Specifications of the Mechanical Structure of 3-Link rigid-Flexible Manipulator

1. It's a three-link manipulator in which one link is rigid and other two links are flexible, rigid link (square cross-section) is mounted in the vertical direction on a rigid base and its supports two flexible links, which are in the horizontal direction. Each flexible link has one accelerometer to measure the links endpoint velocities and accelerations that is attached at the end of the flexible links, and each flexible link also has a strain gauge to measure the deflection of the flexible links, strain gauge is attached at the base of each flexible link (Refer figure-1). Dimensions of the one vertical link and two flexible links are as follows: -

Link type	Material(mm)	Length(mm)	Width(mm)	Thickness(mm)
Rigid	Aluminium	600-700 (L1)	60-80	same as width
Flexible	Steel	500 (L2)	25-30	1-2
Flexible	Steel	500 (L3)	25-30	1-2

2. For the motion of rigid link 1 in vertical direction, a single start lead-screw with nominal diameter of 8-10 mm with guide rails to be used.

3. For the motion of the flexible link-2, Motor-3 is to be provided with the modular mounting option, it can be placed either at the tip or can be the base of the first flexible link and it also has an option to add dead weight. The flexible link-2 should also be detachable so that the set-up can be used as a single-link flexible manipulator.

4. Motion transfer from motor-3 (placed on the base of the flexible link -1) to flexible link-2 is to be done with the help of timing belt.

5. The complete structure is placed on a rigid base frame and it can support the weight of all the links and hardware attached to it.

6. The complete project setup is to be provided with suitable (branded) power supply (24V) for 3 motors (all motors) with input 10 amp. If any change is required, vendor can decide based on his requirement. After discussion with PI's.

7. The task of mounting all the actuators (motors), sensors, DAC and other relevant hardware is to be done by the vendor. All the above mentioned actuators, sensors and DAC will be provided by the institute.

8. Purchase and mounting of the relevant strain gauges to measure the deflection of both the flexible links are to be done by the vendor. The vendor will provide extra strain gauges (minimum 5) with suitable adhesives at the time of delivery for any future requirements.

9. All the interfacing is to be done and demonstrated by the vendor where the functionality of each sensor and actuator will be checked in Labview software (will be provided by TIET).

10. Two sample programs are to be given by the vendor at the time of inspection and following points will be inspected.

a) All the motors are running for sample programs.
b) All the sensors are working properly.
c) Demonstration of all the parts related to RPM of the motor, strain gauge, accelerometer, angle and deflection and results are to be shown as plots v/s time.
d) Variation in motor rpm is demonstrated through software.

11. If any modification is required in the structure that has to be done with maximum two times within one year of delivery.

12. Our Senior Research Fellow (SRF) from the project will visit the vendor and contribute toward development and interfacing of the whole setup.

13. The complete project setup is to be delivered at the TIET campus within three months of receiving the PO and the relevant hardware.

14. From the total billing amount, 85% of the billing amount will be paid at delivery time and 15% will be paid after 1 year after delivery.

