DEVELOPMENT OF QUALITY ASSURANCE PROCEDURES FOR THE FAST/SLOW TUNERS ON THE 1.3GHZ SRF CAVITIES FOR THE SRF ACCELERATOR TEST FACILITY AT FERMILAB

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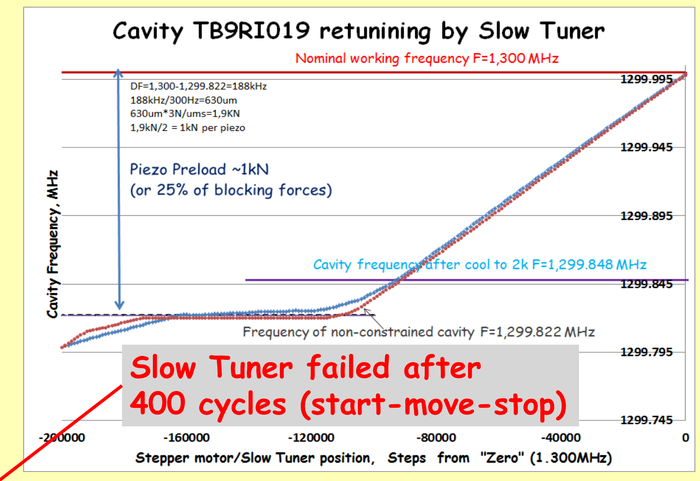
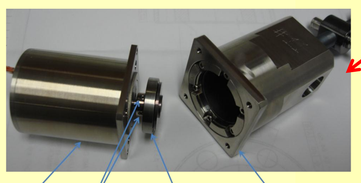
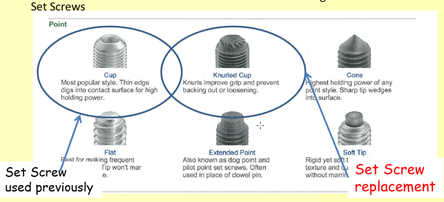
Abstract

The 1.3 GHz elliptical SRF cavities being prepared for cryomodules of the Fermilab SRF Accelerator Test Facility are equipped with coaxial blade tuners. Quality Assurance tests of these tuners during initial installation, cold testing in the Horizontal Test Stand and during string assembly are described.

Automated Slow Tuner -Stepper Motor QA tool



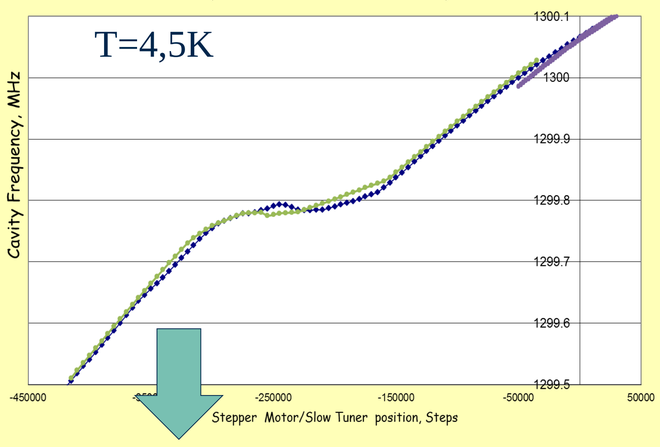




Set Screw used previously

Set Screw replacement

The proposed fix is to replace all the cup point set screws with knurled point set screws for a better grip on the motor shaft preventing backing out or loosening. Loctite™ will also be applied to the threads as a back-up measure against loosening set-screws. The current configuration of the shaft has no flats or thru holes machined. This should be a feature we ask for in future motor purchases.



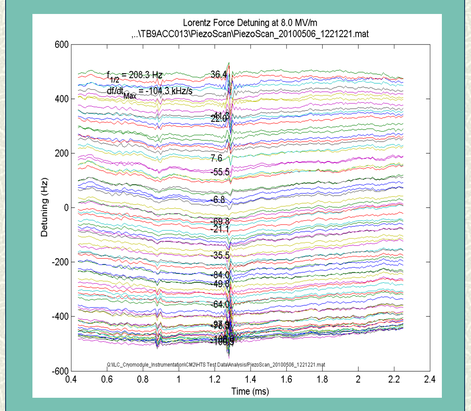
No Slow Tuner Failure or Performance Degradation after:
- **Total number of cycles; ~600 (one cycle start/rotate/stop);**
- **Total amount of steps by motor ~ $2*10^6$ Steps;**
- **Total cavity frequency change: ~2,7MHz;**
- **Continuous operation of the Slow tuner/stepper motor during ~ 7hours**
- **Stepper motor temperature changed from 44K up to 160K.**

