

**INDIAN INSTITUTE OF TECHNOLOGY BOMBAY  
MATERIALS MANAGEMENT DIVISION**

**Purchase Requisition No. 1000006921 (SRM/Rfx No. 6100000113)  
Technical Specifications for Wireless Centrifuge Data Acquisition System (WCDAS)**

**Short Description:**

**National Geotechnical Centrifuge Facility (NGCF)** of Department of Civil Engineering, IIT Bombay is mainly used for modeling the response of materials and structures made with the soil, such as, dams and foundations, slopes, subjected to natural and manmade hazards such as earthquakes/near field earthquakes, rainfall, loading, rainfall, and floods.

There is a need of upgrading the existing Data Acquisition System. Hence, NGCF requires the quotation for high-performance “**Wireless Centrifuge Data Acquisition System (WCDAS)**” to monitor, acquire and analyze number of channels simultaneously which are connected to various kinds of sensors. The New Data Acquisition Unit must therefore be, wireless and modular in nature with the ability to expand the number of available channels and type of sensors from which data is to be acquired; while being easily serviceable and with a longer life-time of support.

The WCDAS should comply with or comply better than all of the specifications mentioned in **Annexure-1**. Block diagram of centrifuge system for reference is attached as **Annexure-2**. Centrifuge modeling technique is a physical modelling technique in which a small scale model instrumented with various transducers (like Potentiometers/LVDTs/Laser LVDTs/Load Cells/Pore Pressure Transducers/Accelerometers/Pressure sensors, strain gauges, etc.) is subjected to high gravities by rotating about a vertical axis in horizontal plane. The proposed WCDAS is required to acquire the data from the transducers fitted within the model, during operation of centrifuge, from Revolution Per Minute's (RPM's) ranging from 46 (10 gravities) to 160 (130 gravities). Location of WCDAS for reference is attached as **Annexure-3**. Brief technical specification of the Centrifuge Equipment for reference is attached as **Annexure-4**.

During the **Pre-Bid meeting**, a visit to the NGCF Facility, Department of Civil Engineering, IIT Bombay, Mumbai - 400076 will be arranged for understanding about the logistics and operational parameters of the WCDAS, along with the physical inspection of the facility.

**INDIAN INSTITUTE OF TECHNOLOGY BOMBAY**  
**NATIONAL GEOTECHNICAL CENTRIFUGE FACILITY (SUDERSHAN)**  
**Specifications for Wireless Centrifuge Data Acquisition System (WCDAS)**

S No.	Particulars	Technical Requirement
<b>1</b>	<b>The WCDAS should be capable of accepting the following sensors</b>	
	<b>a) Displacement Transducer (DC-DC) LVDT (Transtek make or equivalent)</b>	Working Range: +/- 25mm , 50mm, 100mm Input Voltage: 6-30V DC; Voltage Output: 4.6V @6V input or better for 25mm LVDT; Voltage Output: 3.9V @ 6V input or better for 50mm LVDT; Frequency Response: Up to 100 Hz 3db or better; Temperature Range: -54° C to 120°C or better; Non-linearity: +/- 0.5% of Full Scale; <b>No. of LVDT Channels: 12 Nos.</b>
	<b>b) Potentiometer / Displacement Transducer (Sakae/Gefran, or equivalent)</b>	Working Range: 25mm and 50mm Resistance: 10KOhms; Linearity: +/- 1.0% or better; Power Rating: 0.4W for 25mm and 0.7W for 50mm; Friction: 0.5N or less; Spring return; <b>No. of Potentiometer displacement channels: 12 Nos.</b>
	<b>c) Laser LVDT (Baumer make or equivalent)</b>	Measuring Distance: 20mm, 30-50mm, 100mm Resolution: 0.05mm or better; Linearity: +/- 0.15mm or better; Laser class: 2; Output: 4-20mA and/or 0-10V DC <b>No. of Laser LVDT channels: 6 Nos.</b>
	<b>d) Pore Pressure Transducers (GE or Strain sense make or Entran type Pressure Sensors or equivalent)</b>	1. Range 1 Bar - Excitation: 5VDC; Output: 0 to 50mV or better 2. Range 1.5 Bar – Excitation 1 to 10 VDC; Output 7.5mV/V FSO 3. Range 3 Bar - Excitation: 5VDC; Output: 0 to 75mV or better 4. Range 3.5 bar – Excitation 1 to 10 VDC; Output 19mV/V/FSO 5. Range 7 Bar - Excitation: 5VDC; Output: 0 to 75mV or better 6. Range 15 Bar - Excitation: 5VDC; Output: 0 to 75mV or better (Other Pressure Ranges, like 2 Bar, 5 Bar, 10 Bar, etc. with similar Excitation and suitable Output Ranges may also be used and should be accommodated on the WCDAS) <b>No. of Pore Pressure channels: 20 Nos.</b>
	<b>e) Load Cell (HBM Make or equivalent)</b>	1. Range 2 kN - Sensitivity: 1mV/V or better; Class: 0.5, Input Voltage – 5 to 12 VDC 2. Range 5 kN - Sensitivity: 1mV/V or better; Class: 0.5, Input Voltage – 5 to 12 VDC 3. Range 10 kN Sensitivity: 1mV/V or better; Class: 0.5, Input Voltage – 5 to 12 VDC

