Performance Evaluation of KEK Tuner

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- Study of Slide-Jack Mechanism
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Purpose and Flow

- Purpose
  - Performance evaluation of KEK tuner used in ERL main linac.

- Flow

  - Evaluation under room temperature (This report)
    - Basic specification
    - Establishment of assembling method
  - Evaluation under cold temperature

Requested Specifications

- Cavity:
  - Frequency/Elongation: 300kHz/mm
  - Spring constant: 300kgf/mm
- Coarse adjustment：slide jack: about 3000um
- Micro adjustment ：Piezo module: 80um

  →Cantilever:40um

  →cooling,load:4um estimated

- Slide jack is requested to adjust with 1um accuracy
- Condition
  - Max 1000kgf loaded. But load to piezo module is half.
  - In superconductive condition

Study of Mechanism

- Smoothness of motion

- Influence of load

  - "load" is output of the load cell and half of total load

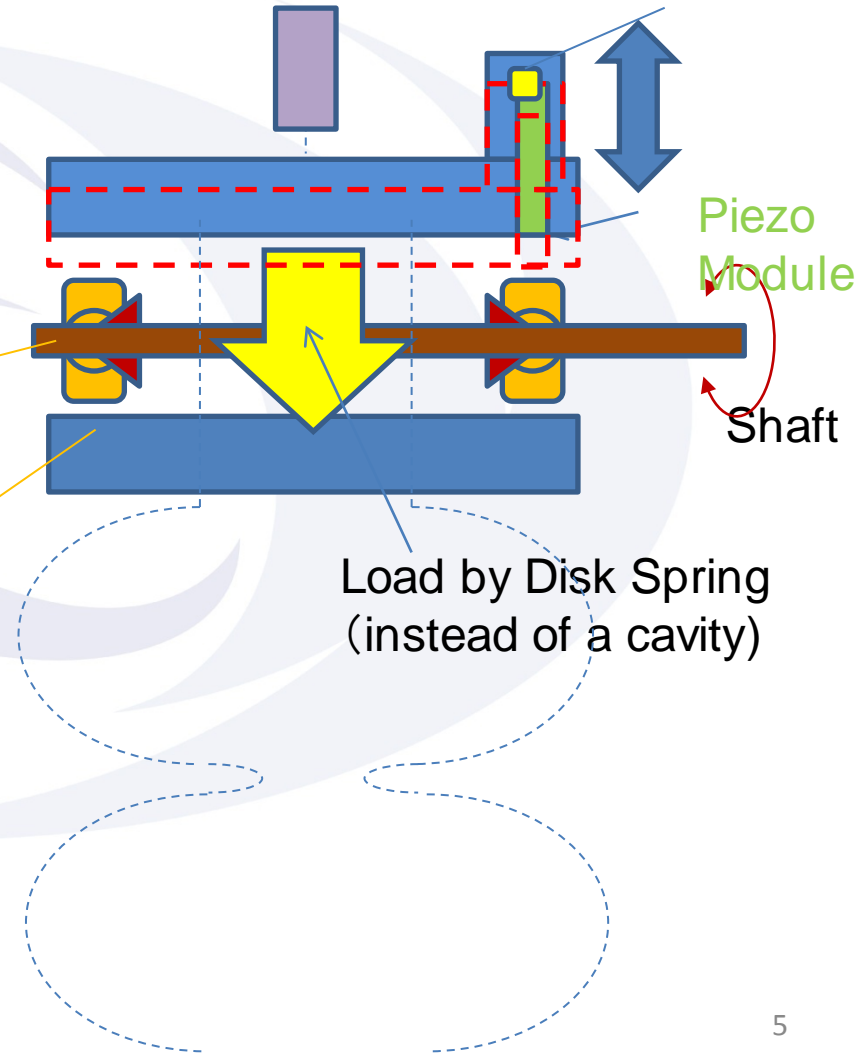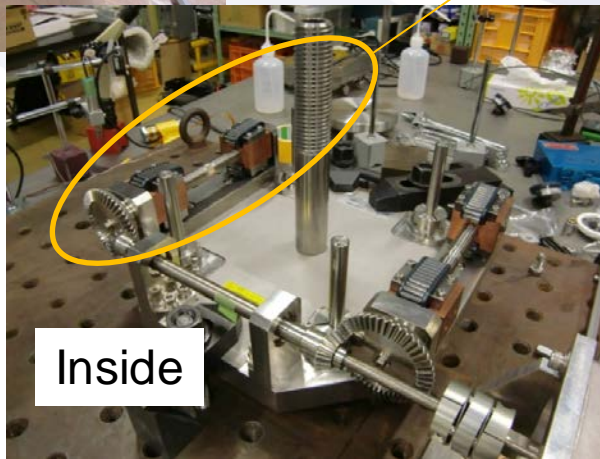Slide-jack

Inside

Displacement Gauge
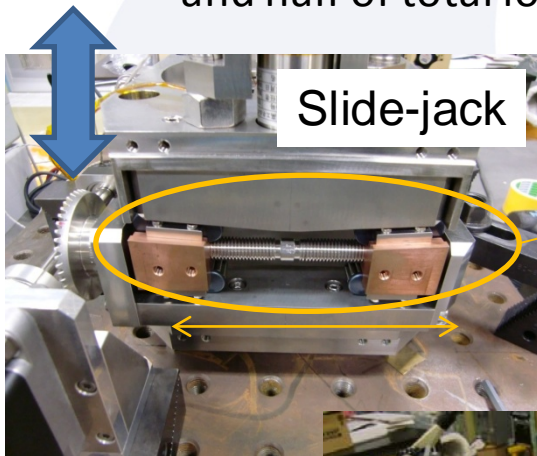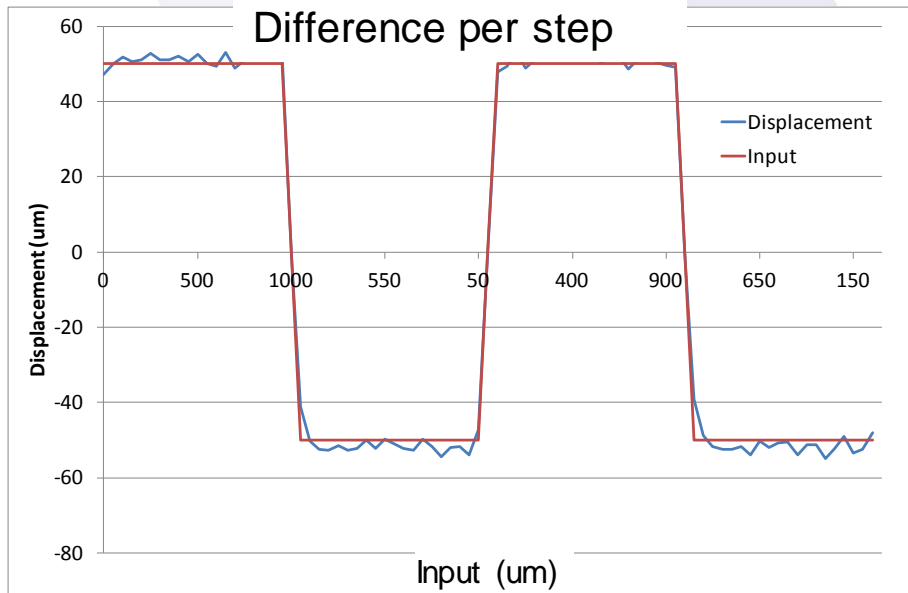(Capacitive Sensor)

