Ultrasonic motor

Tiny Ultrasonic Linear Actuator

• TULA series

• PUMR series

Technohands Co., Ltd.
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**Overview**

In general, actuators in mainstream use are electromagnetic and fluid (air and oil pressure) types, but in recent years, ultrasonic motors have appeared as a completely new trend. They were previously used in the industrial field, but they are now increasingly being used as mobile actuators for digital cameras and cellular phones. We coordinate with our company partners to commercialize new products, offering much sounder, better service. From rotary modules to linear modules, we supply our customers with a wide variety of this latest developed ultrasonic motor.

**What are Ultrasonic Motors?**

The ultrasonic motor operates using a piezoelectrical mechanism to convert a vibration movement into a displacement movement. Ultrasonic motors are used in either rotary modules or linear modules.

**Main Features of Ultrasonic Motors**

- Attain low speed and high torque (thrust) without slowing down the machine
- Maintain high torque (thrust), with no electric current present, therefore, no heat is generated
- When movement is stopped, frictional force brings movement to a complete stop with no unwanted vibration
- Direct mechanism allows high machine responsiveness
- Simpler and fewer parts allow for decrease in mass production cost
- Nonmagnetic construction allows for unaffected operation in presence of magnets
- Vacuum application is available by changing materials.

**Applications**

- Microscope stage
- Small interferometer stage
- Stage for vacuum use
- Stage for medical devices
- Stages for zero gravity
- Stage for semiconductor equipment
- Stage for precision small-scale application
- Mirror alignment unit for optical system
- Stage for strong magnetic field environment
- Flow adjustment for valve and nozzle
- Camera (AF, Zoom, Anti shake)
- Small manipulator
- IR filter for camera
- Laser beam adjustment unit
- Surveying equipment
- Stage for object lenses
- Small robot
- Unit for braille
- Actuator for surveillance camera
- Industrial shutter
Micro-miniature Ultrasonic Linear Actuator:
TULA, is either a unimorph or bimorph type of next generation actuator that operates through piezo-ceramic vibration control. Piezoelectric ceramic is fixed to the end of the drive shaft, putting the preloaded friction in the drive shaft, preventing heat emission and vibration that would occur with electromagnetic motors. The principle mechanism is the transference of vibration from the piezoelectric ceramic to the drive shaft. The movement from the vibration pulls the friction by changing the duty ratio of the forward and reverse movement, using this action to create motion. Minute movement is controlled by high frequency vibration, allowing the actuator to move smoothly. For its micro-miniature shape, it can provide high thrust and motion retention; it is an ideal actuator for micro positioning.

**Drive Principle**

Direct piezoelectric effect

\[ P_i = d_{ijk} T_{jk} \]

Inverse piezoelectric effect

\[ S_{ij} = d_{kij} E_k \]
TULA (Tiny Ultrasonic Linear Actuator)

Standalone Actuator Specification (TULA35, 50, 70, 70W)

- **TULA35**
  - Trembler Diameter: φ3.5mm
  - Shaft Length: 14mm (available from 3 ~ 14mm)
  - Thrust: 15 ~ 25gf
  - Holding Force: 30 ~ 80gf
  - Stroke: 3 ~ 6mm
  - Vibration Frequency: 70 ~ 100KHz
  - Drive Voltage: 12 ~ 30V

- **TULA50**
  - Trembler Diameter: φ5.5mm
  - Shaft Length: 22 (available from 3 ~ 22mm)
  - Thrust: 25 ~ 40gf
  - Holding Force: 100 ~ 150gf
  - Stroke: 3 ~ 9mm
  - Vibration Frequency: 50 ~ 90KHz
  - Drive Voltage: 10 ~ 38V

- **TULA70**
  - Trembler Diameter: φ7.5mm
  - Shaft Length: 22 (available from 3 ~ 30mm)
  - Thrust: 25~ 40gf
    - TULA70W (available from 3 ~ 45mm)
  - Load: 100g
    - TULA70W: 150g
  - Holding Force: 150gf
    - Varies with the pressure force of the moving body
  - Stroke: 3 ~ 30mm
  - Vibration Frequency: 30 ~ 70KHz
  - Drive Voltage: 20 ~ 38V

“W” notation is for double piezo elements on both sides

Example of Friction Body Structures
Evaluation Kit (with friction body)