		4. Range 20 kN Sensitivity: 1mV/V or better; Class: 0.5, ,Input Voltage – 5 to 12 VDC <b>No. of Load cell channels: 8 Nos.</b>
	<b>f) IEPE/ICP Accelerometer (DJB/B&amp;K/PCB/ make or equivalent)</b>	Sensitivity: 100mV/g or better; 8pC/g or better Frequency Response: DC to 10KHz; Light weight; Stud mounting; (10 channels for ICP Accelerometer Must be Supported with Suitable C to V Converters and must be provided by the Vendor) <b>No. of Accelerometer Channels: 18 Nos. including 10 Channels having Charge to Voltage Capability</b>
	<b>g) Strain Gauges (TML/Kyowa/HBM make or equivalent)</b>	Electrical Resistance Type Strain Gauges Gauge Length: 2mm, 5mm, 10mm; Gauge Resistance: 120 Ω, 350 Ω; Gauge Factor: about 2; Bridge Configuration: Quarter, Half and Full; Bridge Excitation: 2.5V, 5V, 3.3V, 5V, 10V <b>No. of Strain Gauge Channels: 16 Nos.</b>
	<b>h) Valve Control</b>	Suitable Digital/Relay Control for Switching on/off Solenoid Valve – 24V DC <b>No. of Valve Control Channels: 8 Nos.</b>
	<b>i) Analogue Control</b>	+/- 10 V Signal at 100 KS/s, 16 Bit or better resolution <b>No. of Analogue Channels: 8 Nos.</b>
<b>2</b>	<b>Hardware requirements of WCDAS</b>	
	<b>2.1 Wireless information &amp; Connector units Junction boxes for accepting the signals</b>	The Centrifuge System comprises of Swing Basket, Arm, and Central Axis. The Slip Rings are in line with central axis and are located at the first floor level. Sensors (as mentioned above) will be embedded within the model placed on the swing basket and wired to junction boxes of WCDAS located on the swing basket. The Junction boxes will be wired to the WCDAS located at/closest point to the central axis on the rotating arm. WCDAS in turn will be wired to wireless transmitters/routers which are installed at the central axis on the rotating arm. Wireless receivers will be located at the Central axis at First Floor level next to slip rings. Wireless receivers are further wired to the Computer Placed in the Instrumentation room located in the Ground Floor. (Distances from top surface of the Basket to the Central Axis is 6 Meters and from Central Axis to the First Floor is about 2 Meters and from the First Floor Room to the Instrumentation Room is about 40 Meters.) Uninterrupted Power (220V AC or 24V DC) – can be accessed on the Central Axis for the WCDAS through the already available slip rings. This wireless data acquisition system will have to operate without loss of any data (Data throughput should be without any loss of data during rotation from 46 (from <b>10 gravities</b> ) to 160 RPM; up to <b>130 gravities</b> ) of 4.5 m radius beam centrifuge equipment available at NGCF; Gravity levels ranging from <b>10 gravities to 130 gravities</b> will be subjected with an uniform angular velocity of the beam centrifuge equipment rotating with RPM's in the range of 46 to 160 RPM. Adequate number of receiver antennas will have to be installed close to slip ring stack unit in the first floor level of the NGCF and its counterpart at the Centre of beam centrifuge equipment, adequate number of source antennas will have to be housed safely to avoid them flying away during rotation of the

	<p>centrifuge and for ensuring bandwidth of Data Streaming. The Power Supplies for the System shall have to be mounted on the rotating arm in line with slip ring stack unit on the first floor level of the NGCF.</p> <p>Junction boxes to accept the connections from the above mentioned types of transducers at the basket end. The connections shall be of MIL type with proper grounding to get noise free data. The Layout of the Junction Box along with connectors will require Approval from IIT Bombay before Fabrication. At the other end (at the rotating axis) junction boxes will be connected to WCDAS for noise free acquisition. Sensors will be viz. Pore pressure transducers, Load cells, Accelerometers, Laser LVDTs, /LVDTs, Linear potentiometers, Strain gauges, Digital cameras, etc. as mentioned above).</p> <p>The required enclosures, wiring and cabling to the slip ring and to the control room shall have to be included in the scope of the supply of new WCDAS. <b>Annexure-2</b> may be referred to understand the location of components of Centrifuge Facility.</p>
<p><b>2.2 Controller</b></p>	<p><b>Processor</b></p> <ul style="list-style-type: none"> <li>• CPU Intel Atom E3940</li> <li>• Number of cores 4</li> <li>• CPU frequency 1.6 GHz (base), 1.8 GHz (burst)</li> <li>• On-die L2 cache 2 MB</li> </ul> <p><b>Network/Ethernet Port</b></p> <ul style="list-style-type: none"> <li>• Number of ports 2</li> <li>• Network interface 10Base-T, 100Base-TX, and 1000Base-T Ethernet</li> <li>• Compatibility IEEE 802.3</li> <li>• Communication rates 10 Mb/s, 100 Mb/s, 1000 Mb/s auto-negotiated</li> <li>• Maximum cabling distance 100 m/segment</li> </ul> <p><b>Network Timing and Synchronization</b></p> <ul style="list-style-type: none"> <li>• Protocol IEEE 802.1AS-2011</li> <li>• IEEE 1588-2008 (default end-to-end profile)</li> <li>• Supported ether-net ports Port 0, port 1</li> <li>• Network synchronization accuracy &lt;1 μs</li> </ul> <p><b>RS-232 Serial Port</b></p> <ul style="list-style-type: none"> <li>• Maximum baud rate 115,200 b/s</li> <li>• Data bits 5, 6, 7, 8</li> <li>• Stop bits 1, 2</li> <li>• Parity Odd, even, mark, space</li> <li>• Flow control RTS/CTS, XON/XOFF, DTR/DSR</li> </ul>

		<ul style="list-style-type: none"> <li>• RI wake maximum low level 0.8 V</li> <li>• RI wake minimum high level 2.4 V</li> <li>• RI overvoltage tolerance <math>\pm 24</math> V</li> </ul> <p><b>RS-485 Serial Port</b></p> <ul style="list-style-type: none"> <li>• Maximum baud rate 230,400 b/s</li> <li>• Data bits 5, 6, 7, 8</li> <li>• Stop bits 1, 2</li> <li>• Parity Odd, even, mark, space</li> <li>• Flow control XON/XOF</li> <li>• Wire mode 4-wire, 2-wire, 2-wire auto</li> </ul> <p><b>USB Ports</b></p> <ul style="list-style-type: none"> <li>• Port 1: <ul style="list-style-type: none"> <li>• Type USB Type-A, host port</li> <li>• USB interface USB 2.0, Hi-Speed</li> <li>• Maximum data rate 480 Mb/s</li> <li>• Maximum current 900 mA</li> </ul> </li> <li>• Port 2: <ul style="list-style-type: none"> <li>• Type USB Type-C, host port</li> <li>• USB interface USB 3.1 Gen1, Super Speed</li> <li>• Maximum data rate 5 Gb/s</li> <li>• Maximum current 900 mA</li> <li>• Alternate modes Display Port</li> </ul> </li> <li>• Port 3: <ul style="list-style-type: none"> <li>• Type USB Type-C, dual role port (device or host)</li> <li>• USB interface USB 3.1 Gen1, Super Speed</li> <li>• Maximum data rate 5 Gb/s</li> <li>• Maximum current 900 mA</li> </ul> </li> </ul> <p><b>SD Card Slot</b></p> <ul style="list-style-type: none"> <li>• SD card support SD and SDHC standards</li> <li>• Supported interface speeds UHS-I SDR50 and DDR50</li> </ul> <p><b>Memory</b></p> <ul style="list-style-type: none"> <li>• Nonvolatile memory (SSD) 4 GB</li> <li>• Nonvolatile memory (SSD) type Planar SLC NAND</li> </ul>
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	<ul style="list-style-type: none"> <li>• Volatile memory (DRAM) <ul style="list-style-type: none"> <li>o Density 4 GB</li> <li>o Type DDR3L</li> <li>o Maximum theoretical data rate 12.8 GB/s</li> </ul> </li> </ul> <p><b>Reconfigurable FPGA</b></p> <ul style="list-style-type: none"> <li>• FPGA type Xilinx Kintex-7 7K70T</li> <li>• Number of flip-flops 82,000</li> <li>• Number of 6-input LUTs 41,000</li> <li>• Number of DSP slices (18 × 25 multipliers) 240</li> <li>• Available block RAM 4,860 kbits</li> <li>• Number of DMA channels 16</li> <li>• Number of logical interrupts 32</li> </ul> <p><b>Voltage input range</b></p> <ul style="list-style-type: none"> <li>• V1 9 V to 30 V</li> <li>• V2 9 V to 30 V</li> <li>• Maximum power consumption 60 W</li> </ul> <p><b>Environmental</b></p> <ul style="list-style-type: none"> <li>• Temperature (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2)</li> <li>• Operating -40 °C to 70 °C</li> <li>• Storage -40 °C to 85 °C</li> <li>• Ingress protection IP20</li> <li>• Operating humidity (Tested in accordance with IEC 60068-2-30) 10% RH to 90% RH, noncondensing</li> <li>• Storage humidity (Tested in accordance with IEC 60068-2-30) 5% RH to 95% RH, noncondensing</li> <li>• Maximum altitude 5,000 m</li> </ul> <p><b>Operating vibration</b></p> <ul style="list-style-type: none"> <li>• Random (IEC 60068-2-64) 5 grms, 10 Hz to 500 Hz</li> <li>• Sinusoidal (IEC 60068-2-6) 5 g, 10 Hz to 500 Hz</li> <li>• Operating shock (IEC 60068-2-27) 30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations</li> </ul> <p><b>No. of units: As per the number of cards required for different sensors (detailed specifications of controller to be provided)</b></p>
<p><b>2.3 Hardware for Pressure Sensors</b></p>	<ul style="list-style-type: none"> <li>• 50 kS/s per channel sample rate</li> <li>• ±500 mV measurement range</li> <li>• ADC resolution: 24 bits</li> </ul>

