# A POSITION FEEDBACK SYSTEM USING LON FOR THE ACTIVE SUPPORTING TABLE

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## 1. INTRODUCTION

KEK is constructing an Accelerator Test Facility(ATF) for studying the linear collider. ATF consists of 1.54Gev electron linac and a low emittance damping-ring to test and verify many crucial elements of future linear collider[1]. Thirty six active supporting tables are installed in the arc position of the ring. Each table supports magnet-complex. Required accuracy for the vertical position between the tables is less than $20\mu m$, because of the tolerance of the ring $50\mu m$ vertical, $60\mu m$ horizontal and 0.5 *mrad* rotation. Three jacks, which are controllable using pulse-motors, support the table. Each table has three linear sensors(LVDT). These LVDTs maintain the initialized level A Leveling Sensor of Half-Filled with water(LSHF) for every active supporting table is set just in side of the table. In the present paper, we discuss each component of the system as well as feedback system using LONTALK for the active supporting table. LONTALK is a protocol used in the control system of Local Operating Network(LON). We also show the good performance of the closed loop.

## 2. COMPONENTS OF CONTROL SYSTEM

### 2-l. LON

The LON was developed by the Echelon Corporation in the United States of America LON is an intelligent distributed type network system. The VLSI device which is the center of this LON is called a NEURON CHIP. The chip has 8-bit CPU of three pipeline types, 11 programmable I/O pins and a port for the network communication with maximum transmission speed 1.25Mbit/sec. Eleven programmable I/O pins can be used as 29 selectable application I/Os Block diagram of the NEURON CHIP is shown in Fig. 1. As the network protocol, it is using the protocol which is called LONTALK fitted in with the IS0 OSI standard model. The address specification by LONTALK becomes three hierarchies of domain, subnet and node. A maximum of 32,385 nodes may be in a single domain. The application program is using the C language which is called NEURON C. The program of the user is written in ROM with the firmware. The application program can declare a special Network variable. The data can be simply sent through the network with Network variables, This network variable is composed of input and output. When putting data in the output network variable, data is transmitted by the input network variable which is connected with the output network variable. It connects using the network management tool between the output network variable and the input network variable. A network management tool is contained in the Workbench for the developer which is called LONBUILDER.

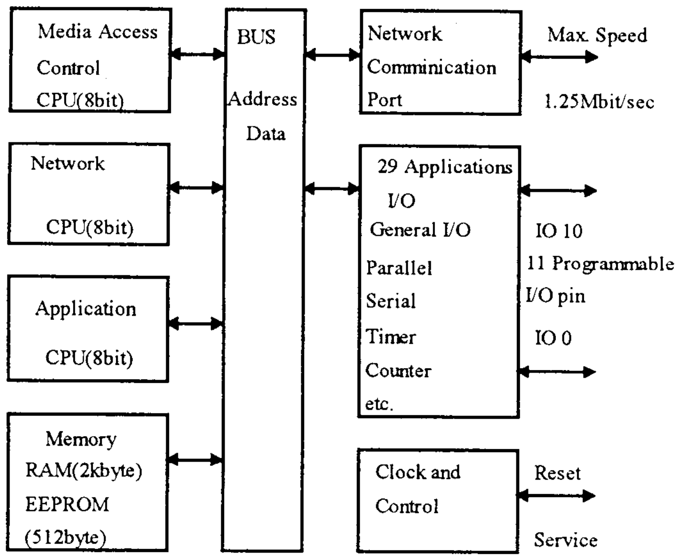


Fig. 1: Block diagram of NEURON CHIP.

**2-2. Modules**

We developed three kinds of module, Analog Input Module(AIM), Pulse Motor Driver(PMD), Main Control Module(MCM). These modules are described as following. Figure 2 shows the block diagram of the measurement and control system. The network interface for the computer is the product of the Echelon Corporation.

