Annexure A

Technical Specification for

Cryo-free High Magnetic Field and Low Temperature Facility for Physical Property Measurements

Supply, installation and performance demonstration of floor mounted of a cryogen free measurement system, which operates over a wider range of temperature and magnetic fields; fully automated and computer controlled and user friendly with necessary hardware and software at the Department of Physics, Central University of Rajasthan, Bandarsindri, Ajmer, Rajasthan. The instrument should be a proven one for multi-functional and capable of performing a broad range of measurements, including magnetic, electric, magneto-electric transport, magneto-thermal transport, thermal transport, heat capacity and ferromagnetic resonance spectroscopy (FMR) on bulk, powders, thin films and single crystal materials.

- *The system must be upgradable to all applications as mentioned in the tender documents without compromising any efficiency and resolution*.
- In the quotation/tender document, all the desired technical specifications of the quoted system should be supported with certified documents/printed brochures/web-site links.
- The capability of the system performance and specifications have to be supported with valid and certified documents and published works (at least 20+) based on the measurements on the exactly quoted system along with list of at least 10+ installations in India for the similar measurement systems. List must include the contact details (address, phones and emails) of the customers.
- The vendor must submit a list of installations including the contacts details (address, e-mail, phone numbers) of the customers, year and/or month of installations, model no. of the system installed.
- Non-compliance of any of the above and any unsatisfactory feedback in respect of above will amount to disqualification of the submitted tender document.

Detailed Specifications:

1. Base System:

A) Basic Unit

(i) Base system should be completely cryogen free, i.e., system should not have any requirement of liquid Helium and/or liquid Nitrogen at any point of time (Small amount of helium gas for its fully automated startup and operation). Close Cycle Cryocooler based on the pulsed tube technology is required to cool both the superconducting magnet and temperature control system. It should provide a low vibration environment for sample measurement.

(ii) Any flow control required for temperature change/stabilization should be handled in fully automated way through the electronic and computer control. The system should NOT have any manual control in the entire operation of the system.

(iii) A dedicated window for monitoring cryostat status.

(iv) The sample chamber with thermal uniformity at both low and high temperature.

(v) All electronics must be modular.

(vi) The system must have a large temperature controlled region, or sample chamber, that can either be under vacuum or use various exchange gases. Material samples can be measured either with, or without, measurement probes giving users more flexibility in research design and scope.

B) <u>Temperature Control</u>

(i) Cryostat assembly which will include sample chamber and radiation shields and other assembly must be cooled by low vibration mechanism.

(ii) The system should enable cooling of samples from highest temperature to the lowest at the highest specified cooling rate at any given magnetic field of up to ±9 T without affecting the system performance including the heating of magnet. The same procedures should be hold for heating of the samples as well.

(iii) System should have sophisticated temperature control and provide seamless transition between high temperature (400 K) with minimal cooling power needs, intermediate temperature with rapid slewing and large cooling needs and stable operation near the base temperature (< 1.8K) with cooling provided by evaporation of liquid helium.

(iv) The sample chamber has to be sealed for controllable sample environment (static He gas, vacuum) and the Helium gas for temperature control shall flow around the sample chamber (“cooling annulus”).

(v) Temperature range of 1.8 to 400 K with milli-Kelvin stability and accuracy.

(vi) Temperature stability should be at least ±0.1 % for T < 20 K and ±0.02 % for T > 20 K irrespective of the magnitude of applied magnetic field.

(vii) Temperature of 1.8 K for the samples must be achieved from room temperature with a fast cooling not more than 60 minutes. Sweeps through 4.2 K are smooth and monotonic on cooling and warming sequences.

(viii) Measurements at T < 4.2 K are possible for a continuous long time.

(ix) Various modes of Fast settle, No overshoot, and sweep mode must be given in details.

(x) Required thermometers and heaters to manage temperature gradients and to ensure smooth temperature control throughout the accessible temperature range

C) Superconducting Magnet

(i) Longitudinal magnetic field ± 9Tesla or more should be available with highly stable bipolar power supply with over voltage protection and low noise.

(ii) Sweep Rate: up to 20 mT/sec

(iii) Field Homogeneity: ± 0.01 % over 3 cm on axis.

(iv) Field Stability: 5 ppm/hr or better.

(v) Magnet has to be cooled by solid conduction without any liquid helium. Time to cool down the magnet from initial starting should be in between 12 to 16 hrs.

(vi) Magnet ramping should not affect the temperature stability.