		<ul style="list-style-type: none"> <li>• Built-in anti-alias filters</li> <li>• 250 V rms channel-to-channel, CAT II isolation</li> <li>• Screw-terminal connectivity</li> <li>• Type of ADC: Delta-Sigma(with analog pre filtering)</li> <li>• Sampling mode: Simultaneous</li> <li>• Internal master time base (fM) <ul style="list-style-type: none"> <li>○ Frequency: 12.8 MHz</li> <li>○ Accuracy: ±100 ppm max</li> </ul> </li> <li>• Data rate range (fs) using internal master time base <ul style="list-style-type: none"> <li>○ Minimum: 1.613 kS/s</li> <li>○ Maximum: 50 kS/s</li> </ul> </li> <li>• Data rate range (fs) using external master time base <ul style="list-style-type: none"> <li>○ Minimum: 390.625 S/s</li> <li>○ Maximum: 51.36 kS/s</li> </ul> </li> <li>• Input voltage range (AI+ to AI-)1 <ul style="list-style-type: none"> <li>○ Nominal: ±0.5 V</li> <li>○ Minimum: ±0.496 V</li> </ul> </li> <li>• Typical scaling coefficient: 74.506 nV/LSB</li> <li>• Overvoltage protection: ±30 V</li> <li>• Input coupling: DC</li> <li>• Input impedance (AI+ to AI-): &gt;1 GΩ</li> <li>• Input noise: 3.9 μV rms</li> <li>• Power consumption from chassis <ul style="list-style-type: none"> <li>○ Active mode: 730 mW max</li> <li>○ Sleep mode: 50 μW max</li> </ul> </li> <li>• Thermal dissipation <ul style="list-style-type: none"> <li>○ Active mode: 1.48 W max</li> <li>○ Sleep mode: 0.5 W max</li> </ul> </li> <li>• Operating vibration <ul style="list-style-type: none"> <li>○ Random (IEC 60068-2-64): 5 grms, 10 Hz to 500 Hz</li> <li>○ Sinusoidal (IEC 60068-2-6): 5 g, 10 Hz to 500 Hz</li> </ul> </li> <li>• Operating shock (IEC 60068-2-27): 30 g, 11 ms half sine, 50 g, 3 ms half sine, 18 shocks at 6 orientations</li> <li>• Operating temperature (IEC 60068-2-1, IEC 60068-2-2): -40 °C to 70 °C</li> </ul>
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		<ul style="list-style-type: none"> <li>• Storage temperature (IEC 60068-2-1, IEC 60068-2-2): -40 °C to 85 °C</li> <li>• Ingress protection: IP 40</li> <li>• Operating humidity (IEC 60068-2-78): 10% RH to 90% RH, non-condensing</li> <li>• Storage humidity (IEC 60068-2-78): 5% RH to 95% RH, non-condensing</li> <li>• Pollution Degree : 2</li> <li>• Maximum altitude: 5,000 m</li> </ul> <p><b>Number of channels for this sensor: 20 [Twenty No.] analog input channels</b>  <b>No. of units: As per the channels per card</b>  <b>(detailed specifications of card/modules to be provided)</b></p>
	<p><b>2.4 Hardware for Load Cell &amp; Strain Gauges</b></p>	<ul style="list-style-type: none"> <li>• 50 kS/s per channel simultaneous AI</li> <li>• ±25 mV/V input range, 24-bit resolution</li> <li>• Programmable half- and full-bridge completion with up to 10 V internal excitation</li> <li>• 60 VDC, Category I bank isolation</li> <li>• Bridge completion <ul style="list-style-type: none"> <li>○ Half and Full: Internal</li> <li>○ Quarter: External</li> </ul> </li> <li>• ADC resolution: 24 bits</li> <li>• Type of ADC: Delta-Sigma (with analog pre-filtering)</li> <li>• Sampling mode: Simultaneous</li> <li>• Internal master time base (fM) <ul style="list-style-type: none"> <li>○ Frequency: 12.8 MHz</li> <li>○ Accuracy: ±100 ppm max</li> </ul> </li> <li>• Data rate range (fs) using internal master time base <ul style="list-style-type: none"> <li>○ Minimum: 1.613 kS/s</li> <li>○ Maximum: 50 kS/s</li> </ul> </li> <li>• Data rate range (fs) using external master time base <ul style="list-style-type: none"> <li>○ Minimum: 391 S/s</li> <li>○ Maximum: 51.36 kS/s</li> </ul> </li> <li>• Typical input range: ±25 mV/V</li> <li>• Scaling coefficient: 2.9802 nV/V per LSB</li> <li>• Overvoltage protection between any two pins: ±30 V</li> <li>• Half-bridge completion <ul style="list-style-type: none"> <li>○ Tolerance: ±1200 μV/V max</li> </ul> </li> </ul>