- ST50S-16.5 Type
- ST70S-22 Type
- ST50A-16.5 Type
- ST70A-22 Type
- ST35P-14 Type
- ST50P-16.5 Type
- ST70P-22 Type

PCD302 Type + ST***-*** Type + 5V Power supply, USB cable

Open Loop Type

Drive Thrust

- ST50S-16.5 Type: 30 ~ 40gf
- ST70S-22 Type: 40 ~ 60gf
- ST50A-16.5 Type: 25 ~ 40gf
- ST70A-22 Type: 100gf
- ST35P-14 Type: 150gf
- ST50P-16.5 Type: 80gf

Holding Force

- ST50S-16.5 Type: 100gf
- ST70S-22 Type: 150gf
- ST50A-16.5 Type: 80gf
- ST70A-22 Type: 150gf
- ST35P-14 Type: 80gf

Compatible Driver/Controller

- PCD301 Type
- PCD302 Type

The Ultrasonic Linear Actuator operates using friction caused by the repetition of the expansion and contraction of the axel (impact type) with the vibration from the piezoelectric element. This is why the moving body (friction body) is an important element in TULAs.
Encoder Type

- Ultra Small Ultrasonic Linear Stage
  Capable of high precision with integrated high precision optical encoder.
  This product features significant strong holding force capability for an Ultrasonic actuator.

1. X Axis Stage
   - XDT50-042 Type 5P
   - XDT70-102 Type 6P
   - XDT70-152 Type 6P

2. XY Axis Stage
   - XYDT50-042 Type 7P

3. Theta Axis Stage
   - Θ DT70-0062 Type 7P

4. XY-Theta Axis Stage
   - XYDT50-042/Θ 70-0062 Type 8P

5. XY Axis Hollow Stage
   - XYHDT50-042 Type 8P

6. X Axis Stage (Resolution 1 μm, 5 μm)
   - XDT50-041 Type 9P (Avago)
   - XDT50-069 Type 9P (Micro E)

- Specifications-
  1. Stroke : ±2mm
  2. Resolution: 1 μm/p (A, B Phase)
     Option : 0.1 μm/p
  3. Repeatability : ±3 μm
  4. Thrust : 80gf
  5. Holding Force : 300gf
  6. Moving Speed : 10mm/s
  7. Driver : PCD302 Type
  8. Actuator : TULA50 (16.5mm)
Encoder Type

- **X Axis Stage (st:10 mm)**
  - Model Number: XDT70-102 Type
  - Specification:
    1. Stroke: ±5mm
    2. Resolution: 1 μm/p (A,B Phase)
    3. Repeatability: ±3 μm
    4. Thrust: 60gf
    5. Holding Force: 300gf
    6. Moving Speed: 10mm/s
    7. Driver: PCD302 Type
    8. Actuator: TULA70 (22mm)

- **X Axis Stage (st:15 mm)**
  - Model Number: XDT70-152 Type
  - Specification:
    1. Stroke: ±7.5mm
    2. Resolution: 1 μm/p (A,B Phase)
    3. Repeatability: ±3 μm
    4. Thrust: 50gf
    5. Holding Force: 300gf
    6. Moving Speed: 10mm/s
    7. Driver: PCD302 Type
    8. Actuator: TULA70 (28mm)
TULA (Tiny Ultrasonic Linear Actuator)

### Encoder Type

**XY Axis Stage**

Model Number: XYDT50-042 Type

- **Specification**
  1. Stroke: XY ±2mm
  2. Resolution: 1μm/p (A,B Phase)
     - Option: 0.1μm/p
  3. Repeatability: ±3μm
  4. Thrust: 60gf
  5. Holding Force: 250gf
  6. Moving Speed: 10mm/s
  7. Driver: PCD302 Type
  8. Actuator: TULA50 (16.5mm)

**Theta Axis Stage**

Model Number: θDT70-0062 Type

- **Specification**
  1. Movement Amount: ±3°
  2. Resolution: 1p: 0.005°
     - Option: 1p/0.0005°
  3. Repeatability: ±3p: 0.015°
  4. Torque: 50gcm
  5. Holding Torque: 150gcm
  6. Moving Speed: full Moving 0.4seconds or less
  7. Driver: PCD302 Type
  8. Actuator: TULA70 (22mm)
**TULA (Tiny Ultrasonic Linear Actuator)**