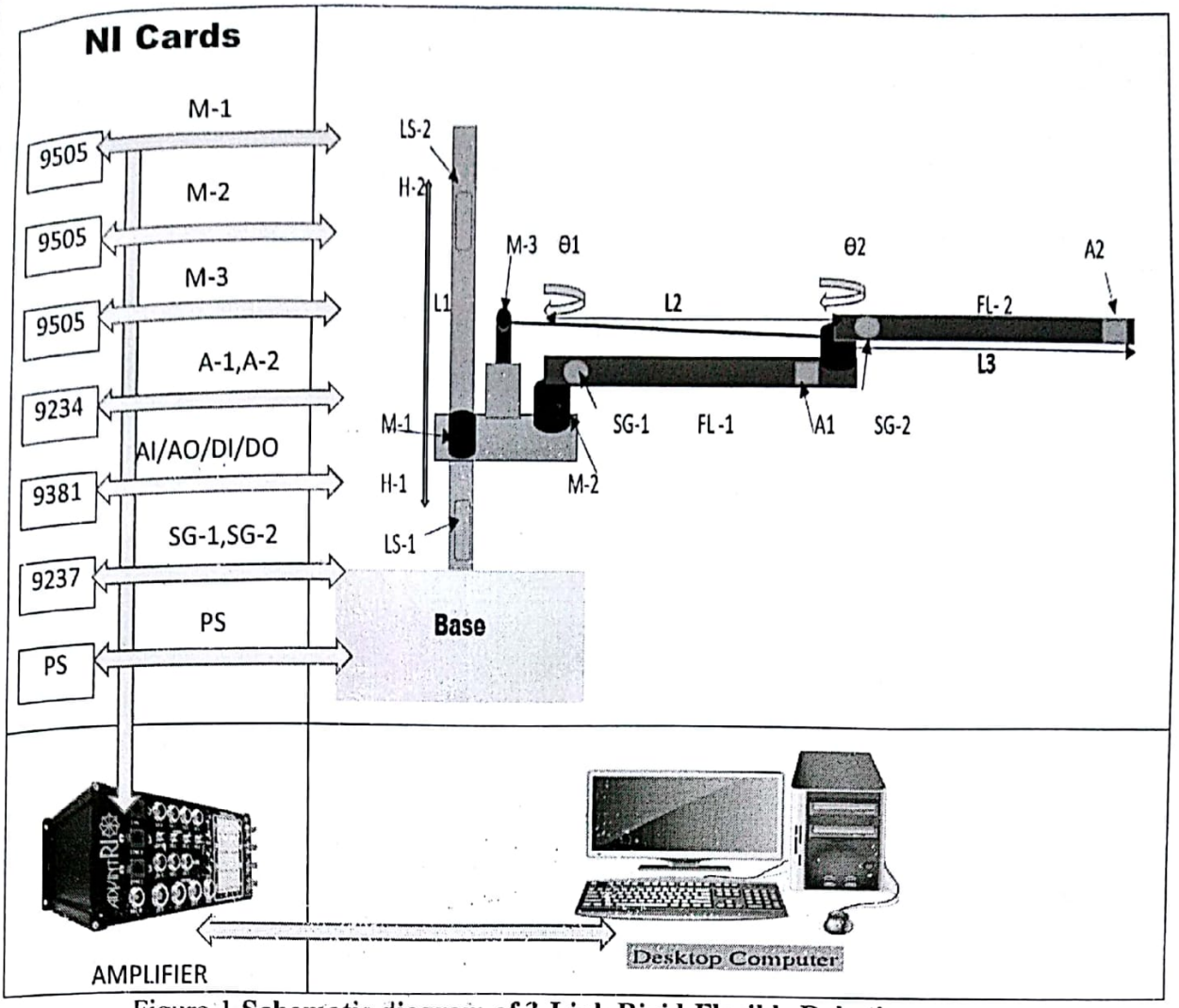

Figure-1 **Schematic diagram of 3-Link Rigid-Flexible Robotic arm**

Nomenclature	
M-1	MOTOR-1
M-2	MOTOR-2
M-3	MOTOR-3
A-1	ACCELEROMETER-1
A-2	ACCELEROMETER-2
SG-1	STRAIN GAUGE-1
SG-2	STRAIN GAUGE-2
PS	POWER SUPPLY
LS-1	LMIT SWITCH-1
LS-2	LIMIT SWITCH-2
H-1	HEIGHT-1
H-2	HEIGHT-2
FL-1	FLEXIBLE LINK-1
FL-2	FLEXIBLE LINK-2

Motor and Cards Details	
Items	**Specifications**
MOTOR-1	Maxon motor (part no- 273759) with planetary gear head (part no-203125) and encoder(part no-225787)
MOTOR-2	Maxon motor (part no- 273759) with planetary gear head (part no-203125) and encoder(part no-225787)
MOTOR-3	Maxon motor(part no- 118752) with planetary gear head (part no-166939) and encoder(part no-225780)
NI Card-9505	1-Axis DC brushed servo drive w/encoder feedback
NI Card -9234	four-channel dynamic signal acquisition module for making high-accuracy measurements from IEPE sensors, 102 dB of dynamic range,4 AI,24 Bit, 51.2 kS/s/ch Simultaneous, AC/DC Coupling, IEPE,AC coupling
NI Card -9381	multifunction I/O module, 8 AI/8 AO/4 DIO,12 Bit, 20 kS/s Aggregate
NI Card -9237	4 channels, 50 kS/s per channel simultaneous AI,24-bit resolution, Programmable, half- and full-bridge completion with up to 10 V internal excitation, RJ50 or D-SUB connectivity options