	<ul style="list-style-type: none"> <li>o Drift: 1.5 <math>\mu\text{V/V}</math> per <math>^{\circ}\text{C}</math></li> <li>• Total Harmonic Distortion (THD) <ul style="list-style-type: none"> <li>o 1 kHz, -20 dBFS: -95 dB</li> <li>o 8 kHz, -20 dBFS: -95 dB</li> </ul> </li> <li>• Excitation noise: 100 <math>\mu\text{Vrms}</math></li> <li>• Crosstalk (not including cable effects) <ul style="list-style-type: none"> <li>o <math>f_{in} = 1</math> kHz: 110 dB</li> <li>o <math>f_{in} = 10</math> kHz: 100 dB</li> </ul> </li> <li>• Excitation <ul style="list-style-type: none"> <li>o Internal voltage: 2.5 V, 3.3 V, 5.0 V, 10.0 V</li> <li>o Internal power: 150 mW max</li> <li>o External voltage: 2 V to 10 V</li> </ul> </li> <li>• Power consumption from chassis <ul style="list-style-type: none"> <li>o Active mode: 740 mW max</li> <li>o Sleep mode: 25 <math>\mu\text{W}</math> max</li> </ul> </li> <li>• Thermal dissipation (at 70 <math>^{\circ}\text{C}</math>) <ul style="list-style-type: none"> <li>o Active mode: 740 mW max</li> <li>o Sleep mode: 25 <math>\mu\text{W}</math> max</li> </ul> </li> <li>• Operating vibration Random (IEC 60068-2-64): 5 grms, 10 to 500 Hz Sinusoidal (IEC 60068-2-6): 5 g, 10 to 500 Hz</li> <li>• Operating shock(IEC 60068-2-27): 30 g, 11 ms half sine, 50 g, 3 ms half sine, 18 shocks at 6 orientations</li> <li>• Operating temperature (IEC 60068-2-1, IEC 60068-2-2): -40 to 70 <math>^{\circ}\text{C}</math></li> <li>• Storage temperature (IEC 60068-2-1, IEC 60068-2-2): -40 to 85 <math>^{\circ}\text{C}</math></li> <li>• Ingress protection: IP 40</li> <li>• Operating humidity (IEC 60068-2-56): 10 to 90% RH, non-condensing</li> <li>• Storage humidity (IEC 60068-2-56): 5 to 95% RH, non-condensing</li> <li>• Maximum altitude: 2,000 m</li> <li>• Pollution Degree: 2</li> </ul> <p><b>Number of channels for this sensor: 24 [Twenty Four No's] analog input channels</b>  <b>No. of units: As per the channels per card</b>  <b>(detailed specifications of card/modules to be provided)</b></p>
<b>2.5 Hardware for IEPE Accelerometer</b>	<ul style="list-style-type: none"> <li>• 102.4 kS/s per channel simultaneous AI; 41 kHz bandwidth</li> <li>• <math>\pm 30</math> V input, 24-bit resolution, 99 dB dynamic range</li> </ul>

	<p><b>(with provision for 10 channel for C to V converters for ICP accelerometers)</b></p>	<ul style="list-style-type: none"> <li>• Software-selectable AC/DC coupling; AC coupled (0.1 Hz)</li> <li>• Software-selectable IEPE signal conditioning (0 or 4 mA); IEPE open/short detection</li> <li>• Smart TEDS sensor compatibility</li> <li>• Type of ADC: Delta-Sigma (with analog pre-filtering)</li> <li>• Sampling mode: Simultaneous</li> <li>• Type of TEDS supported: IEEE 1451.4 TEDS Class I</li> <li>• TEDS capacitive drive: 3000 pF</li> <li>• Internal master time base ( fM) <ul style="list-style-type: none"> <li>o Frequency: 13.1072 MHz</li> <li>o Accuracy: ±100 ppm</li> </ul> </li> <li>• Data rate range ( fs) using internal master timebase <ul style="list-style-type: none"> <li>o Minimum: 0.985 kS/s</li> <li>o Maximum: 102.4 kS/s</li> </ul> </li> <li>• Input coupling: AC/DC (software-selectable)</li> <li>• AC cutoff frequency <ul style="list-style-type: none"> <li>o -3 dB: 0.1 Hz</li> <li>o -0.1 dB: 0.87 Hz max</li> </ul> </li> <li>• DC voltage input range <ul style="list-style-type: none"> <li>o Minimum: ±30.87 V</li> <li>o Typical: ±31.5 V</li> <li>o Maximum: ±32.13 V</li> </ul> </li> <li>• AC voltage full-scale range <ul style="list-style-type: none"> <li>o Minimum: ±30.87 Vpk</li> <li>o Typical: ±31.5 Vpk</li> <li>o Maximum: ±32.13 Vpk</li> </ul> </li> <li>• IEPE excitation current (software-selectable on/off) <ul style="list-style-type: none"> <li>o Minimum: 4 mA</li> <li>o Typical: 4.25 mA</li> </ul> </li> <li>• IEPE excitation noise: 100 nArms</li> <li>• IEPE compliance voltage: 22 V min</li> <li>• Power consumption from chassis <ul style="list-style-type: none"> <li>o Active mode: 1 W max</li> <li>o Sleep mode: 25 µW max</li> </ul> </li> </ul>
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	<p><b>2.6 Hardware for Laser LVDT, LVDT, Linear Potentiometer</b></p>	<ul style="list-style-type: none"> <li>• 100 kS/s per channel sample rate</li> <li>• ±10 V measurement range, 16-bit resolution</li> <li>• ±30 V overvoltage protection</li> <li>• 250 Vrms channel-earth, CAT II (spring-terminal), or 60 VDC channel-earth, CAT I (D-SUB) isolation</li> <li>• Spring-terminal or D-SUB connectors</li> <li>• ADC resolution: 16 bits</li> <li>• Type of ADC: Successive approximation register (SAR)/ Delta-Sigma (with analog pre-filtering)</li> <li>• Input voltage ranges Measurement Voltage (AI+ to AI-) <ul style="list-style-type: none"> <li>○ Minimum: ±10.4 V</li> <li>○ Typical: ±10.5 V</li> <li>○ Maximum: ±10.6 V</li> </ul> </li> </ul>

- Maximum voltage: (Signal + Common Mode) each channel must remain within  $\pm 10.4$  V of common.
  - Overvoltage protection:  $\pm 30$  V
- Conversion time: 10  $\mu$ s min
- Sample rate: 100 kS/s max
- Stability
  - Gain drift: 5 ppm/ $^{\circ}$ C
  - Offset drift: 29  $\mu$ V/ $^{\circ}$ C
- CMRR ( $f_{in} = 60$  Hz): 70 dB
- -3 dB bandwidth:  $>100$  kHz
- Input Impedance:  $>1$  G $\Omega$
- Input Noise: 0.85 LSB rms
- Crosstalk: -90 dB
- Power consumption from chassis (full-scale input, 100 kS/s)
  - Active Mode: 1 W max
  - Sleep mode: 4 mW max
- Thermal dissipation (at 70  $^{\circ}$ C)
  - Active Mode: 1.250 W max
  - Sleep Mode: 510 mW max
- Operating vibration
  - Random (IEC 60068-2-64) - 5g rms, 10 Hz to 500 Hz
  - Sinusoidal (IEC 60068-2-6) - 5 g, 10 Hz to 500 Hz
- Operating Shock
  - (IEC 60068-2-27) - 30 g, 11 ms half sine, 50 g, 3 ms half sine, 18 shocks at 6 orientations
- Operating temperature
  - (IEC 60068-2-1, IEC 60068-2-2) -40  $^{\circ}$ C to 70  $^{\circ}$ C
- Storage Temperature
  - (IEC 60068-2-1, IEC 60068-2-2) -40  $^{\circ}$ C to 85  $^{\circ}$ C
- Ingress protection: IP 40
- Operating Humidity: (IEC 60068-2-56) 10% to 90% RH, non-condensing
- Storage Humidity: (IEC 60068-2-56) 5% to 95% RH, non-condensing
- Pollution Degree: 2
- Maximum Altitude: 2,000 m