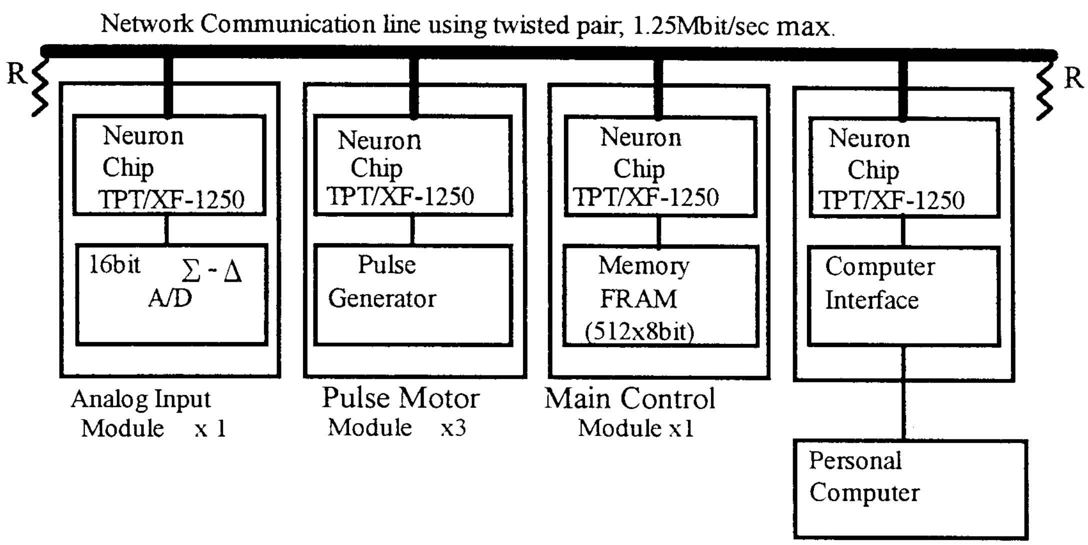


Fig. 2: Block diagram of control and measurement system using LON

**2-2-l. Analog Input Module**

Analog Input Module(AIM) is composed of 16bits Analog/Digital converter chip with sigma-delta type and twisted-pair control module(TPT/XF-1250) by Echelon. AIM has four input channels, and two network ports. We use the single size EUROCARD to set all of the parts in the printed circuit board, as shown in Fig. 3.

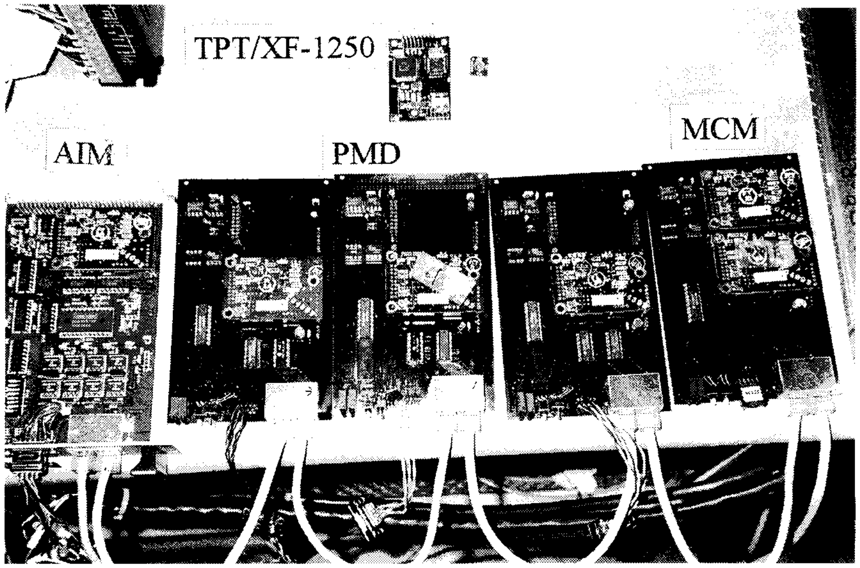


**Fig. 3: Developed modules; AIM, PMD and MCM.**

### 2-2-2. Pulse Motor Driver

Pulse Motor Driver(PMD) control the jacks of the active supporting table. The module has also LED a numeric display to show the number of pulses for the pulse motor and the number of rotations of the pulse motor.