(vii) Thermometer directly on the magnet. Automatic discharge of the magnet if the cryocooler system fails (For example, due to water chiller failure).

(viii) Magnet control software monitors the temperature of the magnet and cryostat at various locations to ensure proper operation of the magnet system from quenches.

(ix) Various operating modes: Linear, Oscillating, No Overshoot must be given in details. There should be no overshoot in the field or the tolerable overshoot in "No Overshoot" mode should be specified for various field strengths.

(x) A built in magnetic shield to maintain 5 gauss line < 30 cm from the surface of the cryostat cabinet allowing the system to be installed closer to other sensitive instrument for better lab space utilization (provide data).

(xi) Magnet should be protected from quenches with proper built in safety measures.

D) Vacuum Pumps and Fittings

(i) Vacuum pumps and fittings along with vacuum gauges, meter, standard vacuum coupling essential for the uninterrupted functioning of the instrument and its various measurements options must be included.

(ii) All pumps must be oil free dry pumps.

(iii) The system should have an integrated cryopump and necessary vacuum gauges for controlling sample environment.

E) Data Acquisition and Analysis

(i) Fully automated measurements (except changing samples). Temperature, field control and sample measurement shall be fully automated. The software shall control all aspects of the instrument's electronics, hardware, gas handling, data acquisition

and data analysis. The software shall include a comprehensive sequence editor for setting up unattended measurement runs. Each user shall be able to set their own measurement sequences and data files so experimental set-ups and data are safe on a multi-user system.

(ii) System should have capability to control temperature and magnetic field from external programs like lab view or any other third party software. The software must allow the users to remotely control and monitor experiments over any internet connection.

(iii) Licensed windows based operating software and State-of-the-art computer control system with latest configuration (at least 8 GB RAM and 2 TB of ROM) and 23″ inch screen compatible with the measurement options for data acquisition, where operating system and the data acquisition software are preloaded. Data acquisition system must be the latest version based on modular architecture (company must specify their data acquisition system) not using GPIB. The software should be able to run the various measurement options automatically and in different modes. There must be a scope to control the external instruments by using different programs for the experiments designed by users.

2) Measurement options: (Each measurement options have to be quoted separately)

All these measurement capabilities with its specified resolution/efficiency must be demonstrated with the standard samples at the installation site.

A) DC Magnetization Measurement

(i) Option must integrated with First Order Reversal Curve (FORC) measurements and their subsequent analysis to provide additional insights into the magnetic reversal mechanisms of bulk, thin film, and nano-patterned samples that conventional major hysteresis loops cannot.

(ii) FORC measurement must be able to provide a qualitative/quantitative fingerprint of the magnetic reversal mechanisms, separating reversible and irreversible switching mechanisms, calculate reversal mechanism phase fractions and calculate coercivity and interaction field distributions. A supporting data sheet/brochure with measurements is essential to support the claims.

(iii) Temperature Range: ≤ 1.8K – 400 K (or above).

(iv) Magnetic Field: ≥ ± 9 Tesla.

(v) Top loading sample arrangement or sample mounting.

(vi) VSM sample holders for powder, bulk (polycrystalline and single crystal samples) and thin films should be included.

(vii) VSM Oscillation Frequency Range: 20 - 60 Hz or wider.

(viii) Relative noise level must be at least 10^{-7} emu per Tesla or per Hz or better.

(ix) Accuracy: 0.5% or better using 2.8 mm diameter x 4 mm high cylinder.

(x) Brass & Quartz sample holders for sample mounting should be included. It must be suitable for powder, pellet and thin films.

(xi) Sample preparation/alignment box with mirror should be included.

(xii) RMS Sensitivity at zero field must be at least 10^{-7} emu / 0.5%, whatever is larger. RMS Sensitivity at Field B: 5 x 10^{-6} emu or better

(xiii) VSM must support an own thermometer

(xiv) Maximum amplitude should be at least 2 mm

(xv) VSM must support auto centering of the sample

(xvi) Coil Set Bore: ≥ 6 mm for relatively small size samples and ≥ 12 mm for relatively large size samples

(xvii) Brass sample holders: 10 no's; Quartz Sample holder: 10 no's; Powder sample holders: 10 no's; Box of Straw: 10 no's; Sample Rods: 5 no's; Sample mounting station: 2 no's. Sample mounting station; Adaptor for connecting straw to the sample stick: 10 no's

(xviii) NIST based samples must be provided for calibration of magnetic moment at low and high magnetic fields/temperatures

(xix) To provide related publications or measurements data to support the measurements and accuracy.