**Number of channels: 30 [Thirty No's] analog input channels**

	<p><b>No. of units: As per the channels in each card (detailed specifications of card/modules to be provided)</b></p>
<p><b>2.7 Hardware for Valve Control</b></p>	<ul style="list-style-type: none"> <li>• 8 solid-state relay (SSR) outputs</li> <li>• Relay type Normally open solid-state relay (SSR)</li> <li>• 60 VDC, 30 Vrms switching voltage</li> <li>• Switching current of 1.2 A/channel for up to 4 channels;</li> <li>• 750 mA/channel for all channels</li> <li>• 250 Vrms CAT II continuous channel-to-earth ground, and 60 VDC channel-to-channel isolation</li> <li>• Switching rate (90% duty cycle)1 1 operation per second</li> <li>• Relay open time 0.5 ms typ</li> <li>• Relay close time 9.0 ms typ</li> <li>• On resistance 200 mΩ max</li> <li>• Off stage leakage 30 μA typ</li> <li>• MTBF 2,172,740 hours at 25 °C; Bellcore Issue 6, Method 1, Case 3, Limited Part Stress Method</li> <li>• <b>Power consumption from chassis</b> <ul style="list-style-type: none"> <li>o Active mode 500 mW max</li> <li>o Sleep mode 5 mW max</li> </ul> </li> <li>• <b>Thermal dissipation (at 70 °C)</b> <ul style="list-style-type: none"> <li>o Active mode 1.5 W max</li> <li>o Sleep mode 5 mW max</li> </ul> </li> </ul> <p><b>Operating vibration</b></p> <ul style="list-style-type: none"> <li>• Random (IEC 60068-2-64) 5 grms, 10 Hz to 500 Hz</li> <li>• Sinusoidal (IEC 60068-2-6) 5 g, 10 Hz to 500 Hz</li> <li>• Operating shock (IEC 60068-2-27) 30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations</li> <li>• Operating temperature (IEC 60068-2-1, IEC 60068-2-2) -40 °C to 70 °C</li> <li>• Storage temperature (IEC 60068-2-1, IEC 60068-2-2) -40 °C to 85 °C</li> <li>• Ingress protection IP40</li> <li>• Operating humidity (IEC 60068-2-78) 10% RH to 90% RH, noncondensing</li> <li>• Storage humidity (IEC 60068-2-78) 5% RH to 95% RH, noncondensing</li> <li>• Pollution Degree 2</li> <li>• Maximum altitude 5,000 m</li> </ul> <p><b>No. of Channels – 8 [Eight No.] Solid State Relays</b></p>

	<p><b>No. of units: As per the channels in each card. (detailed specifications of card/modules to be provided)</b></p>
<p><b>2.8 Hardware for Analogue Output</b></p>	<ul style="list-style-type: none"> <li>• 25 kS/s per channel simultaneous analog output</li> <li>• ±10 V output range, 16-bit resolution</li> <li>• DAC resolution: 16 bits</li> <li>• Type of DAC: String</li> <li>• Power-on output state: Channels off</li> <li>• Output range <ul style="list-style-type: none"> <li>○ Nominal: ±10 V</li> <li>○ Minimum: ±10.35 V</li> <li>○ Typical: ±10.5 V</li> <li>○ Maximum: ±10.65 V</li> </ul> </li> <li>• Output impedance: 2.0 Ω</li> <li>• Slew rate: 4 V/μs</li> <li>• Settling time (100 pF load, to 1 LSB) <ul style="list-style-type: none"> <li>○ 20 V step: 20 μs</li> <li>○ 1 V step: 15 μs</li> <li>○ V step: 13 μs</li> </ul> </li> <li>• Monotonicity: 16 bits</li> <li>• Power consumption from chassis <ul style="list-style-type: none"> <li>○ Active mode: 1 W max</li> <li>○ Sleep mode: 25 μW max</li> </ul> </li> <li>• Thermal dissipation (at 70 °C) <ul style="list-style-type: none"> <li>○ Active mode: 1 W max</li> <li>○ Sleep mode: 25 μW max</li> </ul> </li> <li>• Operating vibration <ul style="list-style-type: none"> <li>○ Random (IEC 60068-2-64): 5 g rms, 10 to 500 Hz</li> <li>○ Sinusoidal (IEC 60068-2-6): 5 g, 10 to 500 Hz</li> </ul> </li> <li>• Operating shock <ul style="list-style-type: none"> <li>○ (IEC 60068-2-27): 30 g, 11 ms half sine, 50 g, 3 ms half sine, 18 shocks at 6 orientations</li> </ul> </li> <li>• Operating temperature (IEC 60068-2-1, IEC 60068-2-2): -40 to 70 °C</li> <li>• Storage temperature (IEC 60068-2-1, IEC 60068-2-2): -40 to 85 °C</li> <li>• Ingress protection: IP 40</li> </ul>

