shall be provided for all the cables, hardware components, cabinets and racks. Installation materials like cables trays, hangers etc. shall be of a high quality and shall be installed neatly and professionally.	
PRODUCT SUPPORT		
8.	It is desirable to have total *7 years of maintenance support of the system*. The Contractor shall provide sufficient spare equipment so that any faulty equipment shall be possible to be replaced immediately. Any unit or component, which fails during this period, shall be replaced by the contractor at no or reasonable costs depending upon time of repair.	
9.	**Free Warranty:** It is implied that during the **first year** from the date of installation comprehensive warranty would be provided for hardware and software updates and upgrades at no cost to the user. The supplier should give warranty that each product it supplies shall, at the time of delivery and for a period of one year thereafter, be free from defects in material and workmanship. For products that are installed	

	by the vendor, this warranty shall be valid for one year from date of installation. Date of installation should not exceed 30 days after delivery. If any product is found to be defective in material or workmanship under normal usage and maintenance during the warranty period, then the vendor shall repair or replace such defective product at its own expense, exclusively.	
10.	**Extended Warranty:** For **another 3 years**, from the date of expiry of free warranty period, bidders shall guarantee that software upgrades/updates, which are developed from time to time, for the performance enhancement of the offered System, shall be provided. Cost of providing such upgrades, if any, must be quoted. If this will be on payment basis, the buyer has the right to avail/reject this.	
11.	**Comprehensive AMC beyond extended warranty** The **additional 3 years** of comprehensive AMC support should also be quoted however this will be an option and on the discretion of the buyer.	
12.	Maintenance will cover both hardware and software provided at the site chosen by the buyer within the country.	
13.	The firm has to guarantee to support the delivered hardware and software for at least 6 years after the one year warranty period.	

NOTE: Any hardware/software upgrade or updates shall not cause any degradation or deficiencies in performance of the overall system. There must be support for up gradation through any Storage media like CD/External SDD but not on Internet.

11. Other Commercial Aspects

- Supplier must give a declaration stating percentage of Indian/Local content of overall product.
- Turnover of the company should be at least 20 times of the BQ of the offered solution. Documentary evidence to be provided.
- End User Certificate if required should be clearly mentioned with the format.
- Financial Standing Undertaking: Bidder to give an undertaking that firm is not under liquidation, court receivership or similar proceedings, and is not bankrupt.

12. List of Deliverables

Sr. No.	Name/Description of Item(s)/Service(s)	Qty.
1.	Quantum Simulator (40 Qubits or higher)	01
2.	Industrial cabinet/Rack with 40KVA or more UPS and Cooling arrangement	As required
3.	Interface/Power supply cables and accessories	As required
4.	Monitoring System/Administrator	01
5.	User terminals (to access Simulator through LAN)	04