B) AC Susceptibility Measurement

(i) Temperature Range: 1.8 K – 400 K.

(ii) Magnetic Field: ±9 Tesla.

(iii) Accuracy: +/- 0.5% over entire temperature and field range.

(iv) Stability: +/- 1% for T ≤ 50K; +/- 0.5% for T > 50K.

(v) Frequency Range: 10Hz – 10KHz.

(vi) Drive AC Amplitude: 0.005Oe – 15 Oe (peak).

(vii) Phase Resolution: 0.5 degrees.

(viii) Sensitivity should be 10^{-7} emu (for AC measurements) and 3×10^{-6} emu (DC measurements).

(ix) Along with AC magnetization option, DC magnetization measurement should be permitted without any change in the hardware, sample or sample mount.

(x) Ability to accurately separate real and imaginary components of AC response.

(xi) Thermometer mounted directly on the AC coil. This reduces errors from the thermal lags that may exists, particularly higher temperature.

(xii) Linear motor transport moves the sample with a position encoder output (same motor as VSM option).

(xiii) Option to measure immediate or sequence mode.

(xiv) Measurement mode like five, three and one point option should be available.

(xv) Option for higher harmonic measurements.

(xvi) ACMS calibrates itself real-time at each measurement point while performing measurements rather than relying on a calibration table or data that was collected at a previous time.

(xvii) To provide related publications or measurements data to support the measurements and accuracy.

(xviii) Upgrade option to measure AC susceptibility down to 50 mK

C) Electrical Transport Measurement

(i) Temperature Range: 1.8 K to 400 K (or above)

(ii) 4-wire & 2-wire resistivity and simultaneous Hall effect measurement, I-V characteristics and differential resistance measurement (dV/dI vs. I or dV/dI vs V).

(iii) Should have two built-in independent sources and meters so that two measurement channels are truly independent.

(iv) In addition to standard mode (4-wire resistance up 10 MΩ), there should be high impedance mode - 2-wire resistance measurement up to 5 GigaΩ.

(v) Current Source: DC & AC, 10 nA (or less) to 100 mA (or more) or better continuous (1 Hz to 200 kHz or better for ac).

(vi) Sensitivity: 20 nV or better

(vii) Resistance resolution: 20 nΩ at 0.1 A.

(viii) Setup to check the contacts prior to measurement

(ix) Consumables required for sample mounting should be provided by the company.

(x) Multifunctional probe should be provided so that user designed experiments can be performed.

(xi) To provide related publications or measurements data to support the measurements and accuracy.

D) Heat capacity Measurement

(i) Temperature Range: 1.8 K – 400 K, with a ± 5% between 2 K to 10 K.(Range need to be specified by the company).

(ii) Magnetic Field: ±9 Tesla.

(iii) Relaxation technique, two-tau model fit analyses, corrections of back grounds from sample platform, adhesives through sophisticated software routines that is fully integrated to the main system software (to be specified by the company and the claim need to be supported by references of the papers published and patents).

(iv) Sample Mass: 1 - 20 mg or more.

(v) Measurement Accuracy: less than 5% over 2K – 300K.

(vi) Heat Capacity resolution: less than 10 nJ/K at 2 K temperature

(vii) Thermometers on the platform.

(viii) Consumables required for sample mounting should be provided by the company.

(xix) To provide related publications or measurements data to support the measurements and accuracy.

E) High Temperature DC Magnetization Measurement

(i) Magnetic Field: Up to ± 9 Tesla

(ii) Range of Temperature for Oven must be 300 K - 1000 K or higher.

(iii) The temperature range from 1.8 K to 1000 K should be achieved with minimum number of stages (preferably, 1.8 K to 400 K and 300 to 1000 K) (to be specified by the company and the claim need to be supported by references of the papers published and patents).

(iv) RMS Sensitivity at Zero Field: $< 1 \times 10^{-5}$ emu or better

(v) Accuracy: $< 1 \times 10^{-5}$ emu/tesla

(vi) Accuracy: 0.5 percent using standard calibration sample

(vii) Temperature Precision must be 0.5 K or better.

(viii) Temperature Accuracy: 2.0%

(ix) NIST based samples must be provided for calibration of magnetic moment at low and high magnetic fields/temperatures.

(x) Alumina cement for sample mounting.

(xi) VSM oven sample mounting assembly

(xii) To provide related publications or measurements data to support the measurements and accuracy.