		<ul style="list-style-type: none"> <li>• Operating humidity (IEC 60068-2-56): 10 to 90% RH, non-condensing</li> <li>• Storage humidity (IEC 60068-2-56): 5 to 95% RH, non-condensing</li> <li>• Maximum altitude: 2,000 m</li> <li>• Pollution Degree: 2</li> </ul> <p><b>Number of channels: 8 [Eight No.] analog output channels</b>  <b>No. of units: As per the number of channels</b>  <b>(detailed specifications of card to be provided)</b></p>
		<p><b>Note:</b></p> <ul style="list-style-type: none"> <li>• All the Above Modules are to be placed in a Single Data Acquisition Enclosure.</li> <li>• The Above Units are to be securely mounted on the Centrifuge, close to the Slip Ring. The required mounting mechanisms for the enclosure require to be provided by the vendor and should be pre-approved by IIT-Bombay</li> <li>• The Cabling from the Data Acquisition Modules, need to be drawn and terminated on a junction Box, with suitable MIL connectors, on the Basket side of the Centrifuge. The Connectors, should also possess, the suitable Power for the Sensors.</li> <li>• The Power to the data Acquisition unit is going to be provided vide power Supplies mounted in an enclosure in the room above the Slip Ring. The Power to the units and sensors, is going to be drawn vide the existing slip rings.</li> <li>• The data Acquisition units, should Transmit Data Wirelessly to another Access point, which is placed in the Room above the Centrifuge. This Ethernet Gateway should be connected to the Computer panel placed in the instrumentation room, through suitable wiring.</li> </ul>
3	<b>Application Software Requirements</b>	<p>Application Software:</p> <ul style="list-style-type: none"> <li>• Suitable Data Acquisition Software must also contain multiple graphs (at least eight numbers of graphs to be displayed with <b>real-time</b> data). Allowing the user to segregate and view data information in an orderly fashion.</li> <li>• The Software will also possess a user Login and modification functions</li> <li>• The Software will possess a Channel Configuration Function that will allow the Operator to choose Names/Aliases, Engineering Units, Acquisition Rates, Set Scaling Options, enable or disable channel acquisition, etc.</li> <li>• The Sensor configuration will require the user to configure all the sensors that he/she will be using.</li> <li>• The Sensor will need to be enabled / disabled. This allows the sensors to be identified and only the required sensors can be selected to avoid clutter.</li> <li>• The Sensor Alias is the name given to a particular sensor whose configuration is being set.</li> </ul>

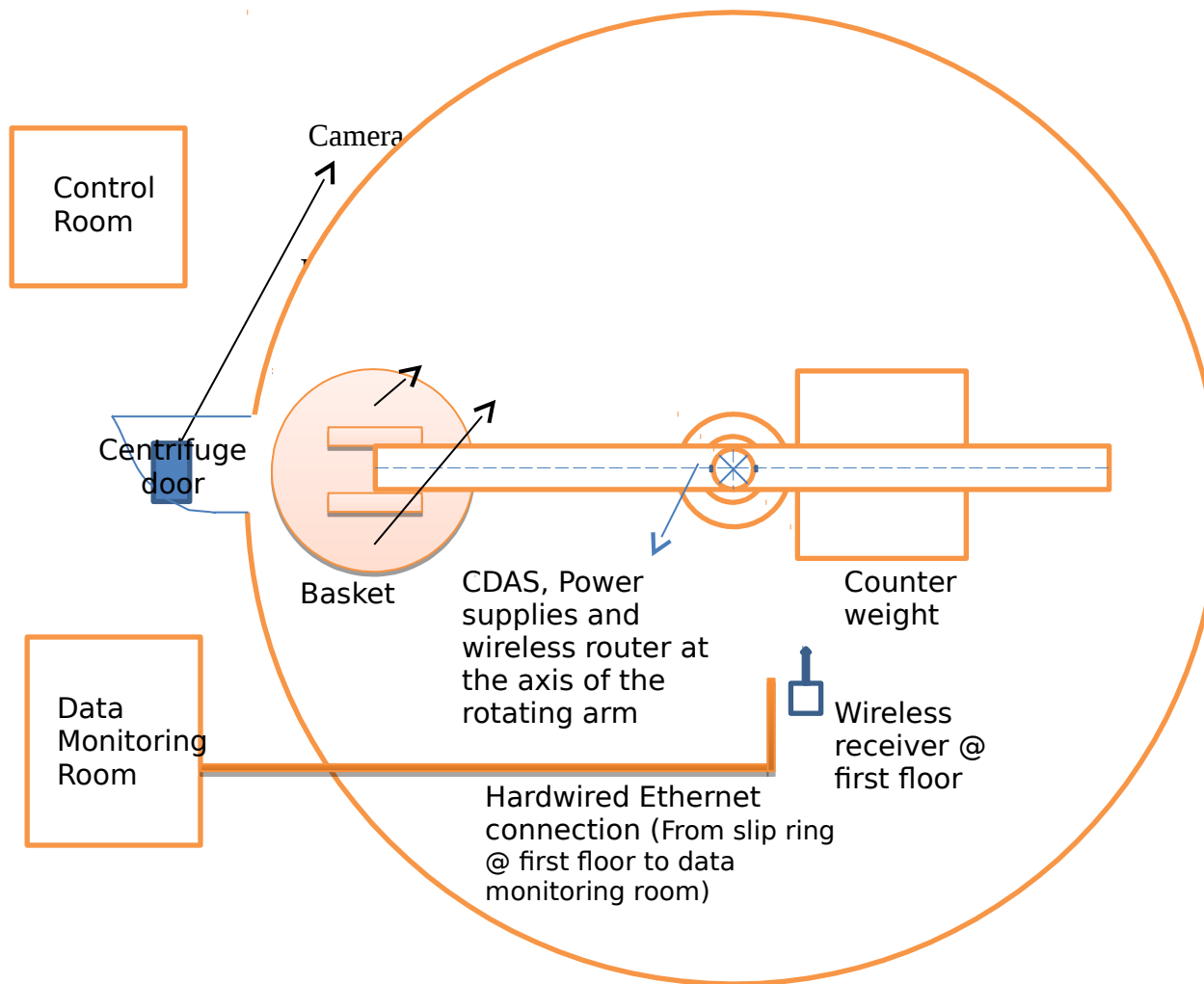
		<ul style="list-style-type: none"> <li>• The Graph Display allows you to select which graph out of the 4 shown on the User Interface; Will the User like to see a particular sensor reading being plotted.</li> <li>• The User can also select the Signal type namely (Pressure, Current, Voltage etc.)</li> <li>• The Signal Unit is then set for the display and allows users to achieve their accurate readings.</li> <li>• The User can also set the scaling options of the Sensor data. This setting is repeated for every sensor that will be connected to the system for testing.</li> <li>• The Information will be automatically stored on the system to ensure, that repetitive data input is not required in successive runs.</li> <li>• The user can also select the type/scale of the chat/graph he/she would like to see the sensor readings on. The user can select the Y-Scale number, X-Scale number and the Scale of the minimum range required as per where they have set their sensors to be displayed.</li> <li>• The user has the ability to view their sensor data and analyze the data on a Diagnostic mode. This option will be displayed as a pop-up as soon as the Sensor configuration and the Chart Settings have been completed. This is to ensure the functioning of all connections is fine before start of a test.</li> <li>• In addition to the above functions, the software will also possess details of storage, system watch dogs to ensure the proper functioning of all Hardware, etc.</li> <li>• The Software will also provide for a Video interface for the Display of the Camera data with storage setting and parameters display. This will be on a parallel computer based system, to avoid clutter display.</li> <li>• Diagnostic Mode to verify functioning of channel.</li> <li>• Data acquisition, generation of signals (ramp, sine, haversine, square, triangle, random, earthquake time history development and generation, etc.).</li> <li>• Video interface, acquisition of camera data, storage, display</li> <li>• Signal trigger, data export, report generation, etc.</li> <li>• The Software must be based on LabVIEW Application Development Environment.</li> </ul> <p><b>Vendor must Get the Software Requirement Specifications (SRS) approved by IIT Bombay before Providing the Software Solution.</b></p> <p><b>(Details of software and its features to be provided)</b></p>
4	<b>Power, Wireless Communication, Wiring &amp; Looming, Connectivity and Custom Connector</b>	<ul style="list-style-type: none"> <li>• Power Supplies for Sufficient Power to all Embedded Controllers, Data Acquisition Modules, Wireless Transmitters and Sensors at Voltage Levels of 5 VDC, 12 VDC, 18 VDC, 24 VDC and 32 VDC will be required to be provided.</li> <li>• The Wireless Communication Systems for each controller, at IEEE 802.11n or better requires to be provided, suitable for being mounted on the Centrifuge.</li> <li>• All wireless routers must comply with:</li> </ul>