## Encoder Type

### XY-Theta Axis Stage
Model Number: XYDT50-042 / θ 70-0062 Type

- **Specification**
  1. Stroke: XY±2mm, θ±3°
  2. Resolution: 1μm/p, θ 0.005° / 1p
  3. Repeatability: ±3μm, ±0.015°
  4. Thrust: 60gf, 50gcm
  5. Holding Force: 250gf, 150gcm
  6. Moving Speed: 10mm/s, full Moving 0.4seconds or less
  7. Driver: PCD302 Type
  8. Actuator: TULA50 (16.5mm), TULA70 (22mm)

### XY Axis Hollow Stage
Model Number: XYHDT50-042 Type

- **Specification**
  1. Stroke: XY±2mm
  2. Resolution: 1μm/p (A,B Phase)
    - Option: 0.1μm/p
  3. Repeatability: ±3μm
  4. Thrust: 60gf
  5. Holding Force: 250gf
  6. Moving Speed: 10mm/s
  7. Driver: PCD302 Type
  8. Actuator: TULA50 (16.5mm)
**Encoder Type**

**TULA (Tiny Ultrasonic Linear Actuator)**

- **X Axis Stage (Resolution: 5 μm/p)**
  - Model Number: XDT50-041 Type
  - Specification:
    1. Stroke: ±2mm
    2. Resolution: 5 μm/p (A,B,Z Phase)
    3. Repeatability: ±15 μm
    4. Thrust: 80gf
    5. Holding Force: 300gf
    6. Moving Speed: 10mm/s
    7. Driver: PCD302 Type
    8. Actuator: TULA50 (16.5mm)

- **X Axis Stage (Resolution: 1 μm/p)**
  - Model Number: XDT50-069 Type
  - Specification:
    1. Stroke: ±3mm
    2. Resolution: 1 μm/p
    3. Repeatability: ±3 μm
    4. Thrust: 60gf
    5. Holding Force: 180gf
    6. Moving Speed: 10mm/s
    7. Driver: PCD302 Type
    8. Actuator: TULA50 (22mm)
Open Type

◆ (A) XDT50-06 Type
  ~Specification~
  1. Stroke : 3.5mm
  2. Thrust : 50gf
  3. Holding Force : 120gf
  4. Load : 100g

◆ (B) XDT50-09 Type
  ~Specification~
  1. Stroke : 6.5mm
  2. Thrust : 40gf
  3. Holding Force : 120gf
  4. Load : 100g

◆ (C) XDT50-11 Type
  ~Specification~
  1. Stroke : 8.5mm
  2. Thrust : 35gf
  3. Holding Force : 120gf
  4. Load : 100g

● Open X Axis Stage

◆ XLT35-06 Type
  ~Specification~
  1. Stroke : 5.5mm
  2. Thrust : 20gf
  3. Holding Force : 60gf
  4. Load : 50g

● Small size X Axis Stage
Model Number : XLT35-06 Type
TULA (Tiny Ultrasonic Linear Actuator)

Open Type

- Specification -
  1. Stroke: 27mm
  2. Thrust: 30gf
  3. Holding force: 60gf
  4. Load: 50g

- X Axis Stage
  Model Number: XST70W-27 Type

- X Axis Stage
  Model Number: XST70-09 Type

- Specification -
  1. Stroke: 9mm
  2. Thrust: 40gf
  3. Holding Force: 170gf
  4. Load: 50g
TULA (Tiny Ultrasonic Linear Actuator)

TULA Applications

- Specification -
1. Stroke: Maximum 4 mm
2. Thrust: 30 gf
3. Holding Force: 200 gf
4. Load: 50 g or less
5. Resolution: 1 μm, 5 μm
6. Moving Speed: 10 mm/s

- Specification -
1. 2 Axis Finger Stroke: 2.9 mm
2. Finger Thrust: 10 gf
3. Finger Holding Force: 30 gf
4. Control: Pulse Control (open)
TULA Applications

