# DEPT OF OCEAN ENGINEERING IIT MADRAS, CHENNAI

# HPMM SYSTEM

# **TENDER SPECIFICATION**

(Note: Only those who participated in the Pre-Bid meeting held on 06.03.2015 at the Department of Ocean Engineering, IIT Madras are eligible to participate in this Bid)

# **GENERAL GUIDELINES FOR TENDER PARTICIPATION**

# A. Eligibility Criteria to participate in the Tender:

- 1. Vendor should have executed similar Electro-Mechanical System comprising of Servo Motion control with High Precision Mechanical System Projects on a total Turn Key basis with complete ownership in India in last four years period and proof to that effect shall be provided.
- 2. Vendor should have supplied to Institutions as well as Industries to ensure system supplied comply Industrial grade and guidelines. Required Evidence shall be provided along with offer.
- 3. Vendor shall be a Reputed Manufacturer of the Drives/Machines or their authorized Representative and proof to that effect shall be provided.
- 4. Vendor shall be required to present their capabilities to the Technical Committee or Exclusive Purchase Committee, if applicable.
- 5. EMD of specified value shall be enclosed along with the Offer.
- 6. Vendor shall possess ISO 9000 certification for Quality System implementation. Required Evidence shall be provided along with offer.

### **B. Mandatory Guidelines to be followed to participate in the tender:**

- Eligible Vendors shall visit the Towing Tank facility at IIT Madras and understand the equipment Requirements.
- The vendor shall deliver a Pretender Technical Presentation, after the detailed study of the Equipment
- After Pretender Presentation, the selected Vendors shall submit the Offer in a sealed cover as two Bids – Technical Offer and Commercial Offer on or before the deadline specified.
- The selected Vendors shall follow the Tender Specification to Design and Supply of the total system to meet all the Equipment requirements.
- The selected Vendors shall submit a detailed Project schedule for Design, Manufacturing, Testing, Inspection, Delivery, Installation, commissioning and Handing over the equipment to IIT Madras.
- After taking the feedback from the Technical Team of IIT Madras, the above Project schedule shall be updated to meet IIT Madras requirements and shall be enclosed along with the technical Offer.
- Selected Vendors shall comply the technical specifications point wise and Deviations shall be mentioned clearly as part of Technical Offer.
- The successful Vendor of the project shall comply the Design,
   Manufacturing, Testing, Supply and commissioning of the proposed system as per the agreed terms of IIT Madras.

# 1.0 GENERAL

## 1.1 Basic Design Guidelines:

### 1.1.1 General Scope:

This Specification covers design, engineering, manufacture, inspection, supply, storage, site handling, installation, testing and commissioning of DC drives with Existing DC Motor and PAC/PLC, MMI and HMI controls to upgrade the existing system by replacing existing Drive and Automation controls for HPMM Test Bed.

### 1.1.2 <u>Supplier Requirements:</u>

The supplier shall be a recognized leader in Industrial Automation and Control capable of supplying all necessary support services including hardware and software support, configuration services, system installation and commissioning.

### 1.1.3 Standard:

The equipment and accessories covered under this specification shall be designed manufactured and tested in accordance with latest relevant International Standards / Indian Standards and codes of practices published by the International Standards Institution / Indian Standards Institution wherever applicable in order that specific aspects under Indian conditions are taken care of.

### 1.1.4 <u>SAFETY:</u>

All equipment shall be complete with approved safety devices. The design shall include all reasonable precautions and provisions for the safety of operating and maintenance Personnel.

### 1.2 Site Conditions:

The electrical equipment proposed shall be suitable for operation under the following local conditions:

Altitude of site	:	<1000 m (above sea level)
Ambient temperature	:	45 deg. C
Relative humidity	:	95 % Non Condensing

### 1.3 Voltage and Power Supply Conditions:

Low Voltage Supply shall be: System Voltage	:	415 V, 3 phase, 3 wire
Frequency	:	50 Hz
Voltage Fluctuation	:	±10%
Frequency Fluctuation	:	47 – 63 Hz

