Preliminary long pulse operation study of superconducting cavities cryomodule at CMTB

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Abstract

Newly installed XM50.1 European XFEL type cryomodule of 8 superconducting cavities have been operated in Cryomodule Test Bench (CMTB) in DESY. After modification of cavities FPCs this module have been used for CW and Long Pulse (LP) operation studies in high Ql and various gradient conditions. This contribution summarizes first attempts of Long Pulse operation (duty factor in the range of 20% to 50%) of this multi-cavity setup. Achieved regulation performance is discussed together with experience from precise cavities resonance control studies.
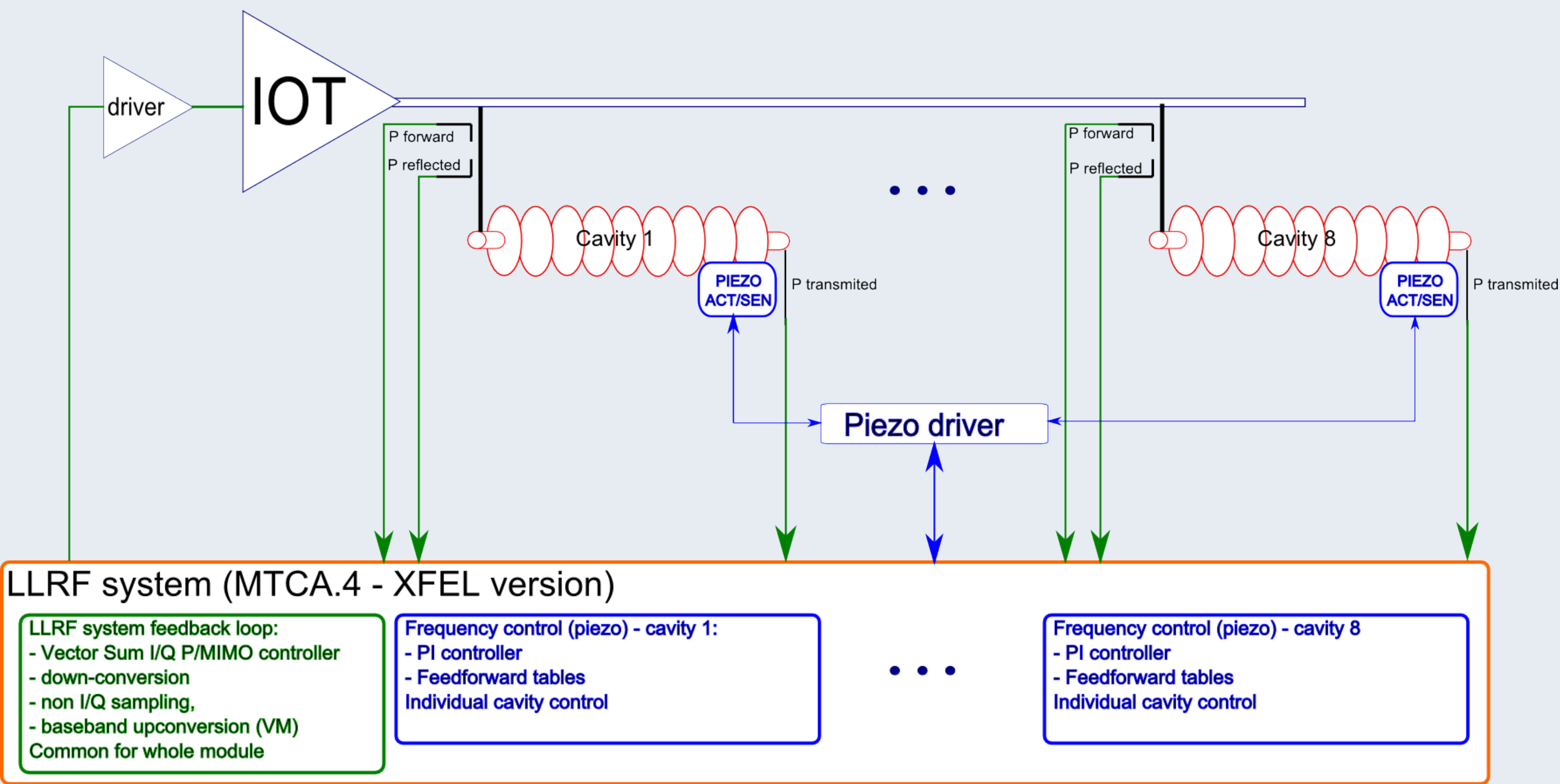
LLRF system @CMTB for LP operation