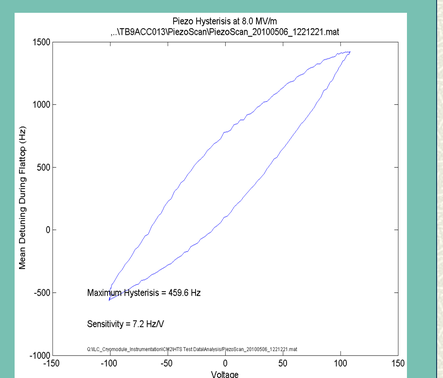
Table: Steps of the overall HTS test procedures related to the tuner performance evaluation

1.	The room temperature cavity resonant frequency is measured prior to cool-down using a network analyser. Cavity response, when voltage on the piezo increased from 0V up to 200V, is measured (Peizo1+piezo2; piezo1 only). Slow tuner/stepper motor exercised in small tuning range.
2.	The cavity is cooled to its operating temperature of 2K. Resonant frequency of the cavity is again measured using a network analyser at 4,5K and at 2K.
3.	The cavity is tuned to the nominal operating frequency of 1.3GHz using the stepper motor.
4.	Cavity response, when voltage on the piezo increased from 0V up to 200V, is measured (Peizo1+piezo2; piezo1 only). "Cold piezo hysteresis curve".
5.	The cavity is connected to the pulsed RF system and the maximum operating gradient is established following coupler conditioning.
6.	The cavity gradient is set to 5 MV/m and the piezo actuators are exercised to ensure the cavity can be set to any frequency within the required fast tuning band.
7	The gradient is increased in 5 MV/m steps up to the maximum gradient and the piezo actuators are exercised at each step.
8.	The gradient of the cavity is set several MV/m below the maximum gradient and the piezo actuators are driven with short pulse 10 ms prior to the arrival of the RF pulse. The piezo-RF delay for the next pulse is shortened to 9.5 ms and this process is repeated until the piezo pulse arrives 10 ms following the RF pulse.
9.	The results of the previous delay scan are used to calculate the piezo waveform needed to compensate for Lorentz force detuning and the fast tuning compensation system is turned on.
10.	The cavity gradient is increased while the piezo compensation system remains active and the level of residual Lorentz force detuning during the RF flattop at maximum gradient is recorded
3.	The tuner stepper motor is exercised extensively (several hundred cycles – start/move/stop; and in the range ~500kHz). Slow tuner change frequency of the cavity up to "shoulder area- or cavity non-constrain region". This value will allow to calculate piezo preload for each cavity.

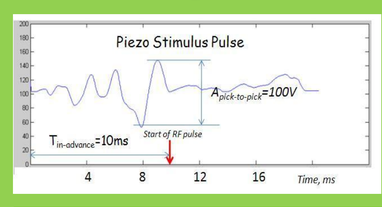
Cavity ID #	Frequency before tuner installation(MHz) 1bar, 300K	Frequency after cool-down (MHz) He -20torr, 2K	Slow Tuner slope (kHz/turn)	Piezo-to-Cavity Sensitivity, Hz/V	Dynamic LFD Hz/s/(MV/m)^2
ACC013	1297.385	1299.900	1.51	7.2	-970
AES009	1297.388	1299.813	1.77	**2.7**	-1240
ACC008	1297.321	1299.750	-	6.5	-860
AES010	1297.200	1299.793	1.59	8.5	-950
AES008	1297.175	1299.735	1.51	7.3	-1600
AES016	1297.415	1299.899	1.60	10.5	-880
RI029	1297.106	1299.757	-	14	-650
AES007	1297.338	1299.791	1.49	10.4	-740
RI018	1297.417	1299.882	1.59	13(15)	-740
RI019		1299.848	**1.63**	10(13)	-760
RI024		1299.530	1.50	10(14)	-960
RI027		1299.749	2.02	9(10)	-950
Average	**1297.336**	**1299.813**	**1.62**	**9.7**	**-960**
σ	***0.116***	***0.065***	***0.16***	***2.8***	***295***

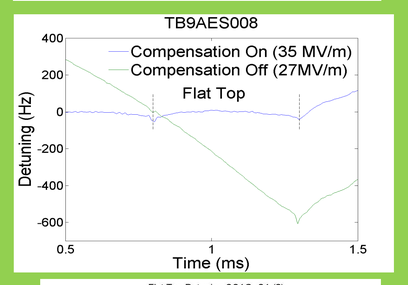
Fast Tuner parameters study with Piezo DC Voltage scan at E_{acc}=5,10,15,20,25…MV/m