(xiii) Consumables required for sample mounting should be provided by the company.

F) Thermal Transport Measurement

(i) Temperature range 1.8 K to 400K.

(ii) Capability to measure thermal conductivity, seebeck coefficient, electrical resistivity, thermoelectric figure of merit.

(iii) 2 and 4 probe measurement capability.

(iv) Continuous measurements while slewing in temperature provide high density of data.

(v) Required thermometers and heaters should be provided.

(vi) Easy to use fully automated measurement.

(vii) Calibrated sample should be provided preferably Nickel.

(viii) Thermal conductance measurement accuracy: ± 5 % or better.

(ix) Typical accuracy of the Seebeck coefficient: ± 5 % or better.

(x) Seebeck coefficient measurement range: 1 µV/K to 1V/K or wider.

(xi) Slew rate should be 0.2 K/min or larger.

(xii) Thermoelectric Figure of Merit: ± 15% or better.

(xiii) Should be possible to measure rectangular as well as cylindrical samples (pellets). Suitable connectors (shoes) (4 sets) should be provided.

(xiv) Tools: Small slotted Philips screw drivers and extractor tool.

(xv) Consumables required for sample mounting should be provided by the company.

(xx) To provide related publications or measurements data to support the measurements and accuracy.

G) Ferromagnetic Resonance Spectroscopy Measurement

(i) Temperature Range: 4 K – 400 K.

(ii) Magnetic Field: ±9 Tesla.

(iii) Broadband FMR measurement using coplanar waveguide

(iv) The option must be able to measure effective magnetization (Meff), anisotropy (K), gyromagnetic ratio (γ), damping (α), inhomogeneous broadening (ΔHO), exchange stiffness (A), inverse spin Hall effect (ISHE) voltage

(v) FMR Bandwidth: 2 GHz – 18 GHz or higher.

(xxi) To provide related publications or measurements data to support the measurements and accuracy.

H) Multifunctional probe with sample stage and calibrated thermometers

With electrical leads to customize the equipment. This should be compatible with basic unit sample space electrical connections and should be able to utilize the magneto-electrical accessories

3. Future Upgrades:

The system should be field upgradable to add options to

(i) AC susceptibility measurement down to 50 mK
(ii) Dilution Refrigerator
(iii) He3
(iv) Dilatometer
(v) Magneto Optic Measurements
(vi) Horizontal Rotator
(vii) Pressure Cell for Magnetometry & Electrical Measurements
(viii) Photoconductivity Measurements

4. Other Components

(i) **UPS**: A highly reliable true online UPS with at least 1 hour backup must be provided. Specify make and model number. After sale server of the UPS will be the responsibility of the vendor offering the "High Magnetic Field and Low Temperature Facility for Physical Property Measurements"

(ii) **WATER CHILLER:** Suitable water chiller unit with the capacity up to 8 TR and dual compressor for trouble free continuous running of the main system.

5. Terms and Conditions

(i) **PRICE QUOTE**:

(a) All the prices must be quoted up to FOR Central University of Rajasthan.

(b) Quote each item separately. Depending upon the budgetary provision and priority, the items to be purchased will be decided.

(c) Bidder should quote all the sub-parts with all the mandatory accessories and parts. Thus, the bids quoting only for a few sub-part(s) of the system will be out-rightly rejected.

(ii) **COMPLIANCE OF THE OFFER**:

In order to qualify for the technical bid, the vendor should qualify the following:

(a) The system must be upgradable to all applications as mentioned in the tender documents without compromising any efficiency and resolution.

(b) In the quotation/tender document, all the desired technical specifications of the quoted system should be supported with certified documents/printed brochures/web-site links. The offer must be supported with the measurement data and literature.

(c) The capability of the system performance and specifications has to be supported with valid and certified documents and published works (at least 20+) based on the measurements on the exactly quoted system.

(d) Have a good track record of at least 10+ installations in India for the similar measurement system and are functioning smoothly. Just the magnet and Cryostat references will not be counted. The vendor must submit a list of installations including the contacts details (address, e-mail, phone numbers) of the customers, year and/or month of installations, model no. of the system installed.

(e) Vendor must provide at least 5 customer satisfaction letter/certificates from Indian Institutes/Labs where similar measurement systems are installed and working satisfactory.

(f) Have qualified technical service personnel for the equipment based in India.

(g) The vendor must provide compliance statement IN TABULAR FORM with respect to each technical specification in the tender document duly supported by the manufacturer's literature and published papers. Any other claim will not be accepted and may lead to rejection of the bid.