Figure: LLRF system overview

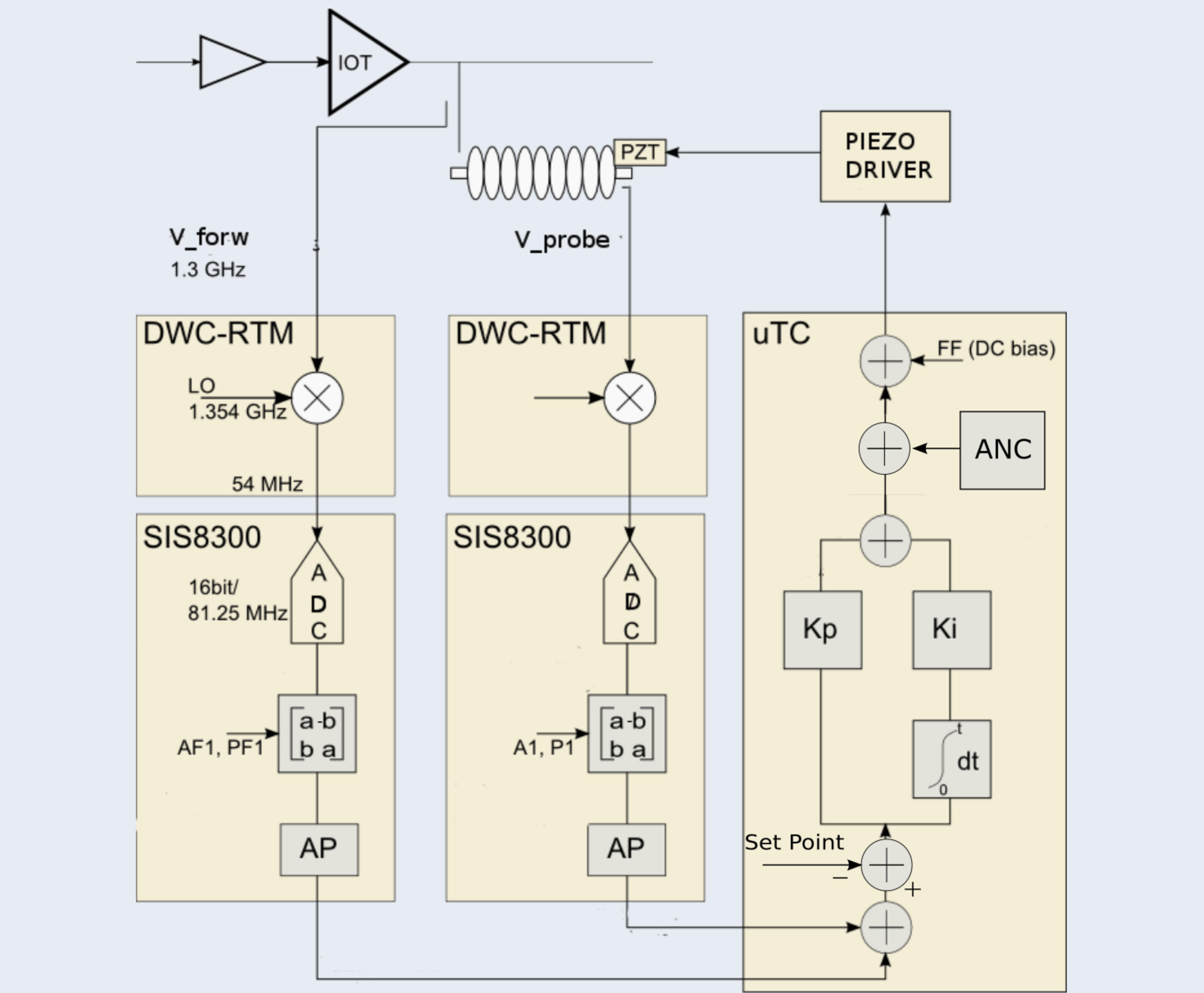## Detuning controller for LFD and Microphonics compensation