### 2-2-3. Main Control Module

Main Control Module(MCM) is composed of Nonvolatile Ferroelectric RAM(FRAM) to record the data, which is measured by AIM, and a TPT/XF-1250 module.

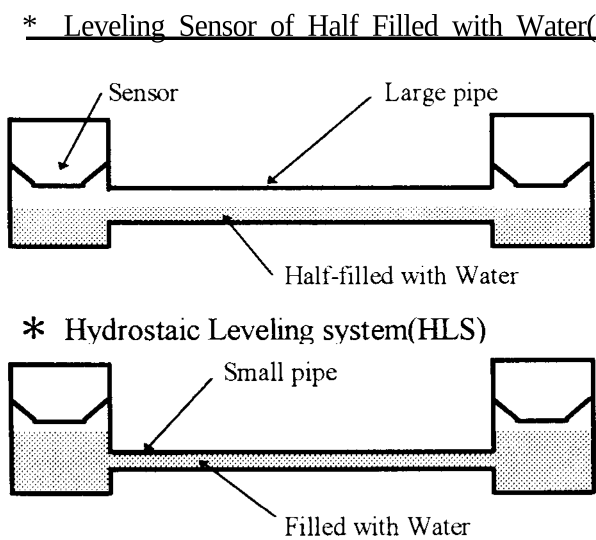


Fig. 4: Comparison between LSHF and HLS.

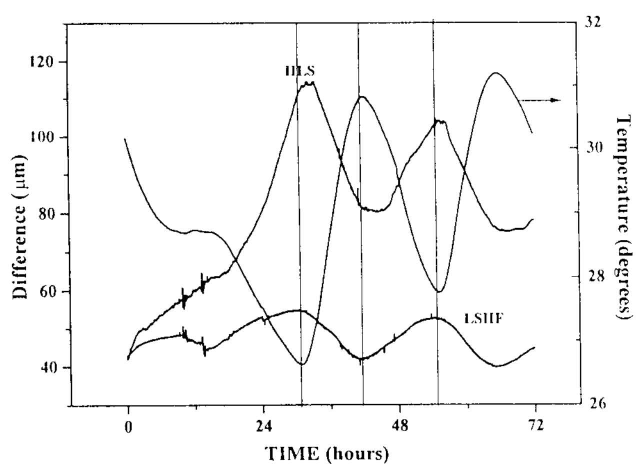


Fig 5: Temperature characteristics of HLS and LSHF

### 2-3. LVDT and LSHF

We use the Linear Variable Differential Transformer(LVDT) to detect the distance between the active supporting table and the reference. The sensitivity of LVDT is $1\mu m / mV$ In order to make a vertual leveling plane, we adopt a Leveling Sensor of Half-Filled with water(LSHF) instead of the existing Hydrostatic Leveling System(HLS) or water tube tiltmeter[2,3]. On the connecting pipes between the vessels to detect the water level, the latter consists of filled with water, while the former half-filled with water. The sensing element of the hydrostatic level was made by Fogale-Nanotech in France. Comparison between LSHF and HLS is shown in Fig. 4 and Fig. 5 shows characteristics of temperature dependence for both sensors [4]. Figure 6 shows the outline of the active supporting table with 4 sensors, that is, 3 LVDTs and one LSHF. Figure 6 includes also a reference LSHF.

