

The tuning system for XFEL SRF cavities is a device based on a double lever driven by a stepping motor with a gear box and a screw-nut system. The cavity is stretched by the tuner thus changing its resonant frequency. The tuner is also provided with fast tuning capability by means of two piezo-ceramic actuators (piezos), which compensate for cavity deformations that are responsible of frequency detuning. During industrial phase is mandatory to ensure a correct tuner assembling both for mechanical parts and actuators. This is provided by an automated device able to check the correctness of piezo-tuner installation on the cold mass string first and after installation in the cryostat, with very simple mounting requirements for the Module Assembling Team.

## System description



- Moves the stepper motor, reads steps made, through LVDT sensors acquires the tuner and
- Reads piezo voltages after charging induced by tuner displacement, determines if polarities are correct.
- Drives piezo with a sinusoidal signal, acquires tuner resulting displacements.
- All is done automatically via computer control. The operators are required just to connect the cables and screw a mechanical frame holding the sensors in contact with the cavity.

DEVICE	Description	Main features and/or req.	#
LVDT	Solartron Model AC15	30 mm range; sensitivity 1 $\mu$ m	3
LVDT control	Solartron CAH Eurocard board	2 channels I/O,	2
I/O Device	Keithley KUSB 3102A (DMM)	16 An Ins, 8 Dig Out + 8 In, 2 An Out	1
motor driver	Phytron MCC 1 USB Stepper Motor Contr.	USB remote control	1
piezo driver	DESY LLRF or Piezomechanik LE-200-070	150 V - 200 V @ 200 mA rms output	1
Computer	e.g.: laptop		1
Software	e.g.: Labview		1
	other hardware	Mechanics, cabling, electronics	

The main steps could be summarized into three easy operations:

- Install, on the cavity end side close to the tuner, a simple frame containing the displacement sensors required.
- Connect piezo, sensors and motor cables to the rack.
- Start the test routine and wait for the results.

## **A Fully Automated Device For Checking XFEL Piezo-Tuner Installation**

cavity longitudinal displacements.



### **Test at DESY**



**Piezo-tuner installed on C26 cavity at DESY** 



Installing a LVDT sensor with its frame





#### **Basically the test procedure is divided into 3 main sequences:**

- Check both piezo capacitance values using a handy capacitance meter. This first operation is very simple and is the direct proof that the piezos has not been damaged or cracked (piezoceramic is very fragile and great care must be taken to avoid that the device accidentally falls down).
- Move the stepper motor while monitoring the displacement sensors and keeping the piezo in open-loop condition. The sign of piezo discharge, after connecting them to the read-out electronics, will show if the piezo cabling polarity is right or wrong. In addition this will be a check of good motor functionality.
- Feed one of the two piezo (alternatively) with a test sinusoidal signal and monitor the response of both the other piezo and the sensors installed. This will be a direct measurement of the piezo efficiency, to be compared with the expected one.

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The Piezos inside their support frame.

Sensor frame fixed to the two reference M8 holes on the cavity helium tank

# **Test results**

Screw turns / motor steps	Piezo discharge (Vpeak)	LVDT sensor
	V	mV
0.5 / 17600	0.5	40 (full range)
1 / 35200	0.9	200 (3 mm range)

The motor was moved initially by half turn and after by a complete turn. Then the two piezos are connected closing the relays to the DMM inputs and their discharges are acquired.

Screw turns /motor steps	Piezo V (V peak)	Vpeak on sensor piezo	LVDT cavity drift	
	V	V	mV	
0/0	20	0.6	2	
0/0	60	1.6	3	
0.5 / 17600	60	2	3	
1 / 35200	60	2	5	
1 / 35200	100	4	15	* with frame installed fixed to
1 / 35200	80	1.5	25†	He tank and hosting the sensor † short range calibration
2 / 70400	80	1.5	30†	
0/0	80	2	25†*	
1 / 35200	80	2	30†*	

**Efficiency Test** 

One piezo is fed with sinusoidal signal. The sensor piezo and the LVDT voltages are acquired.



A prototype device of the Piezo-Tuner test system has been tested at DESY on a typical cavity assembly with good results. The piezos and cavity drift signal are well readable and the values measured are repetitive. Moreover when ad hoc created malfunction occurred, this was detected by the system. Now the definitive device is in construction phase and in short time will be delivered to the XFEL assembling team.

Load conditions (both piezos)	Piezo Voltage	LVDT
	V	mV
Unloaded	No response	No response
Just fixed by hand	1.5	5 - 10
screwed by tool (10 % full load)	1.5	30

**Piezo preload is changed** 

The actuator piezo is fed with 80 V sinus wave. The sensor piezo and the LVDT voltages are acquired. With piezo unloaded (malfunction), just noise is detected.