Figure: Detuning controller

Module Operation Conditions - Cavities

Cavities gradients (from C#1 to C#8) (avg. value 15.6 MV/m):

Gradient [MV/m]	0.09	16.21	14.37	16.81	14.86	15.10	14.77	16.81

Cavities loaded quality factors (from C#1 to C#8) (avg. value 3e7):

Ql	3M	28.6M	29.49M	29.34M	30.08M	32.0M	29.55M	31.77M

Cavity 1 has been detuned due to measured high radiation level.

Module Operation Conditions - Controllers

Long pulse operation with 1s repetition rate. RF filling - 10 %, flat-top - 30%.

RF field control:
- open loop operation,
- close loop operation with proportional controller, with gain scheduling (during filling)

Frequency control:
- integral feedback, set-point slightly shifted from the static drop point,
- ANC filters used for each cavity. Compensation of 29Hz and 50 Hz. Dedicated ANC gains.

Optimization of Piezo Feed-forward Tables

Piezo driver customized feed-forward tables used for filling region cavity tuning.
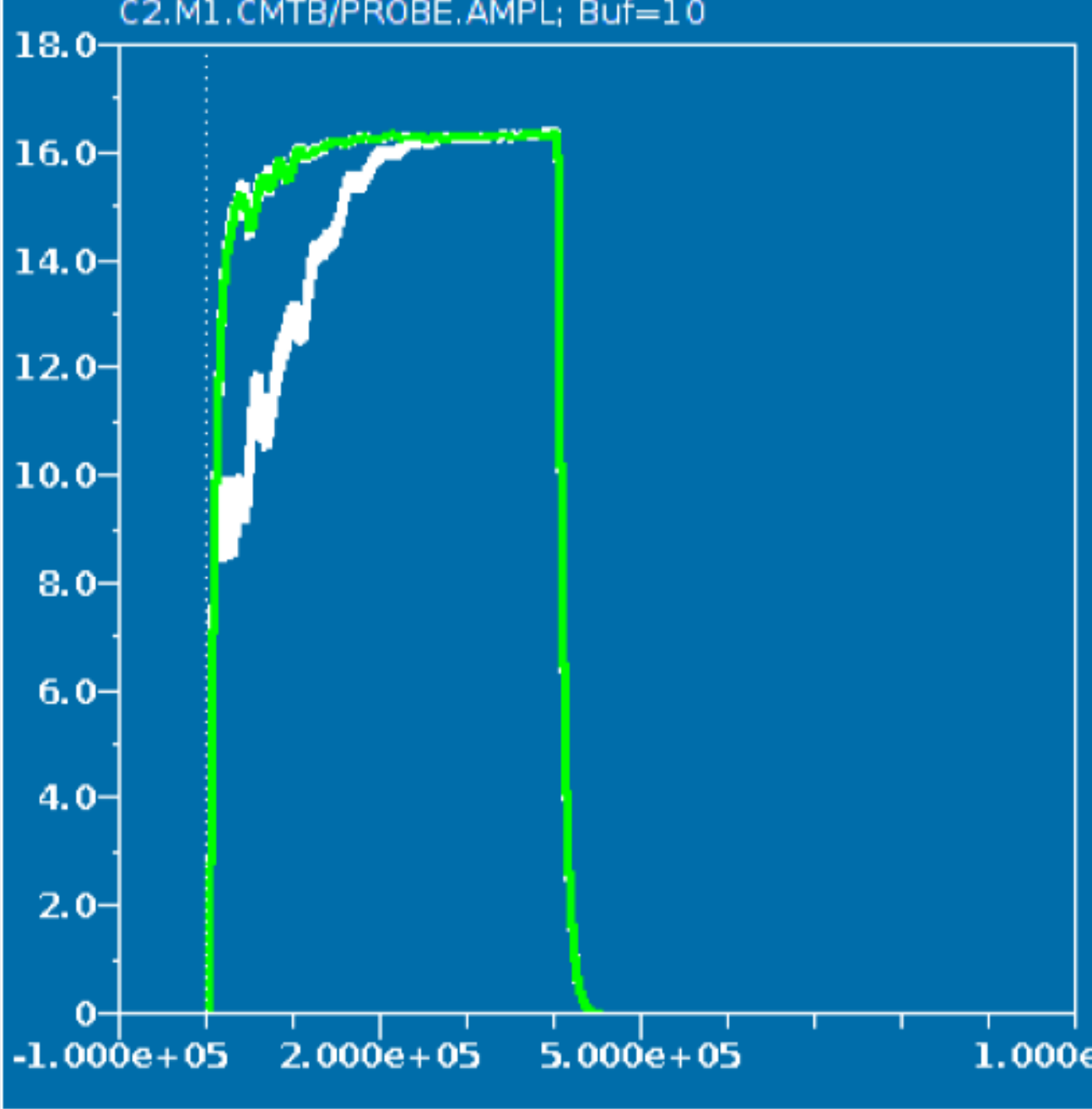
Adaptive feed-forward approach used for repetitive error compensation: linear fitting, various order polynomial fitting, error signal low-pass filtering
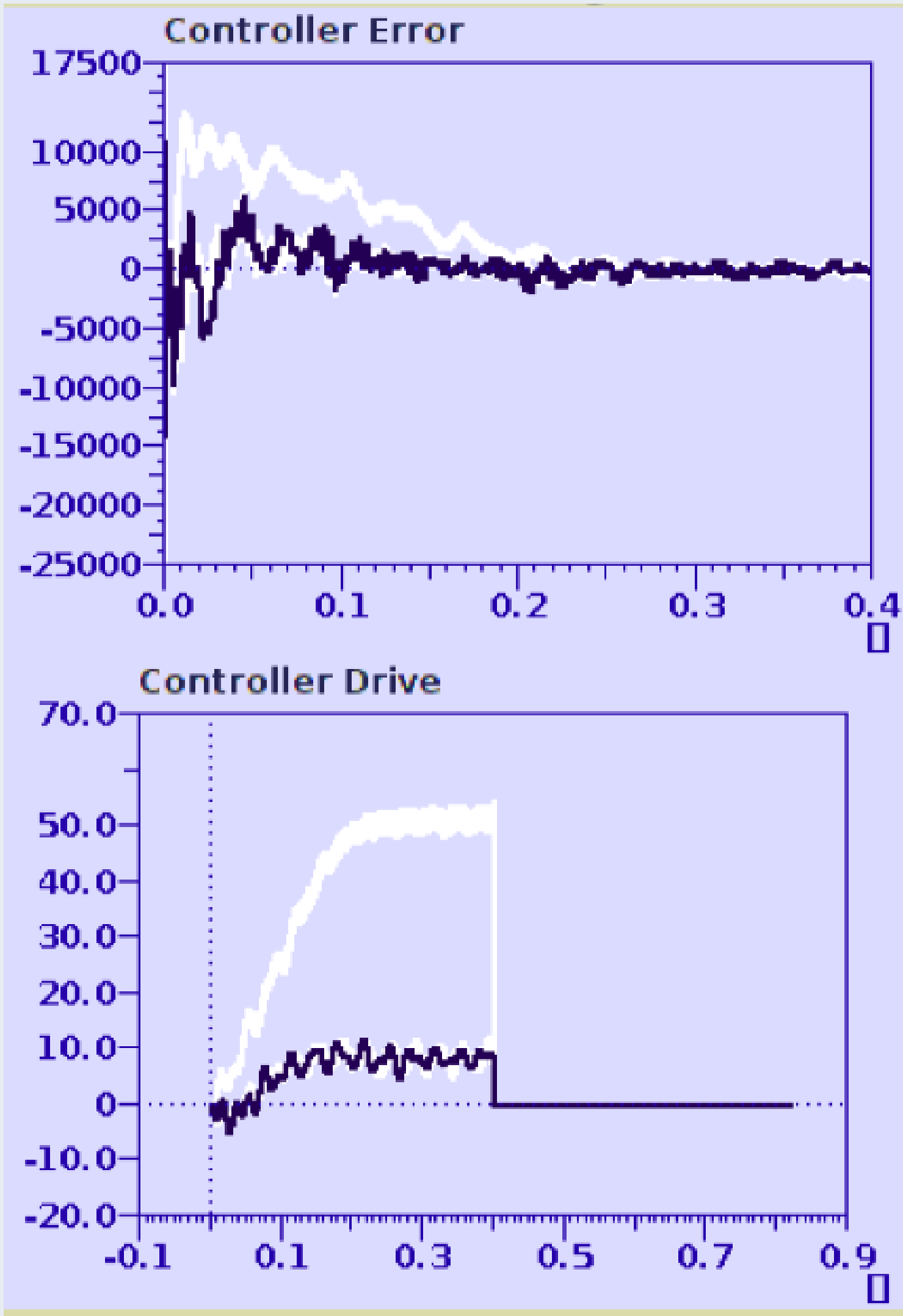