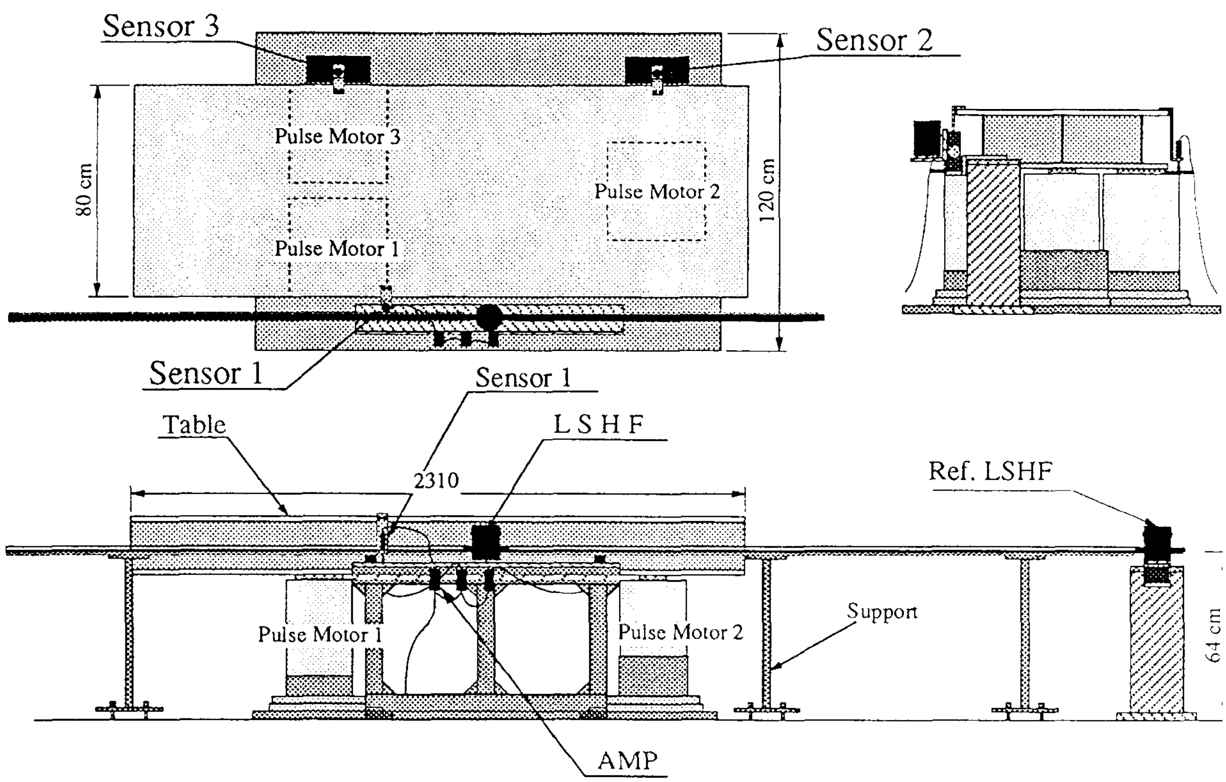


**Fig.6: Active supporting table with three LVDTs and a LSHF.**

## 3. Feedback System and the Characteristics

### 3-l Feedback system for Active supporting table

Figure 7 shows an outline of the feedback system. A computer is used for collecting and storing the data. It is also available to turn on/off the loop of the feedback system. We adjusted the system as following;

1) at first, we drive three jacks independently to level the table using a tiltmeter,
2) three data from LVDTs were stored in order to use as reference data thereafter,
3) data from LSHF was also stored for future:

After these adjustment, we turned on the feedback loop. The feedback system for the table has three kinds of loop as shown in Fig. 8 and Fig. 10. Loop-1 corresponds to control the pitching of the table, loop-2 to control the rolling of the table and loop-3 to control the leveling. Loop-1 and loop-2 keep the preset level of active supporting table. The characteristics of step response of the feedback loop-l and loop-2 is shown Fig. 9. The response time is about 10 minutes. Data collection sampling time was five seconds. This sampling time is possible to change from one to ten seconds by computer.