Load Cell

Piezo Module

Slide Jack
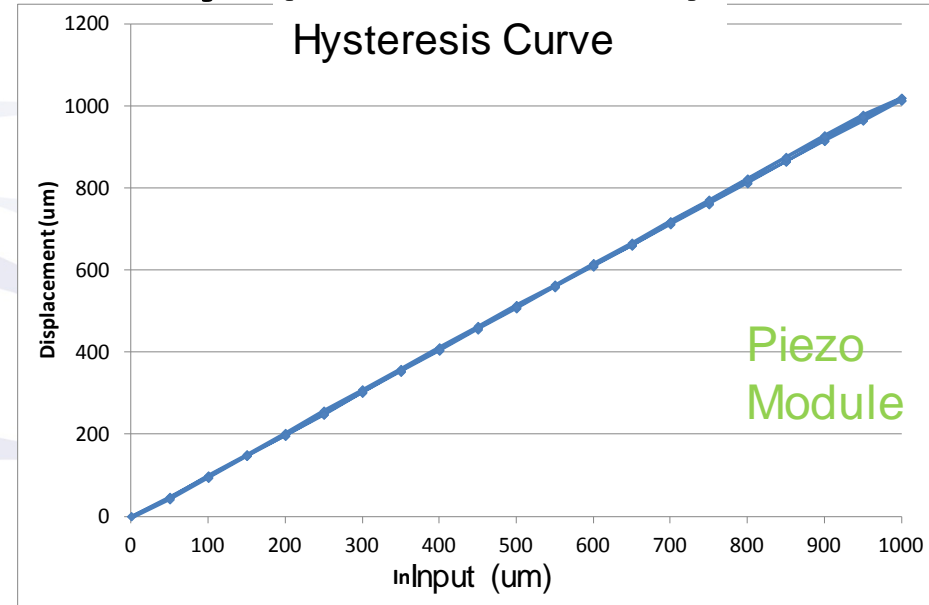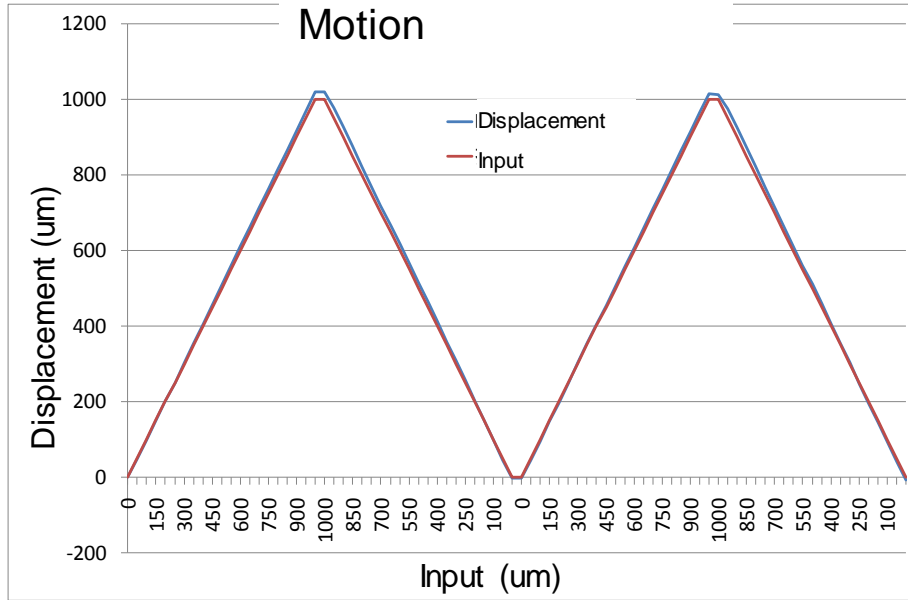
Shaft
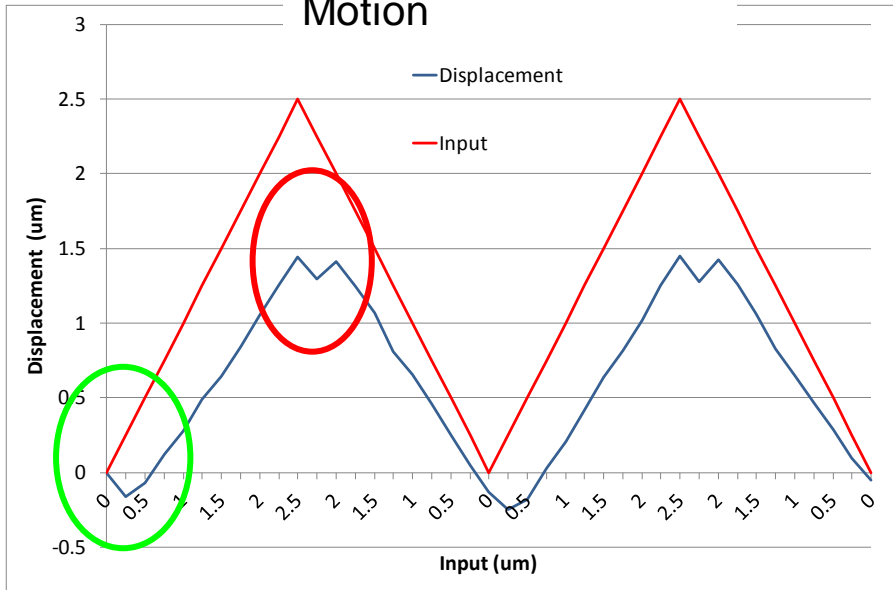
Load by Disk Spring
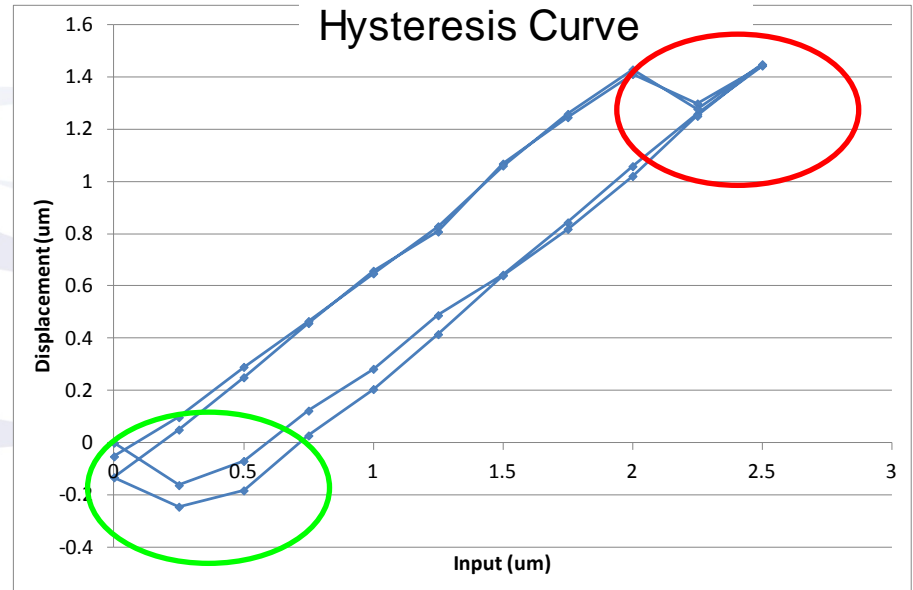(instead of a cavity)