# **2.0 HPMM AUTOMATION**

## **SCOPE OF WORK & SUPPLY**

#### About Planar Motion Mechanism (PMM)

Planar Motion Mechanism (PMM) Equipment is a facility provided in a Towing Tank to perform experimental studies with ship models to determine the manoeuvring characteristics of a ship. The experiment is conducted in the towing tank where the PMM setup is attached with the carriage. The ship model is oscillated, at prescribed frequency and amplitude, in different modes of motion in the horizontal plane while it is towed along the tank at a pre-determined speed. The hydrodynamic forces and moments acting on the ship model are measured, recorded and processed to get the hydrodynamic derivatives appearing in the ship manoeuvring equations of motion. Please refer the **Appendix on "Planar Motion Mechanism (PMM) Equipment"** appearing towards the end of this document for more details on PMM operation and required specifications.

#### Scope of Work and Supply

The scope includes the Design, development and supply of HPMM mechanical System with Force Measurement Unit, Suitable Servo Drive System, Programmable Automation Controller/ Programmable Logic Controller based control System, User Interactive Graphical Operator Terminal, and Exhaustive SCADA system to meet all the requirement for the proposed Test Rig.

The proposal shall comply for high performance in functional accordance with current Industry practice.

### A-1) HPMM Mechanical System:

#### Summary:

- $\circ$   $\,$  The mechanical plugin type structure shall be in line with IIT Madras basic conceptual design.
- Complete Servo Actuators with required motion control system, servo drives and transducers for precise position control application shall be the major requirements.
- The system shall include two units Load cells of suitable capacity with required Signal Conditioners, Power Supplies and required Interface to the Programmable Automation Controllers. The load cells must be capable of handling bending moments in perpendicular axis.
- This system will have basic networking intelligence to get interfaced with Towing Tank Controller so as to work in synchronization.

#### 1. Base Structure:

The base structure shall be fabricated with strong and durable material and sections & duly stress relieved. The structure shall have machined platform plates for mounting the Y- guide ways & all the other sub-assemblies like gear box, transducers, motion mechanisms- etc. The structure should conform to IP67 class.

The structure shall be assembled upon the existing Towing Carriage with proper mounting provisions. The structure must be such that it can be firmly attached to the towing carriage with ease and removed and stored when not required. The storage bin also should be supplied.

#### 2. Mechanism for linear motion & rotary motion:

All the critical mechanical components required for Linear as well as Angular motion- Ball Screw, LM guides, Servo Gear Box, etc. – shall be engineered with high precision.

#### Linear motion.

- The Linear motion shall be realized using suitable Servo motor, Servo Gear Box, LM guides and Machine Tool accessories.
- $\circ$   $\,$  The LM guides will have bottom supporting plates & end butting plates for alignment features.
- A ball screw of required dia shall be selected with end bearing support on either ends.
- $\circ$   $\;$  The whole mechanism is mounted on the slide plates.

• The guide ways & the ball screw shall have suitable covering to protect water entry.

#### **Rotary motion.**

- $_{\odot}$  The rotary motion or the YAW motion of 15 degrees shall be achieved, with a resolution of 0.01 degree.
- A servo motor thru a gear box is connected to the drive pinion through a rotary coupling for rotary motion with zero back lash.
- The whole assembly shall be mounted on the slide plate on the base structure & will have to be mass balanced by design.

#### 3. Mounting arrangements on the existing slide- to the given hardware.

- The whole assembly mounted on the base structure, shall be assembled on the existing Towing Carriage or this assembly shall be integrated with a separate add-on carriage.
- > The assembly shall be suitably designed to assemble & fit without major changes on the existing Towing Carriage.
- Any add-on system must be mounted on the west side of the carriage leaving the other three sides un obstructed.

### Static Converter – Servo Drives System

#### A-2) Multi axes Motion Control System

- 1. Drive system shall be an Integrated Motion Control System
- 2. System shall have two axes Position control system with a common DC bus Technology.
- 3. Servo system shall facilitate both Sway as well as Yaw Motions, independently or in combined mode.
- 4. Servo System shall confirm a position accuracy of 0.01 mm or 0.01 deg at the motor shaft, in case of Linear or Angular Motion respectively.
- 5. Servo system shall use high resolution encoder as the position feedback device for both the axes.
- 6. Servo system shall have Incomer a Multifunction Meter to indicate Voltage, Current, Power with required CT etc. and it should be provided.
- 7. Servo system shall have required di/dt protection for the front end converter.
- 8. Servo system shall have input contactor isolation of suitable rating.
- 9. Drive system shall have 3 phase Isolation through a MCCB of suitable rating.
- 10. Complete Technical Catalog of Servo Drives shall be submitted along with the technical offer.