Figure: Cavity amplitude (upper plot) and phase (lower plot), before (white) and with (green trace) precise cavity resonance control

Figure: Piezo controller error (upper plot) and controller drive (lower plot) without (white trace) and with customized FF tables (black trace)

Piezo Feed-forward tables usage effects

- cavity tuning improvement during filling phase,
- reduction of the controller error signal,
- higher frequency (around 180-250 Hz) oscillation visible on the cavity phase signal - under investigation
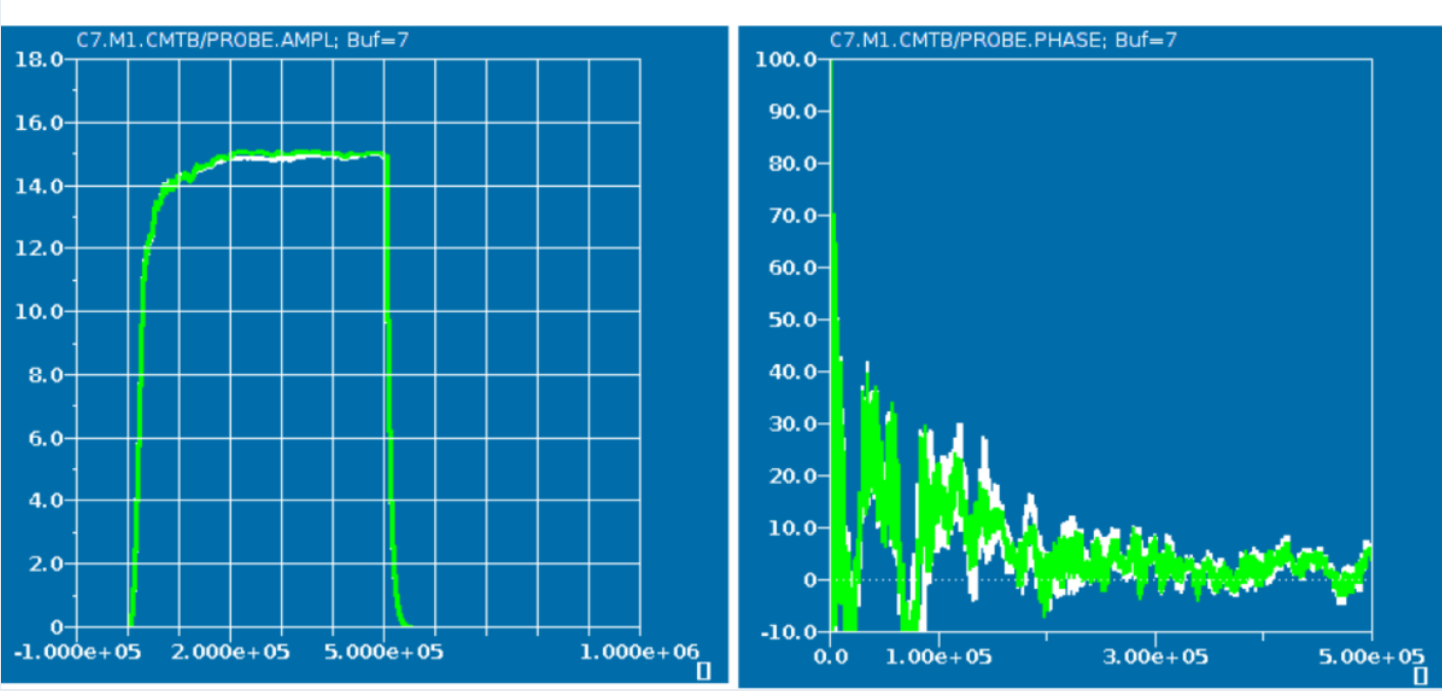