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Macro Motion Study (no Load)

- Tuner run the tuner 2 round-trip at full stroke
- Tuner moves lineally at macro level with no load
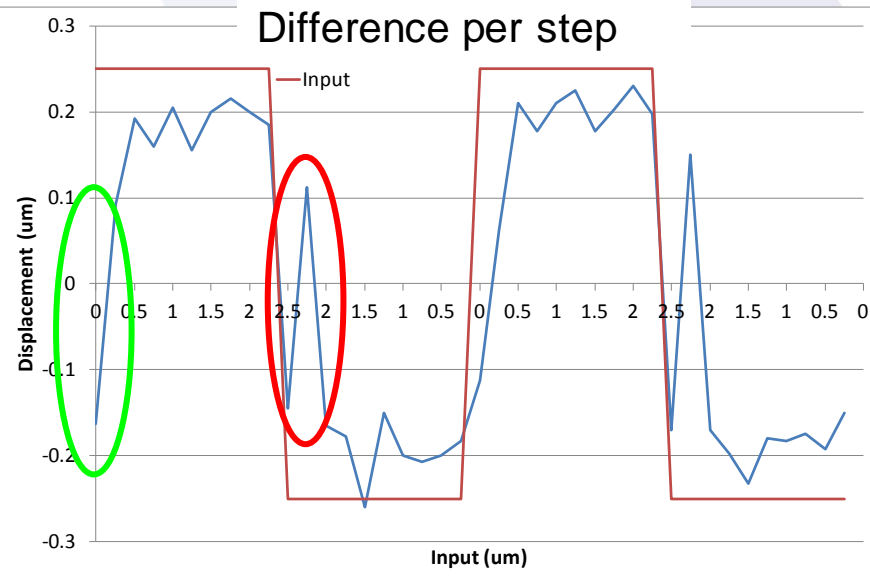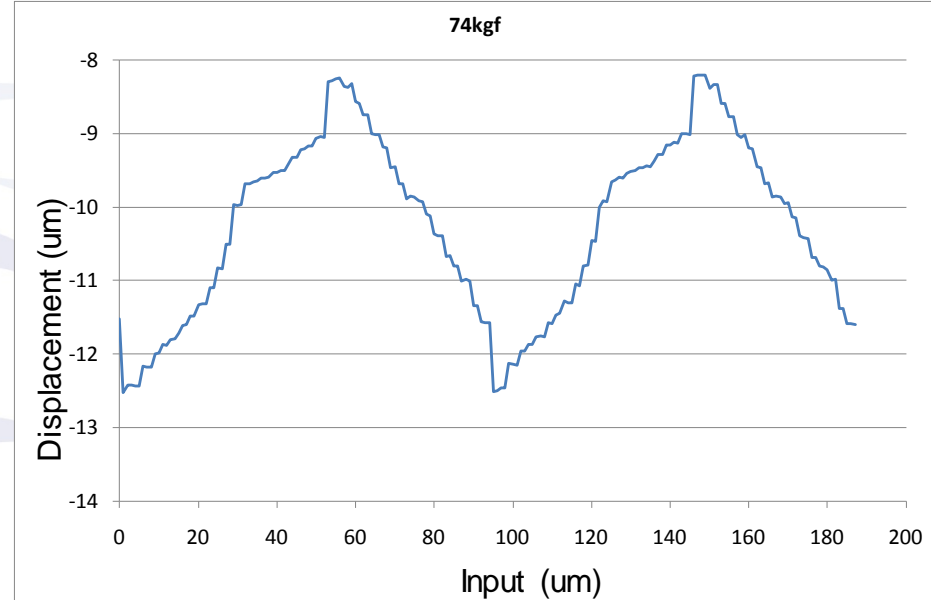
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Micro motion Study (no Load)

