Indian Institute of Technology Delhi
Electrical Engineering Department

06-12-2012.

Sub : NIQ for Mechanical Servo Experiment and Haptics Device.

On behalf of duly constituted purchase committee, sealed quotations are invited from the dealers for **Mechanical Servo Experiment and Haptics Device** as per specifications given below.

1. Mechanical Servo Experiment :

The mechanical servo experiment setup needs to consist of the following components.

a) **Modular Servo Plant :** The servo plant shall be ideally suited to introduce fundamental control concepts and theories on an easy-to-use and intuitive platform.
- The plant should consist of a DC motor in an anodized solid aluminum frame.
- The motor should be equipped with a gearbox that drives external gears.
- The servo plant shall be equipped with a potentiometer to measure the output/ angular load.
- The architecture should be flexible to accommodate attachment of different experimental modules to perform different experiments that can be interchangeably run using the same servo motor.
- Rigid geared system with direct drive motor (not belt-driven mechanism) to actuate load with minimal controller lag.
- High quality internal gear-box and re-configurable output gears for achieving different combinations of gear ratios

b) **Ball and Beam Module :** The Ball & Beam module should consists of a steel rod in parallel with a nickel-chromium wire-wound resistor forming the track on which a metal ball is free to roll.
- The position of the ball should obtainable by measuring the voltage at the steel rod. When the ball rolls along the track.
- There should a potentiometer like set up on the track, which as a wiper resulting in the measurement of the position of the ball.
- When coupled to the servo plant, the DC motor should be able to drive the beam such that the motor angle controls the tilt angle of the beam.
- Technical Specifications of the Ball-beam Module :
  i. Base Dimensions : not more than 50 cm x 25 cm
  ii. Mass of the module : Not more than 0.65 Kg
  iii. Beam length : between 40-45 cm
  iv. Lever arm length : between 10-13 cm
  v. Support arm length : between 15-18 cm
  vi. Ball diameter : 2.5 ± 0.1 cm
  vii. Ball mass : Not more than 65 grams
  viii. Beam sensor bias power : ± 12 V
  ix. Beam sensor measurement range : ± 5 V

c) **Data Acquisition Card :** The Experiment setup should include a Data Acquisition card with the following specifications :
- Multiple OS compatibility and Interrupt support USB for the encoder index pulses.
- Number of I/O shall be : 8 ADCs,, 8 DACs ,
- 8 encoder inputs with 4X quadrature position and 1X quadrature velocities ,

- 8 PWM ,
- 8 digital input
- DAQ maximum pulse output frequency of 49.766 MHz. DAQ maximum encoder frequency 99.5 MHz in quadrature mode.

d) **Curriculum** : Curriculum must include modeling, position control, speed control and Ball & Beam. Student workbook, teacher workbook and lab setup guide must be provided in electronic format on CD.

- Modeling the electro-mechanical plant of a servo DC motor and load shaft, actuator dynamics
- Open-loop and closed-loop analysis
- Frequency response analysis
- First order system identification using the bump test
- Model validation
- Closed-loop transfer function
- Using high pass filter instead of direct derivative and implications
- PID control design based on time domain transient and steady state specifications (response time, steady state error, percentage overshoot)
- System response to various input types such as square, ramp, sine wave, etc.
- Actuator saturation
- Integral action
- Actuator dynamics and modeling
- Transfer function representation of the system
- Cascade control design and tuning
- Stability analysis
- Lead-Lag compensation design, parameter tuning and Bode plots
- Sensor noise

e) **Other requirements :**

- The setup should be compatible with MATLAB and SIMULINK.
- The design should be modular with easily-interchangeable parts.
- Open architecture design.
- Windows Single user license for Real-time Control, as Rapid Control and Prototyping Software
- On board sensors should include high resolution encoder, potentiometer and on-board tachometer for directly measuring the output shaft's angular speed.
- System should include remote ball sensor which allows for a master-slave configuration (tele-operation) to control ball position.
- All the components should be compatible with one another.