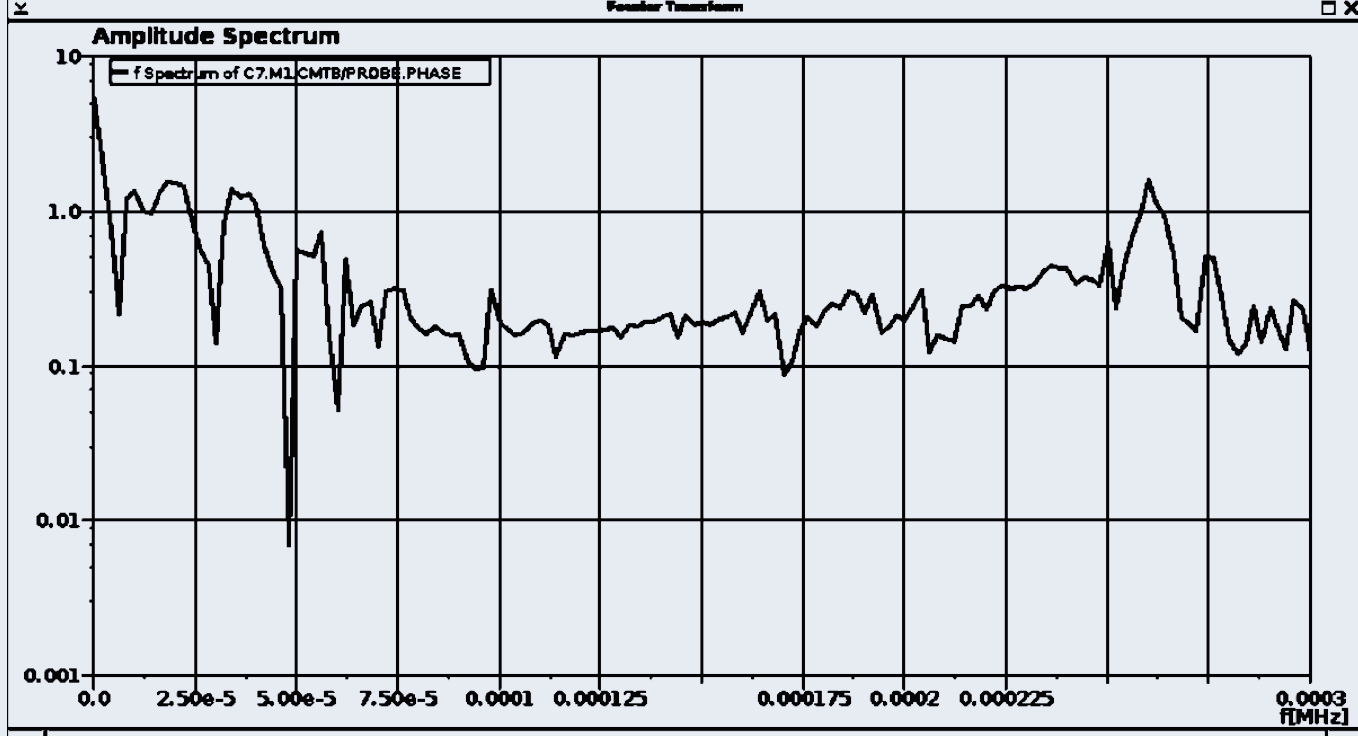Figure: Cavity 7 amplitude (left) and phase (right) waveforms

Figure: Cavity 7 field signal FFT

Summary and Future Plans

- Successful operation of LPO for avg. Ql 3e7 and avg. gradient 15.6MV/m
- piezo FF tables used for PI controller relaxation during cavities pulse filling phase,
- needed optimization of piezo custom tables shape to eliminate higher frequency oscillations,
- LPO study for higher gradients and narrow bandwidth conditions.