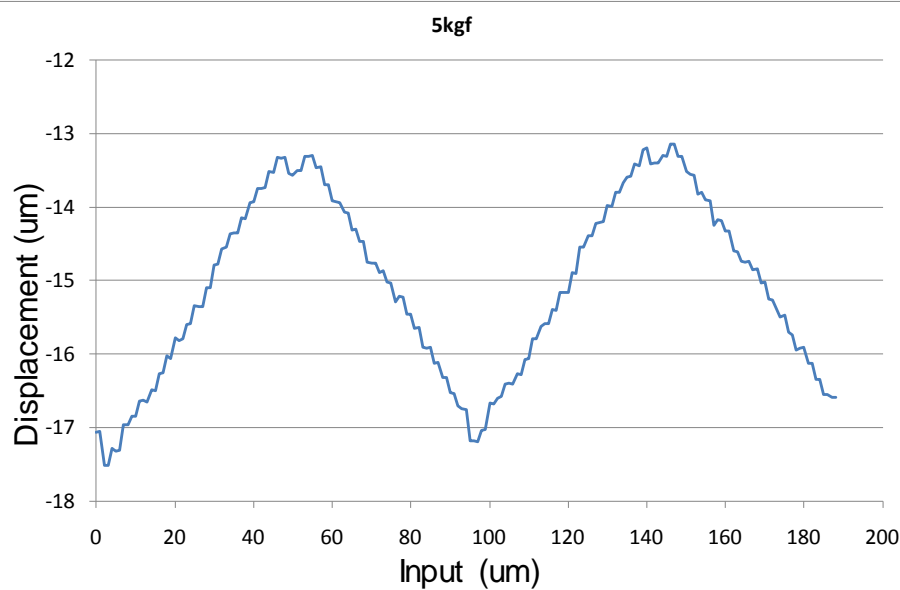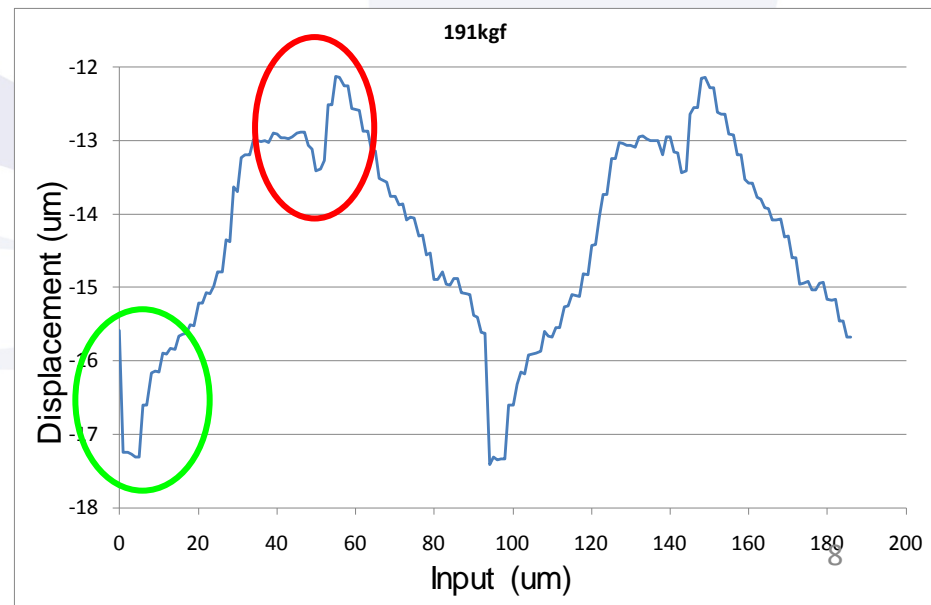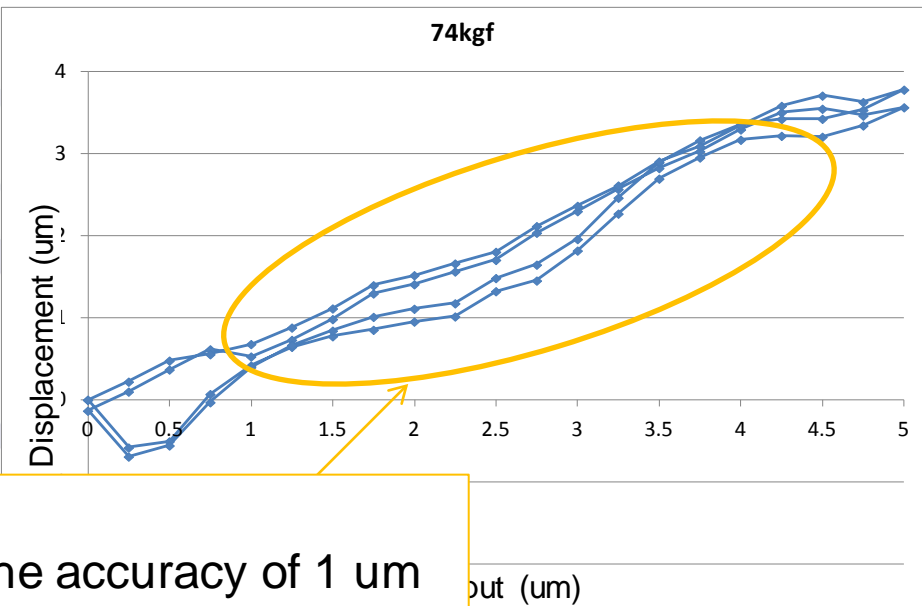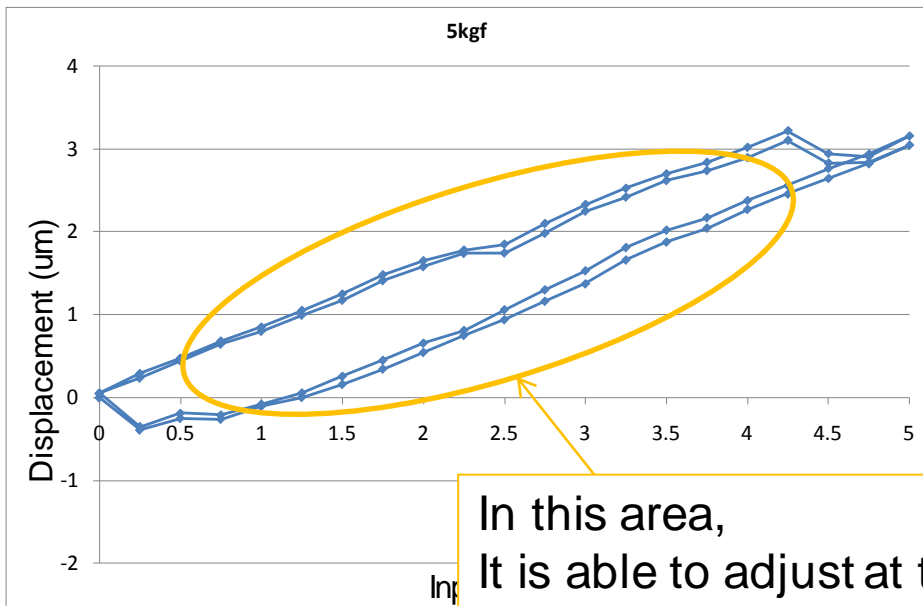- Reverse movement occurs at turning back point.

Influence of Load (Waveform)

- Waveform was distorted under high road.

Influence of Load (Hysteresis Curve)

In this area,
It is able to adjust at the accuracy of 1 um
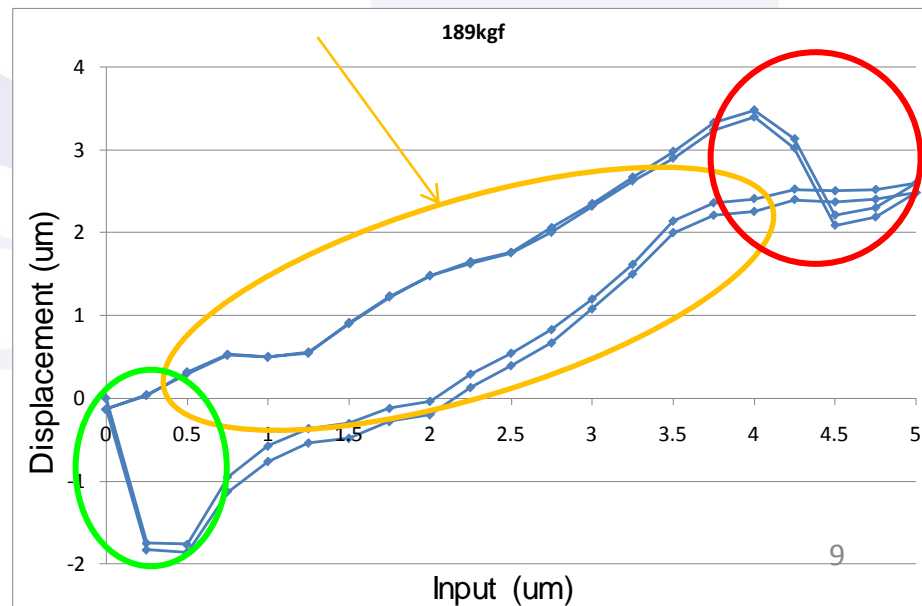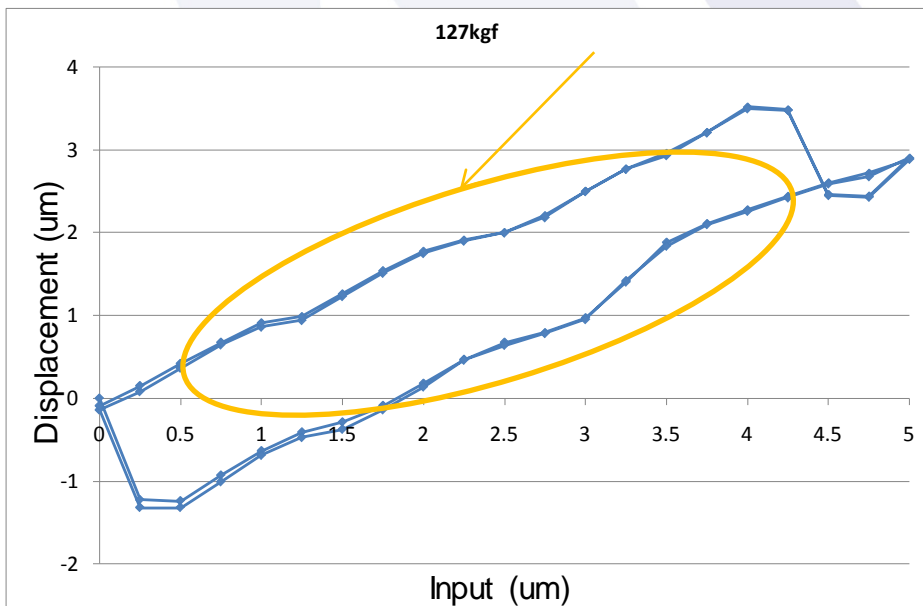
Turning back