# **B-1)** General Specifications of Multi Discipline based Master Controller:

## **B-1.1) General Requirements**

This specification describes the functional requirements, design features, hardware and software required for a Redundant **Programmable Automation Controller (PAC)** / **P**rogrammable Logic **C**ontroller (PLC) for HPMM Lab Facility. For the purposes of this specification, a scaleable PLC is defined as one that provides a robust, secure, cost-effective, and flexible solution with easy-to-use hardware and software.

The PLC shall perform as a minimum the following functions as defined in the specific sections of this specification:

- Tag Based integrated Multi-discipline Controller
- Integrated Alarms and Events

## **B-1.2) Integrated Controllers**

The integrated controller shall be capable of handling the following control requirements:

- Machine control.
- discrete operations,
- continuous processes control, and
- batch processes,

The controller shall seamlessly integrate to the open control system as follows:

- configuration of the integrated controller shall create all the I/O data structures
- changes to a control strategy shall be made in one place and be reflected throughout the system,
- controller data shall be tag based and shall be globally available to all parts of the system by name,
- standard operating displays shall be provided to work with the controller

#### **B-1.3) Programmable Automation Controller / Programmable Logic** Controller Functional Requirement

#### Integrated Controller and I/O

This section describes the requirements of the new integrated controllers to be supplied as part of this System.

The integrated controller shall support:

- I. Analog Inputs.
- II. Analog Outputs
- III. Discrete Inputs.
- IV. Discrete Outputs

## **B-1.4) Integrated Controller:**

- 1. The address of the controller shall be easily visible to the eye, either as an LED display on the controller or on the network card that connects the controller to the system. Use of software tools to identify a controller is not acceptable.
- **2.** The integrated controller shall be capable of supporting a minimum execution rate of 10 msec (for standard applications) or 5 msec (for applications requiring higher speed processing).
- **3.** The system shall support the creation, loading, activation, deactivation and deletion of control strategies on-line.
- **4.** The integrated controller shall support the replacement I/O modules on-line.
- **5.** Existing control strategies and I/O modules will continue to function while on-line replacement is being made.
- **6.** As a minimum, the integrated controller should contain both the Continuous Control and Sequential Control functions.

## **B-1.6) Configuration Software:**

- 1. The configuration software shall be Windows based supporting drag and drop configuration in a natural hierarchical environment.
- **2.** Standard and user-definable templates shall be supported to allow for rapid application development and reuse of existing control strategies.
- **3.** The configuration software shall support on-line monitoring of control modules that have been loaded to the integrated controller.
- **4.** Remote access to the engineering database shall be supported across any media capable of supporting TCP/IP and UDP/IP communication.
- **5.** No additional software should be required for the PLC to see the control strategy once it has been built using this tool.

### **B-1.7) PLC Database Requirement:**

- **1.** The PLC database shall be truly global.
- **2.** This means that a tag shall be defined only once in the system. Once defined it shall be possible to refer to this tag from any node on the network.
- **3.** The configuration of the Server database shall only have to be done once regardless of whether redundancy is employed or data is distributed between servers.
- **4.** PAC/PLC shall allow composite points, where a composite point is a tag that is broken up into discrete components, which are separated e.g. area.point. This allows better segregation of the plant components.

## **B-1.13) Process Control Network and Remote I/O Network**

The process control network and remote I/O network shall be an open, flexible, high performance network such as ControlNet.