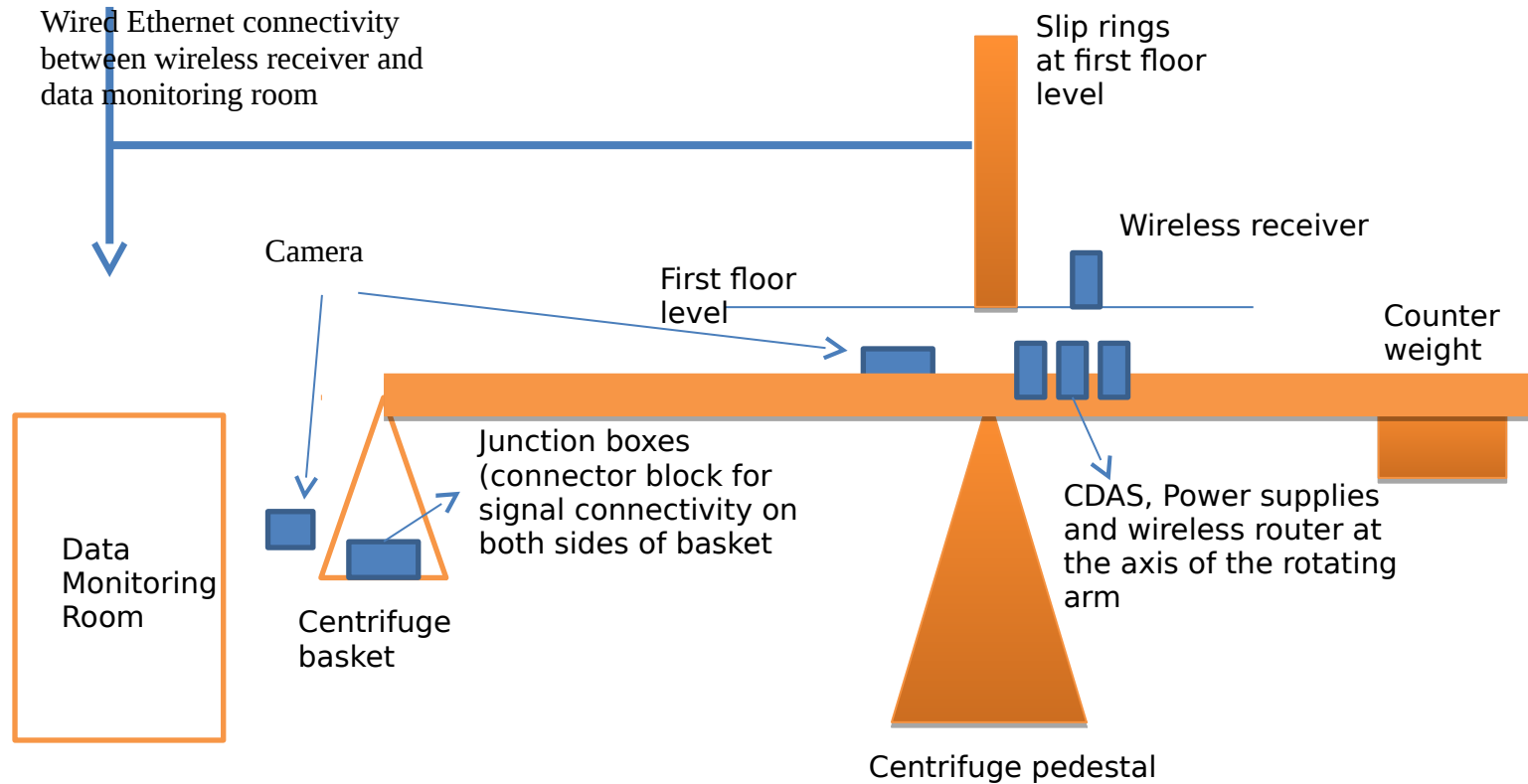
	<b>Modules (Junction Boxes)</b>	<p>IEEE 802.11a/b/g/n compliant  Up to 300 Mbps data rate  MIMO technology increases data throughput and range  Compliant with essential sections of EN 50155  M12 anti-vibration connectors  -40 to 75°C operating temperature range</p> <ul style="list-style-type: none"> <li>• The Wiring and Locking requires to be done using Standard PTFE Cables</li> <li>• <b>Custom Connector Box with Positive Lock Connectors and Crimp type must be provided at the Basket End (Drawings of Junction Boxes to be Approved by IIT Bombay prior to Fabrication)</b></li> </ul> <p><b>(Detailed Wiring Document, Placement Document, User and Maintenance Manual in Hard and Soft Copy must be provided along with the delivery/commissioning of the System)</b></p>
5	<b>Data Display, Processing Units and Cabinets</b>	<ul style="list-style-type: none"> <li>• The data will be connected and displayed on a set of three PC systems. All systems will be i7 and with a minimum of 500 GB HDD. The systems should be running a licensed version of the Windows Operating System.</li> <li>• One Screen, upwards of 20 inches, will be used to Display, Control and Store the Video Data and the suitable Computing System required for the purpose will be provided in the scope of the Project.</li> <li>• Another display, also upwards of 20 inches, with the Processing Unit, will be used to display process, and store the signal data from the unit under test from the data acquisition system.</li> <li>• A third system will be provided to control the data generation aspects of the units.</li> <li>• The units will be placed in a control panel in the Instrumentation room at the Facility.</li> <li>• Fourth screen with a display switch will be provided to broadcast the View from either of the two Computer Systems. This screen will be wall mounted and will be of a size upwards of 35 inches</li> </ul>
6	<b>Installation and Commissioning</b>	<p>The vendor should take full responsibility for supply, installation and commissioning of WCDAS at NGCF of Civil Engineering Department and performance of the system demonstrated to the satisfaction of the users. Necessary fittings and fixtures required for the installation of WCDAS will be in the scope of the vendor.</p>
7	<b>Maintenance and service support of system during and after the warranty period</b>	<ol style="list-style-type: none"> <li>1. The vendor should have competent and reliable service network in India for quick and necessary repair and maintenance of the equipment.</li> <li>2. The vendor should provide the list of users of similar equipment (viz. IITs, NITs, Research and Development laboratories under Government of India, etc.) along with their contact details.</li> <li>3. Vendor must provide Training on the System for 5 working days Post System Prove out.</li> <li>4. Details of the nature of service support the vendor can provide should be given along with the proposal.</li> <li>5. Warranty should be for at least three years (3 years) after System Acceptance by IIT Bombay.</li> <li>6. The vendor should commit to provide maintenance service for the equipment for at least 15 years after</li> </ol>