- At turning back point, The tuner displaces in opposite direction to input.

- Displacement error depends on load. Displacement error is up to 2um at 200kgf loaded.

- Rotation of shaft does not transmit to slide-jack correctly after turning back.

- To adjust at the accuracy of 1 um, It is necessary to avoid turning back point.

Torque vs Load
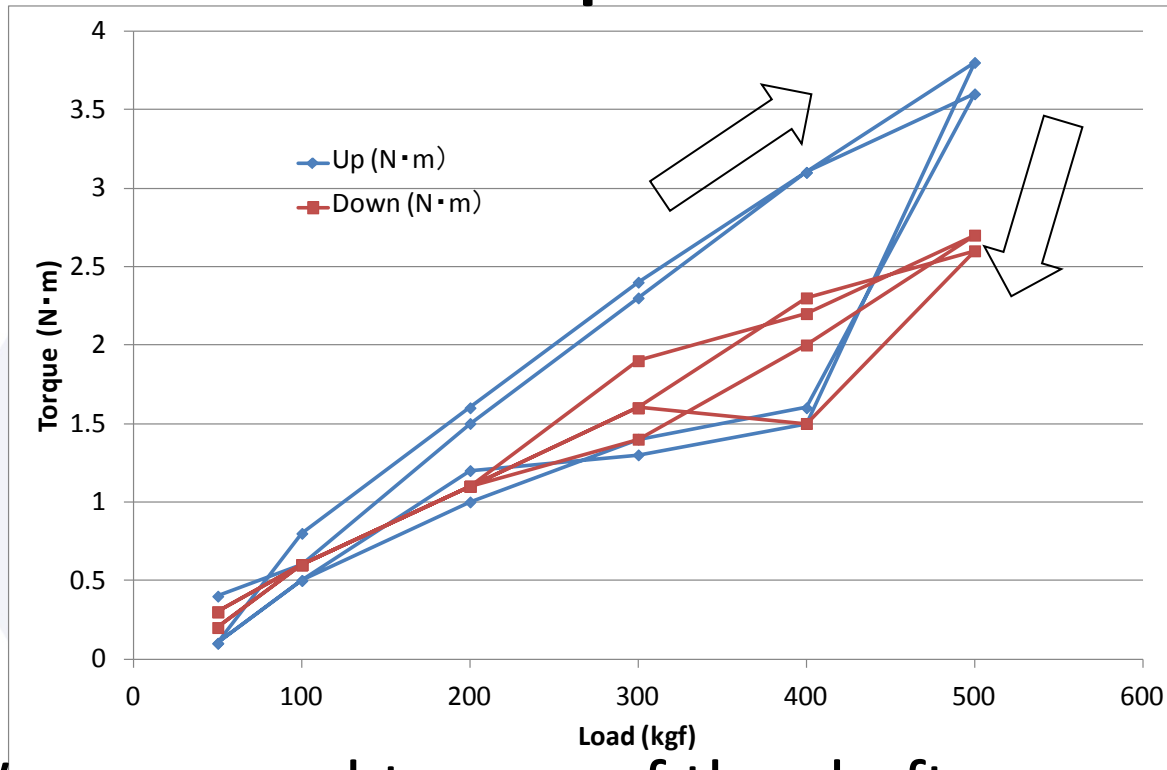
- We measured torque of the shaft.

- "Up" runs against load and "down" along load

- Torque has hysteresis.

- Max torque changes after re-assembling.

Summary of Slide Jack Mechanism

- The tuner moves lineally with ignorable tilt at the macro level.

- Max 2um backlash occurs at micro level at turning back point.

- Displacement error increase in high load

- To adjust at the accuracy of 1 um, It is necessary to avoid turning back point.

- Torque changes by misalignment of assembling.

Study of Piezo actuator

- Basic Experiment

- Influence of Load

- Measured at 2 points

Load Cell

Displacement Gauge
(Capacitive Sensor)