- 1. It shall be possible to locate I/O modules remotely from the processor rack. In addition to I/O modules located at the processor, a minimum of up to twenty four (24) remote I/O sites per controller must be supported.
- **2.** It shall be possible to locate I/O sites up to 1000 meters from the controller without the use of repeaters and fiber optic media.
- **3.** With the use of repeaters and fiber optic media, it shall be possible to locate the I/O up to 10,000 meters from the controller.
- **4.** There shall be no deterioration whatsoever in the speed of the network when the cable is extended to the distance limits mentioned above.
- **5.** The I/O network must meet all of the requirements above. In particular, the media used must be redundant.
- **6.** It is not acceptable to "daisy chain" I/O racks together, such that the loss of a single cable results in the loss of any I/O.

### **B-2) Scope of supply under PLC panel:** ... 1 set.

#### B-2-1) Basic Scope of Supply

- Programmable Automation Controller/programmable Logic Controller, ControlLogix Based Master Controller system for the HPMM consisting of the following:
  - Control Logix Processor
  - Chassis
  - Power Supply for Processor
  - ControlNet Communication Module
  - Ethernet Communication Module
  - Digital Input (24VDC, 16 Ch)
  - Digital Output (24VDC, 16 Ch)
  - Analog Input
  - Analog output

- ... 01 No. ... 01 No ... 01 No. ... 01 No. ... 01 No. ... 16 Points ... 16 Points ... 08 Points ... 04 Points
- Supplier shall validate automation scope to meet equipment functional requirements. Supplier shall consider Distribution of Remote I/O in PLC Panel and Control Desk.
- Complete Technical Catalog of PLC and I/o Units shall be submitted along with the technical offer.

## C) Operator Interface Terminal:

#### ... 1 set.

#### C-1) ELECTRONIC OPERATOR INTERFACE SPECIFICATION:

- The Electronic operator interface shall be Color Active Matrix Thin Film Transistor (TFT) Type having a resolution of 800X600 or better, 18-bit color graphics having a size of 264 X 184 mm (12.1 inches diagonal).
- 2. The Electronic operator interface shall have a standard memory of 64 MB extendable up to 128 MB having Ethernet 10/100MBPS /Profinet , RS-232 Port and USB ports
- **3.** Tags created in the Programmable controller should be used directly in the HMI without creating an additional HMI tag database
- 4. The Electronic operator interface shall support trending up to 8 pens per trend
- **5.** The Electronic operator interface shall support data logging up to 300,000 values locally onto compact flash card
- 6. The Electronic operator interface shall support expressions and animation
- **7.** The Electronic operator interface shall communicate with programmable controller on Ethernet/IP / Profinet network.
- **8.** Run mode object (button) shall be available to place the Operator terminal in Run mode on demand from the configuration mode
- **9.** The Electronic operator interface shall have provision for battery backed time clock stamps critical data. Accuracy +/- 2 minutes per month

C-2)	) Sco	pe of su	pply	under O	perator Interface Terminal:	1 set.

12.1 Inches minimum, Color, Touch type, Operator terminal over EitherNet/IP (To be mounted ON Control Desk)

....01 No.

This operator Terminal shall facilitate operator interactive controls and the System/Drive Parameters display.

Complete Technical Catalog of Operator Terminal shall be submitted along with the technical offer.

D) SCADA (HMI) Station: D-2) Scope of supply of HMI and Engineering Station: 1 set.							
<ul> <li>Industry Standard, FTView HMI Software, unlimited Tags, 25 Screens, Licensed Software</li> </ul>	01 No.						
$\circ$ Engineering Software, Studio 5000 with FTview Studio	01 No.						
<ul> <li>DELL or HP Laptop for HMI station with latest configuration</li> </ul>							

This Scada station is networked with Controller through Ethernet/IP.

with Windows OS and antivirus software

# E) Encoders ... 1 set.

Supplier shall provide an Encoder to be mounted on the Non-driving end of Servo Motors to sense the actual speed and control the same through the Drive. Encoder mounting shall be in the vendors scope of supply:

... 01 set

### I) Control Desk : ....1 No

Control desk shall be fitted with Operator Terminal to indicate system Data like Force, Linear and Angular Position data as against the set set Position reference and other essential controls.

Design, Manufacturing, Supply and locating the control Desk in the existing carriage will be in supplier scope in consultation with IITM.

### I) Drive Control Panel : ....1 No

Vendor shall design a suitable control panel to house the all the drive and control components.