- XY Axis Hollow Microscope Stage
  Model Number: XCT70W-302/YCT70-202 Type

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification (standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Motor Type</td>
<td>Ultrasonic Linear Motor (Friction Motor)</td>
</tr>
<tr>
<td>2. Movement Direction</td>
<td>X, Y 2 directions</td>
</tr>
<tr>
<td>3. Driving Mode</td>
<td>Impact type of piezoelectric ceramic</td>
</tr>
<tr>
<td>4. Maximum Stroke</td>
<td>XAxis: ±15.3mm, YAxis: ±10.1mm</td>
</tr>
<tr>
<td>5. Effective Max. Stroke</td>
<td>XAxis: ±15mm, YAxis: ±10mm</td>
</tr>
<tr>
<td>6. Table Dimensions</td>
<td>75mm × 70mm</td>
</tr>
<tr>
<td>7. Minimum Resolution</td>
<td>1 μm</td>
</tr>
<tr>
<td>8. Positioning Accuracy</td>
<td>±3 μm</td>
</tr>
<tr>
<td>9. Repeatability</td>
<td>5 μm</td>
</tr>
<tr>
<td>10. Withstand load</td>
<td>300g</td>
</tr>
<tr>
<td>11. Holding Force</td>
<td>150g</td>
</tr>
<tr>
<td>12. Mass</td>
<td>320g</td>
</tr>
<tr>
<td>13. Encoder Model</td>
<td>CE300-40E (Micro E)</td>
</tr>
</tbody>
</table>

- IR Filter Changer for CCTV

- Specification
  1. Moving Speed: 10mm/s
  2. Drive Frequency: 65 ~ 75KHz
  3. Power Consumption: < 40mW
  4. Operating Temperature: -10 ~ 50°C
     (option: ~30 ~ 70°C)
  5. Dimensions(W × L × H): 32.0 × 32.0 × 18.9mm
  6. Actuator: TULA50 (20mm)

※Customization of the IR filter for surveillance cameras are available.
TULA Applications

- **Shake Prevention Unit**
  - Features & Application:
    - Shake Prevention Unit for Digital Camera
    1. High responsiveness and retentive force leads to replacement of VCMs
    2. Surveillance cameras with reduced vibration and unwanted motion
    3. Shake prevention for video cameras, and more.

- **micro pump**

- **Braille Module**
  - Specifications:
    1. TULA35, TULA50 Type
    2. Thrust: 20gf
    3. Speed: 8㎜/sec
  (Applications)
  * ATM with braille support, small braille unit for mobile, display surface with braille.

- **Auto Focus Module (under development)**
  - Features & Application:
    1. TULA35, TULA50 Type
    2. Auto focus for bar code reader
    3. Auto focus zoom for digital camera
    4. Auto focus module for industrial use

- **Vacuum actuator (under development)**
  - Specifications:
    1. Vacuum state: 10⁻¹³ Pascal
    2. Stroke: 3 axis 6 mm
    3. Thrust: < 40gf
    4. Holding Force: 150gf
  * Vacuum unit shall be tested by customer.

Specifications:
- Stroke: 0 ~ 2mm
- Thrust: 10gf
- Holding Force: 30gf
**TULA Applications**

- **Objective Lens Attachment Unit**

- **Industrial Lens Drive Unit**

**3 Axis JOG Tracking Unit**

- **Industrial Lens Drive Unit**

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**TULA (Tiny Ultrasonic Linear Actuator)**

**Specification**

1. Effective Stroke (mm): X (+/- 3.2), Y (+/- 3.2), Z (+/- 2.7)
2. Thrust (gf): X(40), Y(40), Z(25): with preload spring (50)
3. Holding Force (gf): X(160), Y(160), Z (130): with preload spring (130)
4. Body Weight (g): XYZ axes (70)
5. Control: Manual operation or command control from PC
6. Option: JOG controller

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**Industrial Lens Drive Unit**

**Specification**

1. Thrust: 45gf
2. Holding Force: 150gf
3. Resolution: 5μm
4. Positioning Accuracy: ±10μm
5. Max Lens Payload: 70g
6. Stroke: ±4 mm
TULA (Tiny Ultrasonic Linear Actuator)

**Features**

1. Compatible to TULA 35, TULA50, TULA70
2. Precise Position Control
   - High precision achieved with use of optical encoder
   - Open Pulse Drive (under 70nm per pulse under in-house test)
3. Digital P.I.D. Tuning
4. Input Command Types:
   1) External digital pulse commands
      - step/dir
   2) Command input
      - LabView/TeraTerm via USB
   3) Analog control input (0 ~ 3.3V, Option)
5. JOG Motion
6. Manual Operation from LCD Panel