Piezo Module

Slide Jack

Shaft (fixed)
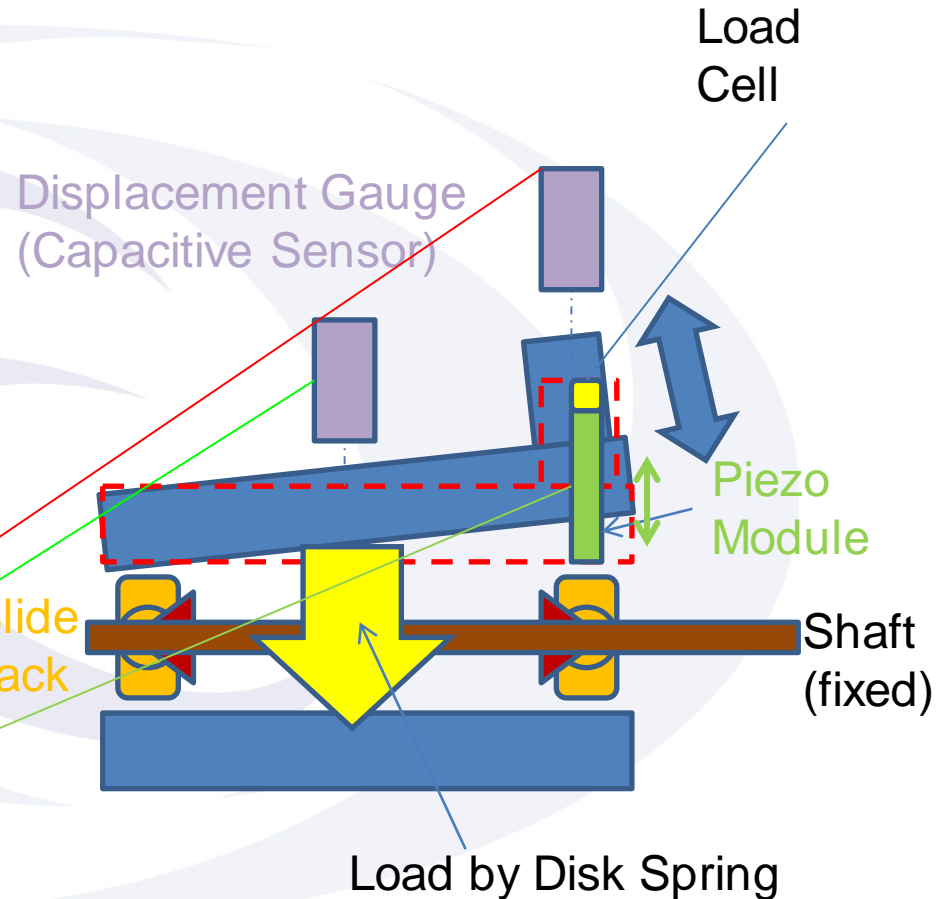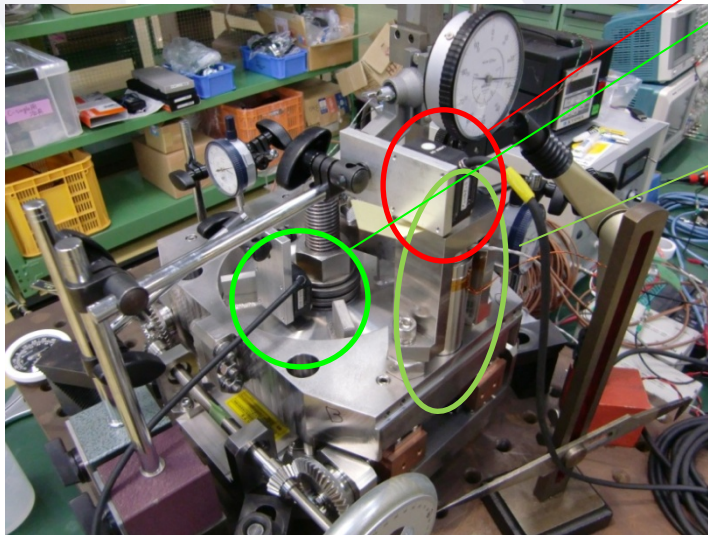
Load by Disk Spring

Motion of Piezo Actuator

0.1Hz, 500±500V

8kgf
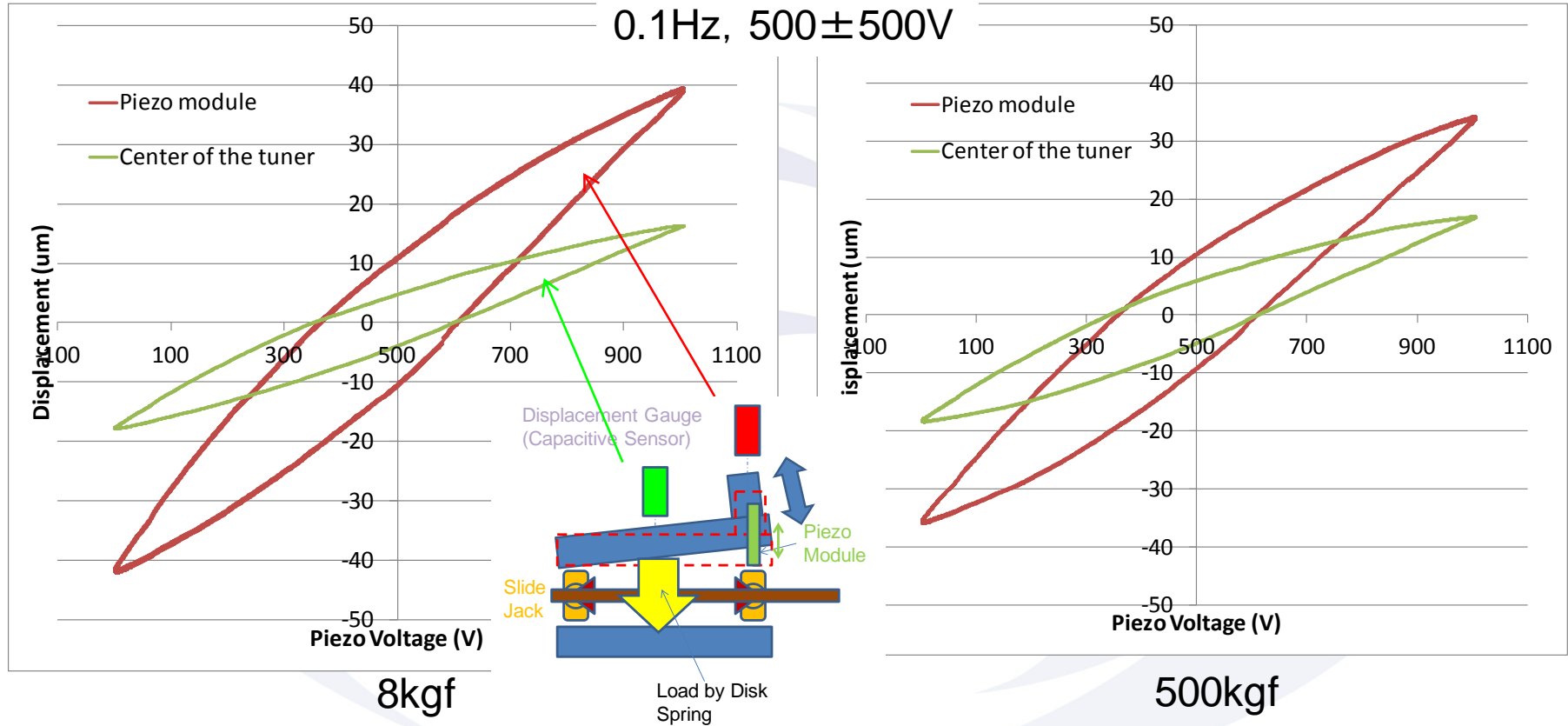
500kgf

- Piezo module moves smoothly.
- It has 80um stroke with no load.