Vendor shall also locate this panel in the existing Towing Carriage without any hindrance for the system operation

## J) Field Cables:

1. Power Cables:

	AC Incoming Cable Motor Power cable Feedback Cable	1 Unit 2 Units 2 Units
2.	Special Cables:	
	Eithernet/IP Cable Controlnet Cable	20 m 20m
3.	Control Cables and screen cables from Driver control Panel to Remote control desk, as required	1 Unit

Note:

- Supplier may consider the required distance between Drive Control Panel and the Motor/ Field devices based on their study
- Supplier may consider the required distance between Drive Control Panel and the Control desk based on their study.

# K) Spares for 2 years:

I.1. Servo Drive critical spares: ... 1 set

1) Servo axis Drive unit with Servo Motor which shall be suitable for both the axes

Supplier shall include any other components, if they are critical spares for the system operation.

I.2. PLC critical spares: ... 1 set

- 1. Processor 1 No
- 2. Power supply 1 No
- 3. DI Card (16 Channels) 1 No
- 4. DO card (16 Channels) 1 No
- 5. AI/AO Card ( 4 ch /2 Ch ) 1 No
- 6. Ethernet Communication Card- 1 No
- 7. Controlnet Communication card 1 No

# L) Services:

J.1) Erection and Commissioning:

- All control panels, control desks Installation and Erection shall be included in the scope.
- The scope shall clearly clarify the number of days are considered for the erection and Commissioning.

#### J.2) Training:

The supplier shall consider two components in their scope with respect to Training.

The supplier shall also include the training for IIT Madras Engineers for 2 days over the system offered after the commissioning at IIT Madras.

# M) Documentation:

The Suppliers shall submit following documentation

- 1. At the time of Techno commercial Offer submission:
  - 1.1. Detailed Technical Offer
  - 1.2. Servo Drive Power configuration diagram in a Single Line Format.
  - 1.3. Total control System Configuration Diagram
  - 1.4. Detailed system description for the proposed solution
  - 1.5. Point wise deviation List for the tender specification
  - 1.6. All the product Catalogs and supporting documents for the confirmed specification
- 2. After the order placement, at the time of Design approval stage:
  - 2.1 Detailed Engineering Drawings of Drive system
  - 2.2 Detailed Engineering Drawings of Control System
  - 2.3 Flow Diagram for Operator Terminal and SCADA system
- 3. After the order placement, at the time of dispatch of the system:
  - 3.1 Complete Schematic Drawings as manufactured.
  - 3.2 User Manual for the complete System
  - 3.3 Trouble Shooting / Maintenance Manual
  - 3.4 Product catalogs and User manual

# N) Reference List:

The Suppliers shall submit the Global and Domestic Reference List for the proposed solution

# **O) Exclusions:**

The Suppliers shall exclusively list out the items which are excluded from their scope of supply.

#### APPENDIX

#### Planar Motion Mechanism (PMM) Equipment

The Department of Ocean Engineering, IIT Madras is planning to install a PMM facility in its existing towing tank facility. Details of the PMM facility are explained below. Technically competent firms involved in the design, development and commissioning of a PMM and interested in this project may please participate in the tender. These firms MUST visit the towing tank at the Department of Ocean Engineering, IIT Madras to understand the existing towing carriage system, and to take required measurements and other inputs for the PMM design and operation.

The following material presented here is a guideline to make the PMM design, including its operation, expected components, technical requirements, data acquisition and processing aspects.

#### About Planar Motion Mechanism (PMM)

Planar Motion Mechanism (PMM) Equipment is a facility provided in a Towing Tank to perform experimental studies with ship models to determine the manoeuvring characteristics of a ship. The experiment is conducted in the towing tank where the PMM setup is attached with the carriage. The ship model is oscillated, at prescribed frequency and amplitude, in different modes of motion in the horizontal plane while it is towed along the tank at a pre-determined speed. The hydrodynamic forces and moments acting on the ship model are measured, recorded and processed to get the hydrodynamic derivatives appearing in the ship manoeuvring equations of motion.