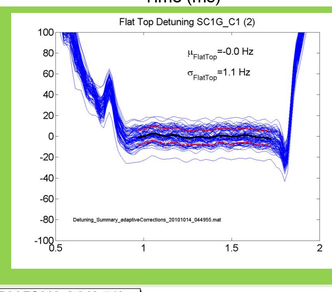




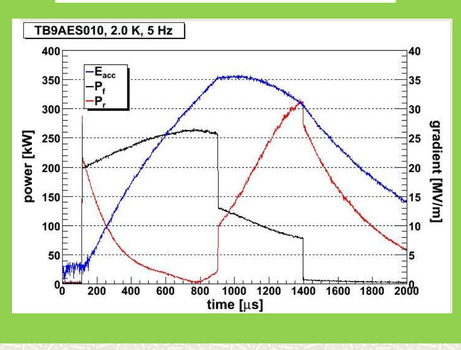
LORENTZ FORCE DETUNING COMPENSATION

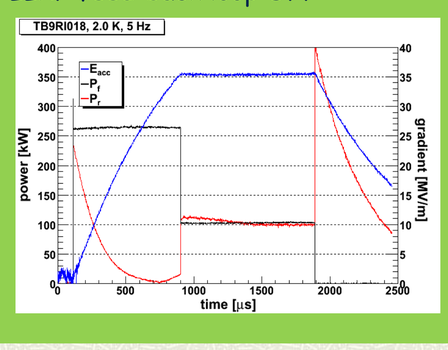






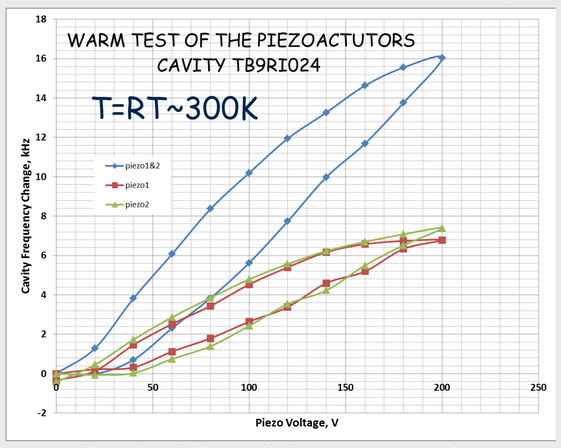
At maximum operating gradient (~35MV/M) LLRF feed-back loop OFF



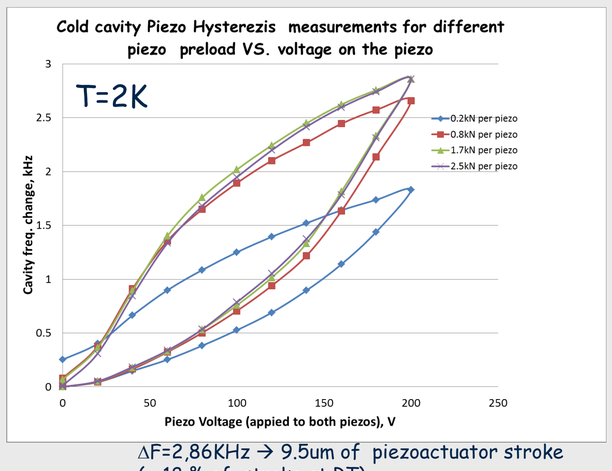


Automated Fast Tuner –Piezoactuator QA tool:

measurements cavity static detuning VS voltage on piezo



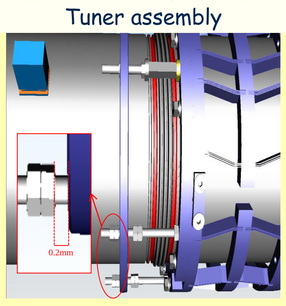
ΔF=16KHz → 53um of piezoactuator stroke
(in the range of manufacture specification)

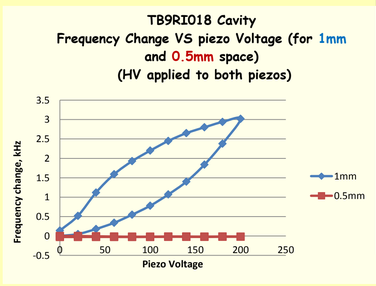


ΔF=2,86KHz → 9.5um of piezoactuator stroke
(~ 18 % of stroke at RT)

Modification of Blade Tuner Assembly Procedure for CM2, based on SRF cavity testing at HTS

INFN Manual for Blade Tuner assembly





For CM2 SRF cavities tuners will be assemble with 1mm clearance. This modification will lead to modification the range of over-pressure test of CM2 at room temperature

CONCLUSION

Cavities for the CM2 cryomodule are subject to a battery of tests to verify that both the slow and fast tuners meet performance specifications.
Implemented set of QA tests allowed to find and fix deficiencies of tuner assembly procedure in the process of cavities testing for CM2.