Stroke of Tuner vs Load

0.1Hz，500±500V
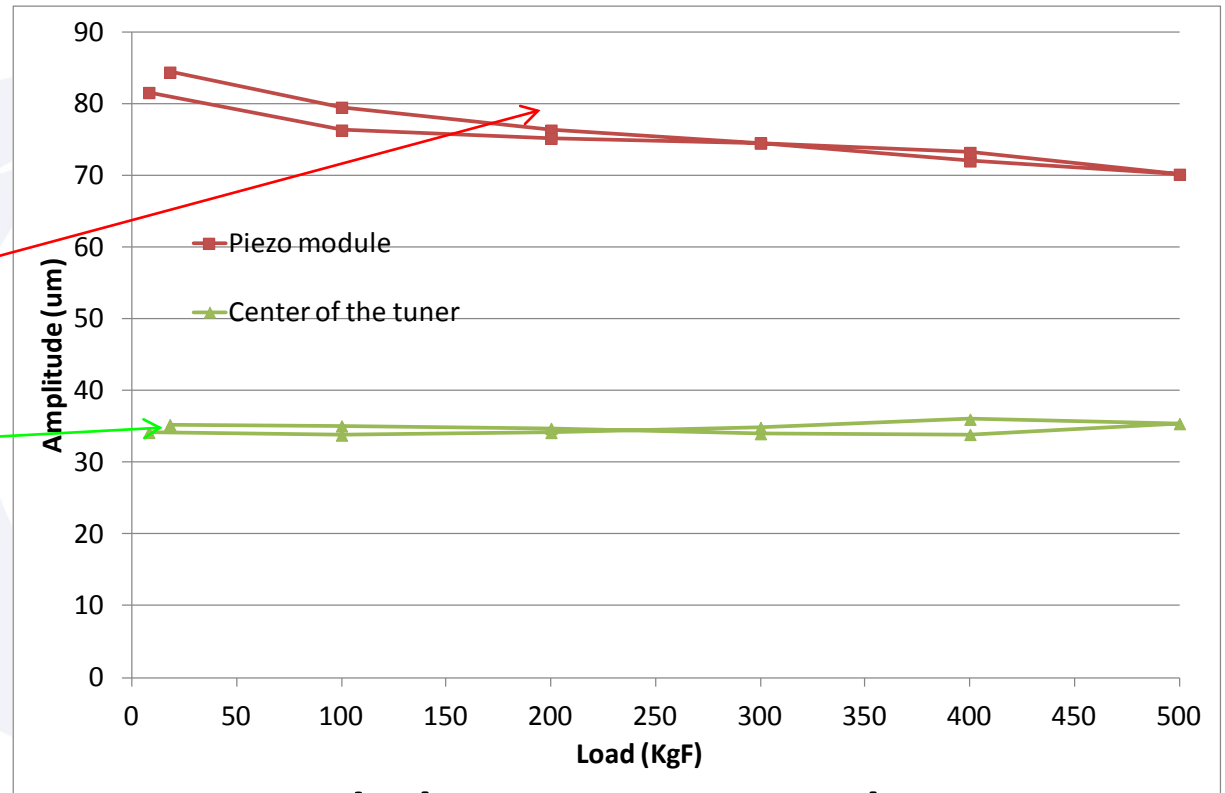
- Stroke of the piezo module to 90% with 500kgf load. But…

- There is no correlation between stroke of the center of the tuner and load

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Summary of Piezo Study

- Stroke of piezo module is 80um. It is enough.
- Tuner stroke by piezo module is 34um
- Stroke of piezo module decreased by 90% at 200 Hz.
- There is no correlation between stroke of center the tuner and load.
- Piezo actuator moves tuner smoothly enough.

Summary

- Slide jack mechanism
  - works well in macro revel.
  - Is not affected by load seriously.
  - causes 2um backlash. It is necessary to avoid this effect.
  - Misalignment in assembling increases shaft torque.

- Piezo actuator
  - has enough stroke and moves smoothly enough.
  - Influence of load and frequency is small enough.

- Tuner System
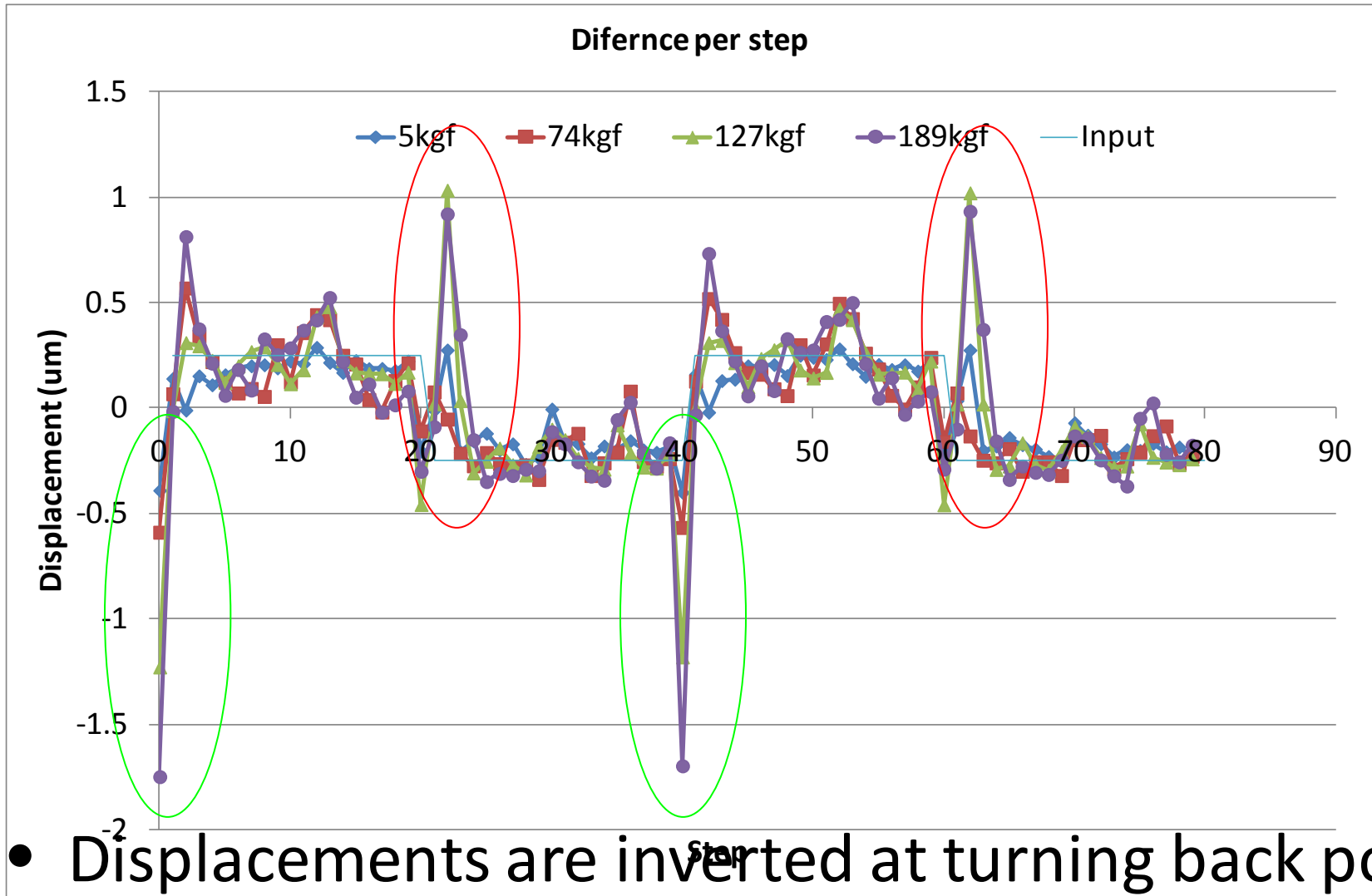 - Is expected to work well to control in considering of backlash

