IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

DEVICE FOR ADJUSTING JOINT STIFFNESS

IITM Technology Available for Licensing

PROBLEM STATEMENT

- **Robots with rigid links** require **adjustable joint elasticity for interaction** with humans, robots, and the environment.
- **Active methods require expensive sensors** or torque-controlled motors, **causing time lag and potential damage** to robot structures.
- **Passive compliance control** uses passive elements like **springs or elastic materials** to maintain stiffness.
- **Conventional devices** use **continuously powered actuators to change joint angle and stiffness.**
- The **stiffness adjusting architecture** is determined by application, with **spring properties changing to vary joint stiffness**.
- The disclosure describes a **device and apparatus for varying stiffness,** addressing limitations in existing compliance control systems for robotic joints, adjusting elasticity based on task requirements.

TECHNOLOGY CATEGORY/ MARKET

Technology: Device for vary stiffness control
Category: Joints of Robotics system
Industry: Electronic system & Design Manufacturing/Robotics Manufacturing
Application: Robotics Joint System
Market: The global market size was **USD 757 million in 2021** and market is **projected to touch USD 4232.94 million by 2031**, exhibiting a **CAGR of 18.8%** during the forecast period

INTELLECTUAL PROPERTY

IITM IDF Ref. 1861
Patent No: IN 494078

TRL (Technology Readiness Level)

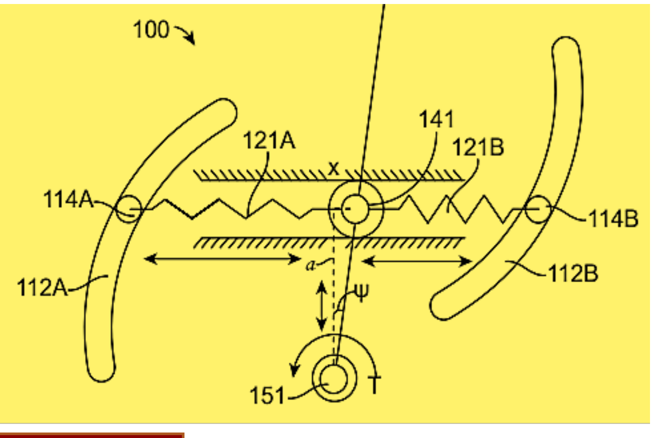
TRL-3, Experimental proof of concept;

Research Lab

Prof. Asokan T,
Dept. of Engineering Design.

TECHNOLOGY

DEVICE



FEATURES

- A **joint axis (151) connecting**
  - **Input link (131)** and
  - **Output link (133)**
- **Includes**
  - **Middle link (117),**
  - **Stiffness axis (141),**
- **Cam (111),**
  - **Pair of Opposing cam followers (114A,114B)**
  - **Pair of Opposing cam slots (112A,112B)**
- **Springs**
  - **First springs (121A) and**
  - **Second springs (121 B)**

Stiffness Variability

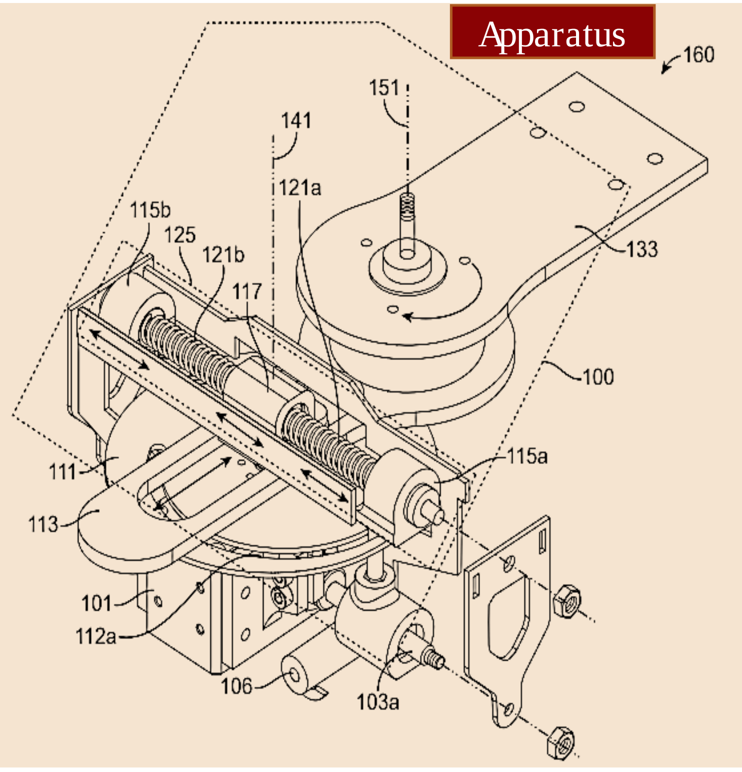
- **Stiffness is variable through springs.**
- **Cam rotated about stiffness axis to adjust tension.**
- **Device adjusts stiffness offset between stiffness axis and joint axis.**

CONTACT US
Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719

Apparatus

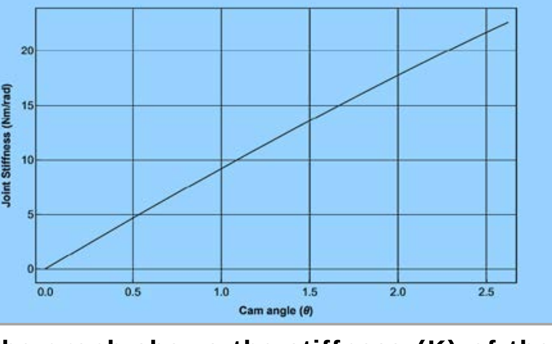


Numerals	Definition
131-Input Link	133-Output Link
100- A Device	101-First Actuator
141-Stiffness Axis	151- Joint Axis
103a,103b-Linear Guiding Elements	106-Lead Screw
111- Cam	112a,112b - opposing cam slots
113-slotted link	115a,117,115b- First,Second,Third Slidable Block
121a,121b- First,Second spring	125-antagonistic arrangement

Key Features / Value Proposition

- The device is **simple and reliable.**
- **Compact**
  - Compactness allows modularity and **less energy** consumption.
  - **Reduces** power consumption without continuous stiffness motor operation.
- **Stiffness**
  - Stiffness of the joint is **related to the offset** '*b*' by:

    $$K = 2kx(x^2 + b^2).$$
  - Stiffness of the output link is **adjusted** by **changing a position of the first and the third block in a linear direction** by the first actuator.
  - Stiffness **controlled** by the **proposed variable stiffness mechanism (VSM).**
- Mechanism can be **scaled based on force, stiffness, or task requirement**.
- **High force bandwidth** enables extreme states without changing components or design.
- **High range** of joint/output link angle for **continuous tuning**.
- **Energy stored** during impact and released for additional energy gain.
- **Robot** or serial/parallel chain configuration **allows modules** with different **cam profiles and nonlinear springs.**
- **Manual** adjustment **decouples joint stiffness and motion.**



The graph shows the stiffness (K) of the joint module with change in cam angle

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IITM TTO Website: https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719