2. Haptics Device :

The Haptics Device setup should include a 6 degrees of freedom haptics device trainer, Rapid Control Prototyping software, Robotics/Haptics Curriculum.

a) **Haptics Trainer :** The Haptics trainer should meet the following specifications :

- Force feedback workspace: greater than 160 mm x 120 mm x 70 mm.
- Footprint (Physical area device base occupies on desk) : approximately 170 mm x 200 mm.
- Device weight : less than 1.8 kg

S. Jayaraman

- Range of motion : Hand movement pivoting at wrist
- Nominal position resolution > 450 dpi. ~ 0.055 mm.
- Maximum exertable force at nominal (orthogonal arms) position 0.75 lbf. (3.3 N)
- Continuous exertable force (24 hrs.) > 0.2 lbf. (0.88 N)
- Stiffness
  - X axis > 7.3 lbs. / in. (1.26 N / mm.)
  - Y axis > 13.4 lbs. / in. (2.31 N / mm.)
  - Z axis > 5.9 lbs. / in. (1.02 N / mm.)
- Inertia (apparent mass at tip) ~0.1 lbm. (45 g)
- Force feedback in all three directions
- Position sensing by Stylus gimbal
- x, y, z (digital encoders)
- Pitch, roll, yaw (± 5% linearity potentiometers)
- Interface IEEE-1394 FireWire® port: 6-pin to 6-pina
- CE certified
- Six degree-of-freedom positional sensing

b) **Hapics Software Environment :** The software environment :
- Should facilitate robotics and haptic technology education through the interface of MATLAB™/Simulink.
- Rapid control and Prototyping software- Windows single-user license for Real-Time Control.
- Support real-time code generation and execution.
- Should be able to quickly create basic virtual environments and use this as a basis for design of more complex structures such as Multi-Object environments, Multi-Contact haptic interaction, force feedback enabled tele-operation and cooperative haptics.

c) **Curriculum :** It should include student workbook, teacher workbook and lab setup guide in electronic format on CD. Topics which should be covered:
- Forward Kinematics and D-H Parameters,
- Inverse Kinematics,
- Joint level PD and PID control,
- Trajectory planning (Joint space vs. Task space),
- Jacobian derivation and application,
- Various "Force Law" Haptic rendering i.e. force fields, hard and soft contacts, etc.
- Graphics development using Virtual Reality Toolbox

d) Other desirable features :
- Removable stylus for end-user customization
- Wrist rest to maximize user comfort
- Stylus-docking inkwell for automatic workspace calibration

Terms and Conditions:-

1. Please submit the TECHNICAL and FINANCIAL bids in separate sealed envelopes. Mark the two envelopes clearly as **"Technical Bid" and " Financial Bid".** Both the sealed envelopes should be sent in a single sealed envelope, with clearly marked as Quotation for as **"Mechanical Servo**

S. Jayadhana

Experiment and Haptics Device". The quote should reach the following address on or before **27/12/2012 up to 5.00PM.**

Name : **Dr. S. Janardhanan**

Address : **Control Lab,**
Room No. II-214,
Department of Electrical Engineering,
IIT Delhi, New-Delhi – 110016 (India)

2. Please quote the price at FOB / CIF New- Delhi, inclusive of installation charges.
3. Quote should be in Indian Rupees as well as US Dollars or GBP and to be valid for at least three months.
4. Attached all technical literature and list of similar installation done in India.
5. Warranty as per OEM.
6. Mention if you can provide any technical support like training of IIT Delhi personnel at IIT Delhi or in your factory and providing a technical person for operation of the equipment for the initial period of 2 years. Kindly mention about this in technical bid.
7. If the quote is being submitted by the representative of the principals/manufactures themselves, a valid Agency ship/ Dealership certificate authorizing the agent to quote to IIT Delhi on behalf of the Principals should be enclosed.
8. The institute reserves the rights to accept/reject any/all quotations without assigning any reasons thereof.
9. Complete set of manuals for the operation of the equipment should be given. All circuit diagrams, other mechanical and electrical schematics must be provided to main unit, sub systems and accessories.
10. Delivery within 16 weeks on receipt of PO.
11. Clearly specify the installation requirements – Such as space, power, frequency, environment (Temperature and Humidity) .
12. If the item quoted are proprietary in nature, please enclose proprietary certificate from the principals stating "certificate that --------- is proprietary item of M/s ------- and no other manufacture make these items".
13. If the bidder is Indian agent, the agency certificate should be enclosed.
14. Please produce compliance certificate for the specification.
15. Please ensure that the Indian agent has been enlisted with the Department of Expenditure, evidence may please be attached.
16. All bank charges payable in India are to buyer's account and the bank charges in seller's country to seller's account.

S. Janardhanan

(Dr. S. Janardhanan)

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