Landscape

- Study about influence of misalignment in assembling
  - Establish the assembling method
  - Improvement of mechanism
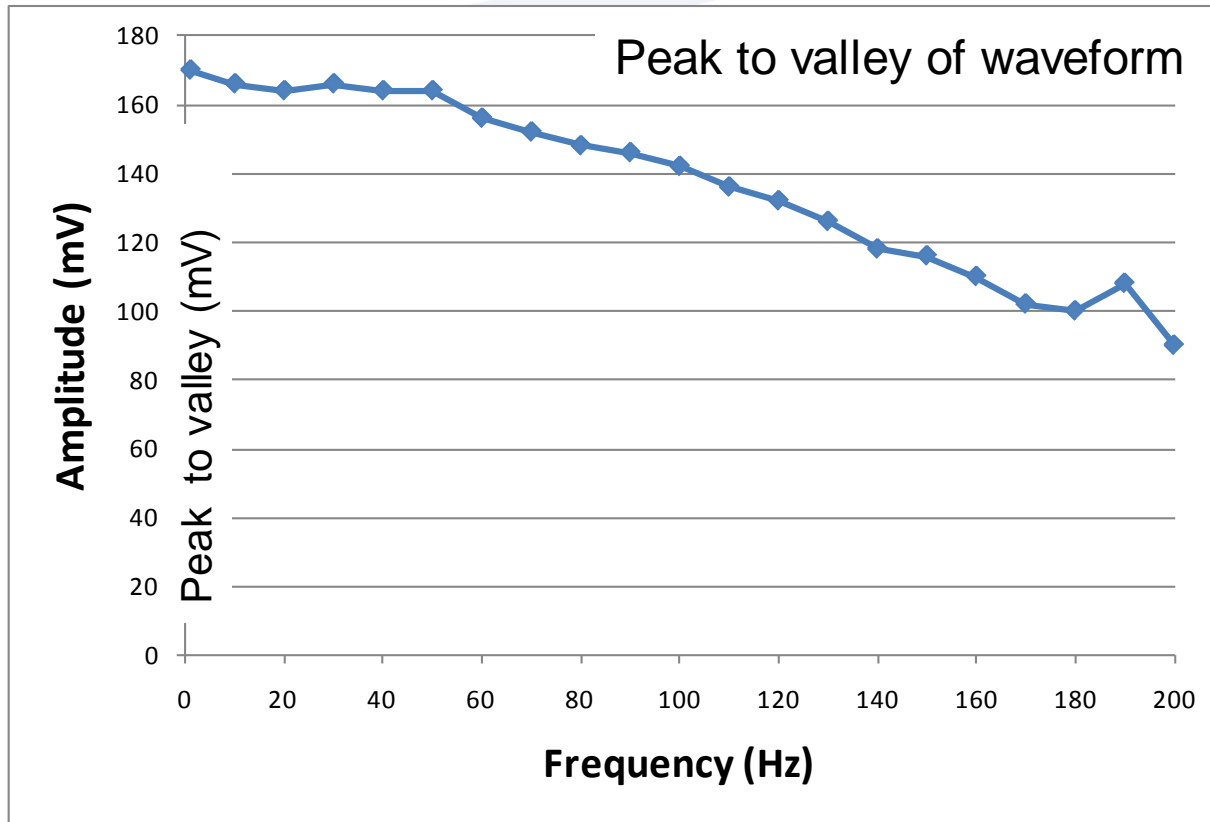- Low temperature experiment.

Additional data

Influence of Load

- Displacements are inverted at turning back point.
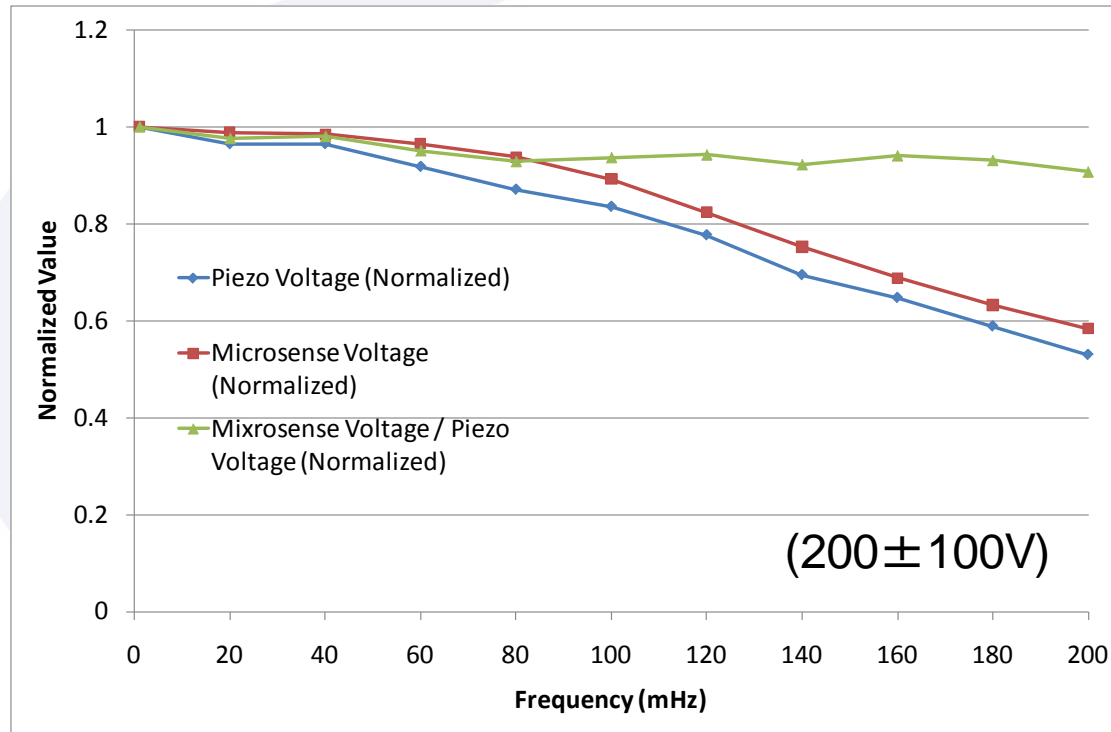- The distance is correlate with load.

Frequency Study (1)
Check of Resonance Frequency

- Resonance frequency does not exist under 200Hz

Frequency Study (2) Amplitude vs Frequecy

- Output(Sensor output/Amplifier output）is normalized by value at 1Hz
- Decrement of vibration amplitude is due to decrement of output of the amplifier
- Normalized amplitude decreased by 90% at 200 Hz

Discharge and countermeasure

- Piezo module discharged when 700V voltage was applied in this experiment.

- Alternative piezo module discharged too.

- Discharge occurred at the base of cable

- Degree of humidity was 70%.

- Discharge did not occurred up to 1000V at 30% humidity