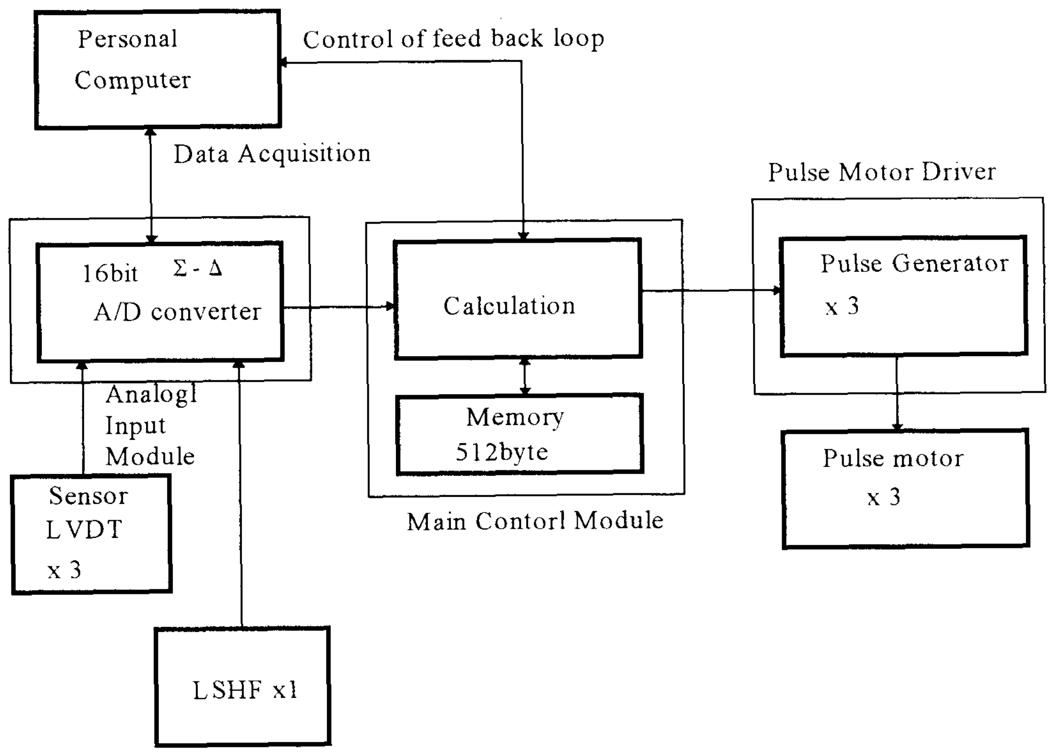


**Fig. 7: Outline of the feedback system**

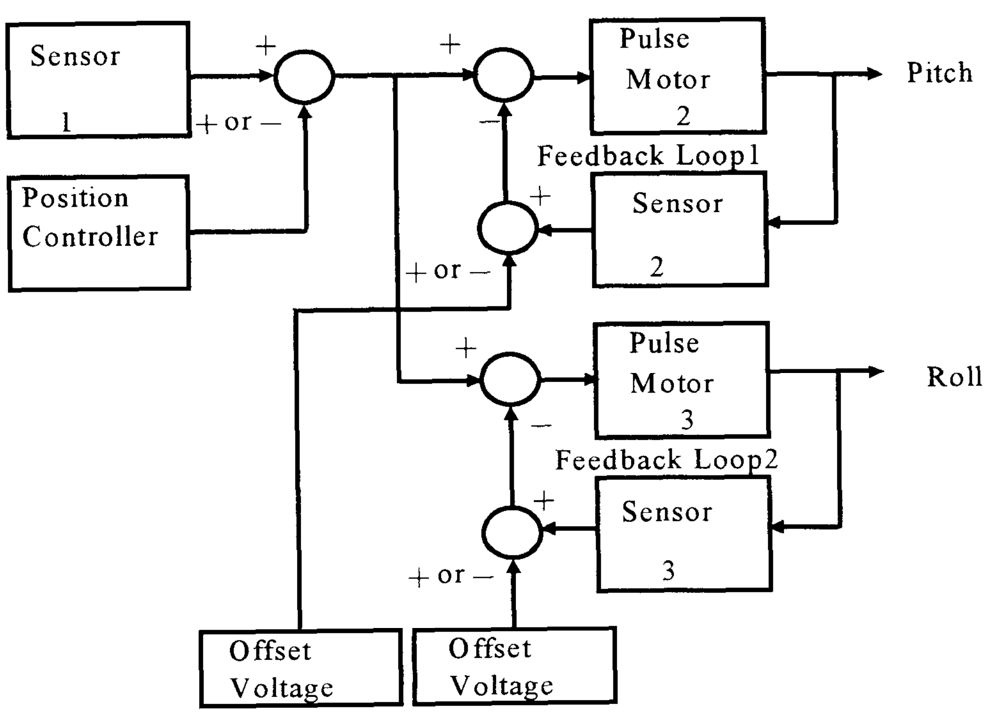


**Fig. 8: Feedback loops for pitching and rolling of the table.**

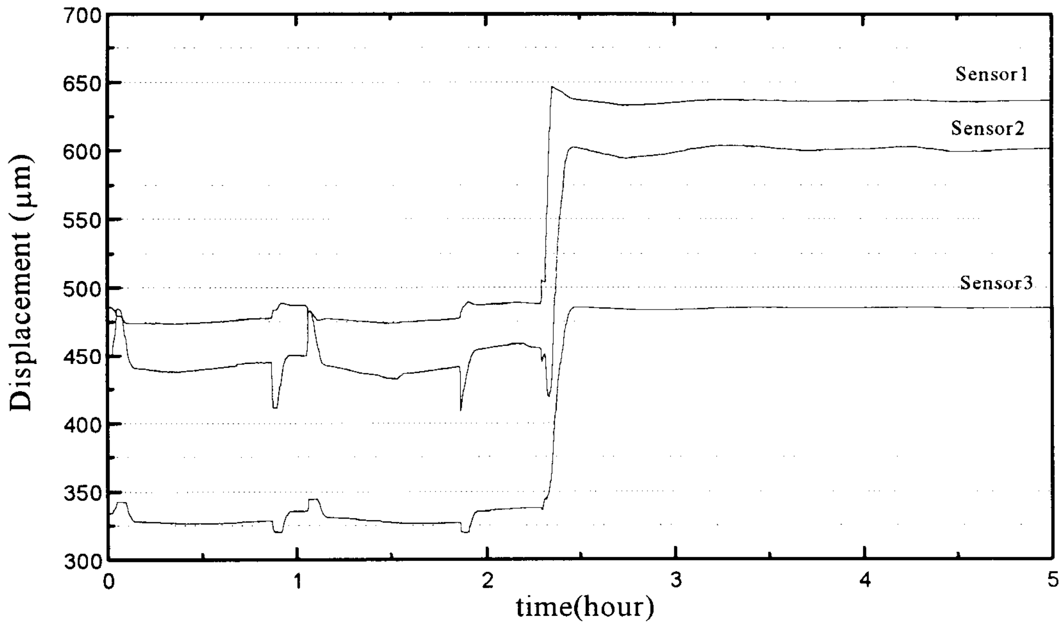


**Fig. 9: Characteristics of step pesponce for the feedback loop-l and loop-2.**

The ground motion is compensated by the feedback loop-3 through LSHF A block diagram of feedback system of LSHF is shown in Fig. 10. Loop-3 controls the vertical position of the table following the surface of the water of LSHF.