		<p>successful installation and commissioning.</p> <p>7. List of necessary Spares to be Provided Along with the Proposal.</p> <p>8. After completion of warrantee of 3 years, AMC to be established on two years basis with mutual agreement mentioning the following tasks.</p> <p>a) Preventive maintenance – 3 visits</p> <p>b) Breakdown maintenance – 2 visit.</p> <p>c) Calibration visit for system and sensors. – 1 visit.</p> <p>d) Any spares used will be on chargeable basis.</p> <p>e) Any extra visit will be on chargeable basis.</p> <p>f) Any maintenance visit not performed in the current year to be carried forward in the next year which is to be performed in addition to the existing visits.</p> <p>g) The payment will be done in partial manner after each visit.</p> <p><b>(Details of AMC to be finalized on mutually agreeable terms)</b></p>
9	<b>Other terms and conditions</b>	<p>1. The vendor must provide an Authorization Certificate from the OEM for the bought out items supporting their bid and their support to the bidder for the deliverable items, with reference to the Tender enquiry Number.</p> <p>2. All Data Acquisition Items required are to be COTS (Commercially off the Shelf) and no development will be allowed. Certificate of Conformance from the OEM should be provided along with the hardware being delivered.</p> <p>3. Since Software is an important component of the systems, the company should have certified developers on the application development environment used for the development of the application. Certificate from OEM's India Office is needed with this regards - mentioning the Tender Enquiry Number directed to the Tendering Authority/ Director. Bids, unaccompanied by the Authorization Certificate are liable to be rejected in the technical stage itself.</p> <p>4. The vendor must be ISO Certified to ensure Quality of the System provided.</p> <p>5. Since all the items are interconnected and required to communicate to the Software and controller unit all the items needs to be ordered on a single vendor only, and part order will not be placed.</p> <p>6. Two sets of operation and maintenance manuals (in original hard copy and soft copy) along with all necessary drawings should be supplied along with the WCDAS system.</p> <p>7. The vendor should enclose all the relevant technical documents and catalogues for all the components included in the proposal. Proposals without proper technical documents and catalogues will be rejected.</p> <p>8. The vendor should impart training to the user viz. faculty, staff, research students and any other personnel nominated by NGCF.</p> <p>9. The parties may visit NGCF of Civil Engineering Department to understand the test set-up (length of hoses, cables, additional fixtures for mounting of WCDAS, etc.)</p> <p>10. Necessary consumables like connecting cables, connectors, etc. will be in the vendor's scope.</p>

		<ol style="list-style-type: none"><li>11. The vendor shall have to integrate the existing transducers in the new WCDAS system and acquire the data to the satisfaction of the centrifuge user. Only after successful acquisition, installation and commissioning shall be taken as complete.</li><li>12. Additional equipment like UPS, Suitable and higher end PCs with compatible operating system, etc. will be in the vendor's scope. The compatibility of operating system with hardware and updates of the software w.r.t change in operating system or change of PC / hardware should be supported and installed for free of cost to IIT Bombay for a period of 10 years from the date of system acceptance.</li><li>13. IIT Bombay may provide the following:<ol style="list-style-type: none"><li>a. Electrical power required for the installation of WCDAS.</li><li>b. Extend the workshop facility (without man power), if required for mechanical works like cutting, welding, drilling, etc. during the installation and commissioning of structural testing system.</li></ol></li><li>14. All the field wiring, modules etc. should be labelled and documented.</li><li>15. Retention accessories to be provided along with individual modules.</li><li>16. All the components to be supplied should be with equivalent or better specifications.</li></ol>
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**BLOCK DIAGRAM OF CENTRIFUGE SYSTEM**



**LOCATION FOR INSTRUMENTATION**

## TECHNICAL DETAILS OF CENTRIFUGE SYSTEM

<b>Radius up to base of basket</b>	4.5 m (measured from the top surface of the basket to centre of the rotating shaft)
<b>Payload Capacity</b>	2.5 tons at 100 gravity and 0.625 tons at 200 gravity
<b>Capacity at maximum payload</b>	250 g-tons
<b>Beam Type</b>	Swing basket and adjustable counter weight
<b>Radius from the axis of centrifuge arm (rpm)</b>	46 to 205 RPM
<b>Acceleration Range</b>	10 gravities to 200 gravities
<b>Platform size (m)</b>	1.2 × 1.0
<b>Maximum container sizes (mm)</b>	1000 × 1200 × 660 and 760 × 1200 × 1200
<b>Drive system</b>	Thyristor controlled 450 kW DC Motor
<b>Maximum payload at various g-levels (includes weight of strong box, shake table, model and accessories; excludes weight of basket)</b>	<ul style="list-style-type: none"> <li>• 2.5 tons at 50 g</li> <li>• 2.5 tons at 100 g</li> <li>• 0.625 tons at 200 g</li> </ul>
<b>Static balancing of counter weight</b>	Manual and Motorized
<b>Maximum unbalance force</b>	100 kN
<b>In-flight balancing range</b>	0 to 100 kN at 200 g
<b>In-flight balancing time</b>	60 seconds
<b>Balancing accuracy</b>	10 kN
<b>Electrical slip rings</b>	<ul style="list-style-type: none"> <li>• Video – 3 nos.</li> <li>• Power (220 V, 20 Amp) – 5 nos.; Power (24 V, 5 Amp) – 5 nos.</li> <li>• Transducers (10 V, 2 Amp) – 100 nos.</li> </ul>
<b>Hydraulic rotary joints</b>	<ul style="list-style-type: none"> <li>• Hydraulic oil rotary joints 0 to 200 bars – 2 nos.</li> <li>• Air/Water rotary joints 0 to 200 bars, flow rate 10 LPM – 4 nos.</li> </ul>
<b>Run-up time</b>	6 minutes
<b>Run-down time</b>	6 minutes
<b>Continuous run time</b>	5 days
<b>Design life</b>	40 years or 24,000 start-stop cycles
<b>Environmental sensors</b>	<ul style="list-style-type: none"> <li>• Unbalance sensor with display at console and alarm</li> <li>• Temperature and humidity sensors with display at console and alarm</li> <li>• Vibration sensor</li> <li>• Infra-red smoke detector with alarm</li> </ul>