The proposed PMM can have two electric actuators which are used in a controlled manner to produce transverse oscillations while the model is towed by the towing tank carriage at the required speed (upto 3.0m/s). The ship model will be subject to pure sway motion (translatory motion along the breadthwise direction of the model), pure yaw motion (rotary motion about the model vertical axis) and the combined sway & yaw motion. The PMM setup should also have provision to orient the model at any static heel angle (inclination of the ship model transverse plane about the vertical) of 15 deg. to either side (ports and starboard sides) with at least in steps of 2.0 deg. The model in this orientation needs to oscillate in different modes as mentioned above. The video in the link <a href="https://www.youtube.com/watch?v=iHGGSdGM7Xk">https://www.youtube.com/watch?v=iHGGSdGM7Xk</a> shows the different modes of motion of a PMM.

In PMM, the different modes of motion are achieved by adjusting the phase difference between the two actuators, where such concepts are used. The supplier has the freedom to choose a different and efficient concept for the PMM. PMM setup will impart sinusoidal motion to the model in the desired degree of freedom. The setup should have provisions to measure and record the sway and yaw oscillation time history at least at every 10 milliseconds, with a sway motion accuracy of 10 micrometers and yaw angle accuracy of 0.01 deg. The surge and sway forces and yaw moment time history have to be measured accurately and recorded for subsequent analysis. Forces and moment will be measured using force sensors attached with the model setup. The model should have mechanical connections/links in the struts to provide freedom of motion for the model in the vertical plane. That is, the model should be free to heave and pitch while the experiments are performed. The PMM facility should have the data acquisition and recording system, preferred to be done using a dedicated laptop computer, feedback arrangements to check and verify the imparted oscillation displacement and frequency/period of oscillation. The proposed PMM facility should integrate well with the existing towing tank facility. The whole system should be free from vibration so as to avoid spurious data due to it, which might vitiate the force data measured from the tests.

#### Modes of Operation in PMM

#### 1. Pure sway



In pure sway mode of operation, the model is oscillated sinusoidally in the lateral direction with its axis always parallel to the axis of the towing tank.



In the combined sway and yaw mode of operation, the model is oscillated sinusoidally in the lateral direction with its axis always having a drift angle with its sinusoidal path.

#### 2. Pure yaw



3. Combined Sway and Yaw



#### **Towing Tank Dimensions and Cycles**

- Length 82.5 m
- Breadth 3.2 m
- Depth 2.8 m
- Tank length available for steady speed testing 50 m
- 50 meter tank length, which is available for steady speed condition is divided into 5 equal parts to get 5 cycles of run.
- Time to complete one cycle (10 m) minimum 10seconds

#### Sway and Yaw Motion & Estimated Force

Sway Motion

- Sway motion amplitude : +/- 0.4 m
- Sway Velocity 0.4 m/s
- Sway Acceleration 0.2 m/s<sup>2</sup>
- Expected mass of the ship model 300 kg
- Expected Force required to move the ship model 1200 N

#### Yaw Motion

- Yaw amplitude 15<sup>0</sup>
- Yaw angular velocity 0.15 rad/s
- Yaw angular acceleration- 0.10 rad/s<sup>2</sup>
- Expected yaw moment 300 Nm

#### Major Components in PMM mechanism and Approximate Specifications

#### 1. Actuators

Actuators are used to move the model in the prescribed path, as required in different modes of motion mentioned above.

- Type Electrically operated
- Actuator Stroke length (sway double amplitude) required 800 mm
- Translational velocity required 0.4 m/s
- Translational acceleration 0.2 m/s<sup>2</sup>
- Actuator Force 1200 N
- Positioning repeatability ± 0.03mm

#### 2. Force Sensors

Sensors are used to accurately measure the surge and sway forces and yaw moment on the model.

- Number of sensors usually 2
- Components to be measured one sensor single component (Sway force), and the other two component (surge & sway forces)
- Force range minimum requirement : ± 1200 N
- **3.** Supporting frames and struts
- 4. Mechanical links
- 5. Guide rails
- 6. Sway trolley
- 7. Display and processing unit.

**Note:** More detailed requirements and specifications are given in the main text of the "TENDER SPECIFICATIONS" document.

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