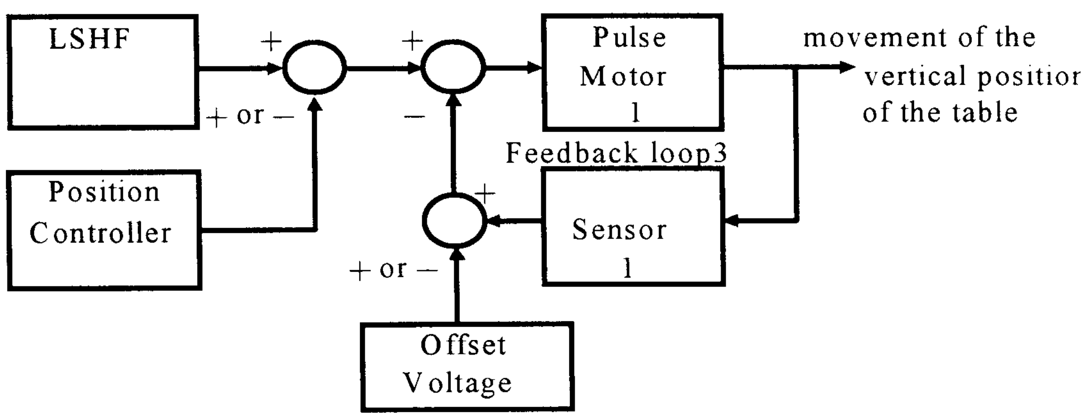


**Fig. 10: Feedback loop-3 using LSHF.**

Fig. 11 shows the transient response for the feedback loop-3 on/off and step change of water level. In the former half part of the figure, it shows the control by loop-l and loop-2, only. The latter half, it shows all of the loops being on. When a transient change is given by the reference LSHF, the table follows the transient movement with the three LVDTs as shown in Fig. 11.

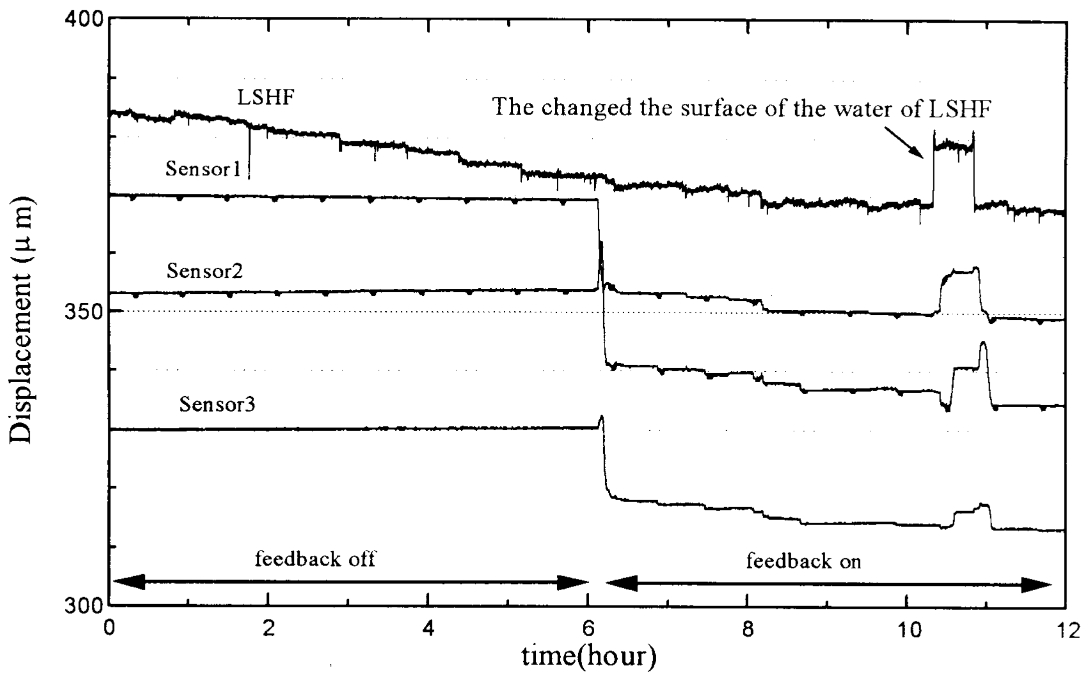


**Fig. 11 Transient response for the feedback ON/OFF and step change of water**

## 4. CONCLUSION

We applied so called LON to the feedback system of the active supporting table Our development of the feedback system was very easy by using LON. The feedback system works very well if it keeps the vertical redundancy of the active supporting table at the range of $\pm 3\mu m$. As a result of the feedback, the active supporting table could be held within a required vertical tolerance $20\mu m$.

## 5. REFERENCES

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