(h) Technical evaluation by the institute may include demonstration to verify functionalities and capabilities of the system quoted.

(i) Vendor must submit factory acceptance test procedures supported with relevant printed literatures and certificates.

(j) *Non-compliance of any of the above and any unsatisfactory feedback in respect of above will amount to disqualification of the submitted tender document*.

(iii) **WARRANTY**:

(a) Standard onsite comprehensive warranty for **Three Year** from the date of installation.

(b) The equipment should include Three -year comprehensive warranty (see specifications in "Annexure A") from the date installation. Annual Maintenance Contract (AMC) rates for next three years (4^{th}, 5^{th} and 6th year) must be quoted separately. Warranty and AMC should be from the manufacturer.

(c) During the Warranty period upgradation/maintenance of software should be done by the supplier free of cost.

(d) For the custom designed sub-parts be provided & International user warranty, wherever applicable in case of sub-parts procured from the original equipment manufacturers (OEMs), should be issued in the name of Central University of

Rajasthan from date of installation of Goods at the Central University of Rajasthan site of installation. The Supplier shall, in addition, comply with the performance and/or consumption guarantees specified under the contract. If for reasons attributable to the Supplier, these guarantees are not attained in whole or in part, the Supplier shall at its discretion make such changes, modifications, and/or additions to the Goods or any part thereof as may be necessary in order to attain the contractual guarantees specified in the Contract at its own cost and expense and to carry out further performance tests.

(e) The Purchaser shall promptly notify the Supplier in writing of any claims arising under this warranty. Upon receipt of such notice, the Supplier shall arrange to repair or replace the defective goods or parts thereof free of cost at the ultimate destination within 02 days from receipt of the notice. The Supplier shall take over the replaced parts/goods at the time of their replacement. No claim whatsoever shall lie on the Purchaser for the replaced parts/goods thereafter. The period for correction of defects in the warranty period is 02 days. If the supplier having been notified fails to remedy the defects within 02 days, the purchaser may proceed to take such remedial action as may be necessary, at the supplier's risk and expenses and without prejudice to any other rights, which the purchaser may have against the supplier under the contract.

(iv) **TRAINING/INSTALLATION/DEMONSTRATION**:

a) Pre-installation site preparation requirements to be included and specified along with the bid.
b) Standard samples to be provided by the company for testing the instruments at the time of installation on site to the quoted accuracy in the given technical specifications for the demonstration of the performance of the equipment.
c) Guaranteed specifications to be demonstrated at the time of installation. Any necessary standard samples for that purpose should be brought by the service engineers.
d) The bidding firm, in the event of getting supply-order from Central University of Rajasthan, will have to supply, install and train research scholars, faculty members for all the options of the system without any extra cost.
e) The equipment or machinery has to be installed or commissioned by the successful bidder within 30 days from the date of receipt of the items at Central University of Rajasthan. In case of any mishappening/damage to equipment and supplies during the carriage of supplies from the origin of equipment to the installation site, the supplier has to replace it with new equipment/supplies immediately at his own risk and cost. Central University of Rajasthan will not be liable to any type of losses in any form.
f) Service manual with complete circuit diagram and PCB layout for all equipment/measurement options to be provided with the instruments. The model number, make and a printed literature of the product should be submitted positively

g) The tender document should also indicate what kind of service/maintenance is required for the system. Whether this service has to be carried out by a company engineer or can it be done by trained service personal within India.

(v) **RIGHT TO USE DEFECTIVE GOODS:**

If after delivery, acceptance and installation and within the guarantee and warranty period, the operation or use of the goods proves to be unsatisfactory, the Purchaser shall have the right to continue to operate or use such goods until rectifications of defects, errors or omissions by repair or by partial or complete replacement is made without interfering with the Purchaser's operation.

(vi) **ACCEPTANCE/ REJECTION OF BIDS**:

(a) The Committee reserves the right to reject or drop any of the sub-parts in the two systems or all offers without assigning any reason. Bid should contain information about the requirement of helium gas replenishment.

(b) Incomplete and conditional tenders as well as tenders received after the due date will be summarily rejected without assigning any reasons thereof.

(vii) Power requirement: 220-230 V, 50 Hz.

(viii) No part shipment will be acceptable.

(ix) In case during shipment period newer versions of software/hardware is available with vendor in lieu of the existing one for which Letter of Credit was opened, then improved version should be made available without any extra cost.