**Specifications**

1. Driving Frequency : 20 ~ 110 KHz
2. Drive Voltage : 16 ~ 40V
3. Drive Duty : 0 ~ 100%
4. USB Interface to PC (use FTDI FT232R)
5. PC Monitor Program
   - Driver Program (Tera Term) included
6. Supply Power : DC12 ~ 24V, 1A

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**PCD-301 Type(1Axis)**

(Power, USB cable included)

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**Driver & Controller**

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**Block Diagram**
TULA (Tiny Ultrasonic Linear Actuator)

Driver & Controller

**PCD-302 Type (1Axis)**

1. Open Loop Type
   PCD-302 Type

2. Closed Loop Type
   PCD-302E Type

**Features**
1. Compatible to TULA 35, TULA50, TULA70
2. Precise Position Control
   - High precision achieved with use of optical encoder
   - Open Pulse Drive
     (under 70nm per pulse under in house test.)
3. Digital P.I.D. tuning
4. Input Command types:
   1) External Digital Pulse Commands
      • step/dir
   2) Command Input
      • LabView/TeraTerm via USB
   3) Analog Control Input (0 ~ 3.3V, Option)
5. JOG Motion

**Specifications**
1. Driving Frequency: 20 ~ 110 kHz
2. Drive Voltage: 16 ~ 38V
3. Drive Duty: 0 ~ 100%
4. USB Interface to PC (use FTDI FT232R)
5. Supply Power: DC5V, 1A
6. PC Monitor Program
   • Driver Program (Tera Term) to be downloaded

**Options**
1. 5V Power, USB Cable
2. Encoder Cable: 1m
   Motor Cable: 1m
3. 1Axis JOG Unit
4. 3Axes JOG Unit

**Block Diagram**

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[Diagram showing the block diagram of the TULA system, including various components such as ADC, DC Step up signal conditioner, PID, Pulse Generator, QEI, Pulse Width Modulator, H Bridge Circuit, and Tula Actuator.]

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[Images of the TULA units, including open and closed loop types, and various accessories like encoder cables and joysticks.]

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[Additional notes and diagrams related to the TULA system, highlighting its compatibility, precision, and control features.]
TULA (Tiny Ultrasonic Linear Actuator)

**Rotary Ultrasonic Motor**

**Features**
- Low speed with high torque without a gear reduction
- No heat is generated when paused with high positioning control
- Simple, slim and lightweight design
- High responsiveness and quiet operation
- Does not contain magnets
- No electromagnetic noise; can be used in MRI and other medical applications
- Large blinds or roll screens for hospitals, offices, and factories
- Actuator for surveillance cameras
- Fingers and arms for robots, manipulators, etc.
- Flow control for various types of valves and nozzles

**Specification**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Model</th>
<th>PUMR 40</th>
<th>PUMR 60</th>
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<tbody>
<tr>
<td>Shaft Diameter (mm)</td>
<td></td>
<td>φ6</td>
<td>φ8</td>
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<tr>
<td>Dimensions (mm)</td>
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<td>65 × 65 × 22</td>
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<td>Weight (g)</td>
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<td>270</td>
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<tr>
<td>Drive Frequency (KHz)</td>
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<td>34～37</td>
<td>40～44</td>
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<tr>
<td>Drive Voltage (V)</td>
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<td>120</td>
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<td>Rotary Speed (rpm)</td>
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<td>100</td>
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<tr>
<td>Torque (kgf・cm)</td>
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<td>Max. Torque (kgf・cm)</td>
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<td>5.5</td>
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<td>Maintain Torque (kgf・cm)</td>
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<td>Encoder (p/r)</td>
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<td>A・BPhase : 1,000 (Option : 5,000)</td>
<td>A・BPhase : 1,000 (Option : 5,000)</td>
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<td>Temperature during continuous</td>
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<td>motor operation (℃)</td>
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<td>(Motor surface) 55</td>
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<td>Storage Temperature Range (℃)</td>
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<td>Life (Hrs)</td>
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<td>3,000</td>
</tr>
</tbody>
</table>

**Application Examples**

- X-Y axis stage
- DVD Pick up system
- Mic moving system
- Diamond cutting machine
- Z axis stage
- Roller screen
- Semiconductor equipment
- Chassis position system
Ultrasonic motor
Tiny Ultrasonic Linear Actuator

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