Piezo control

for ACC3,5,6 in FLASH

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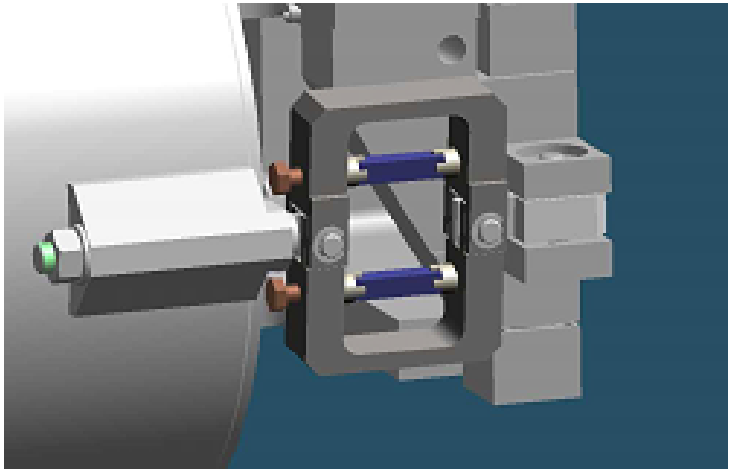
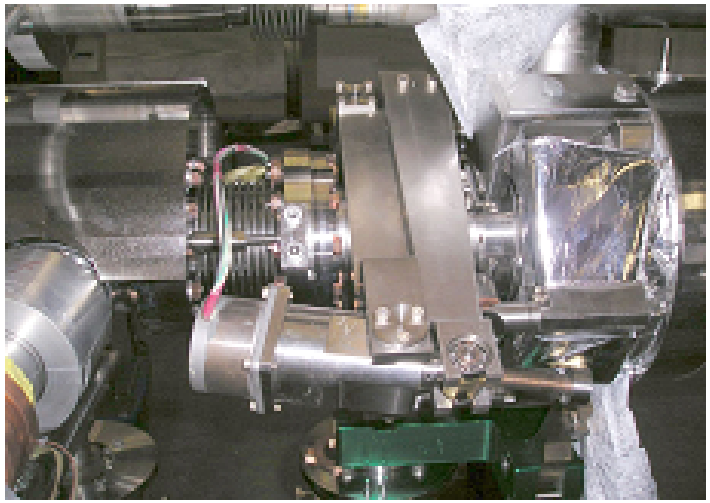
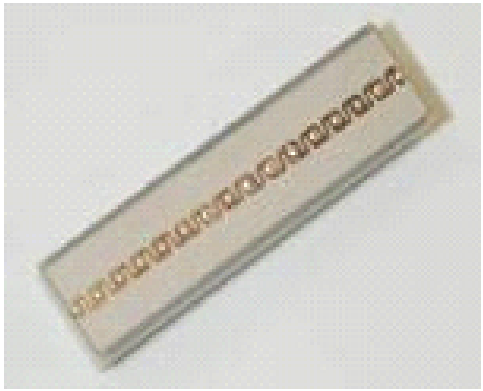
FLASH seminar 18.12.2007

Goal of Piezo Control system

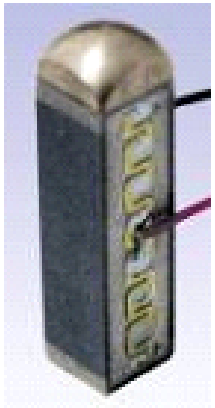
- Drive the piezoelements assembled in fast tuners frames to minimize the Lorentz force and microphonics effects
- On-line frequency detuning calculation
- Microphonics measurement (i.e. diagnostics of cryogenic system)







Dimensions: **10x10x30mm**
Manufacturer: **NOLIAC**



Dimensions: **10x10x36mm**
Manufacturer: **PI**

General requirements of Piezo Control system

- Lorentz force detuning (LFD) during flat-top $\Delta\omega$< 10 Hz for field up to 30 MV/m (compensation up to 600 Hz – possible resonance compensation up to 1kHz)
- Commercial available piezoelements (PI and NOLIAC) C_{2K}= 3÷5 μF, V_{max}= 100 V, oper. freq. for LFD/microphonics up to 1 kHz (full voltage scale), → I_{load} ~ 300mA
- Maximal repetition rate of RF (LFD compensation) pulse 10 Hz
- Piezo must be protected and monitored (piezo is fragile to over current and over voltage (>150÷200), piezo lifetime must by over 1010 pulses, resonance in the cables, piezo might fall out when stepper motor is wrongly tuned)
- Possible microphonics compensation between the RF pulses (sensor/actuator mode)(microphonics has smaller impact than LFD, constant offset of $\Delta\omega$ during flat top, feedback loop

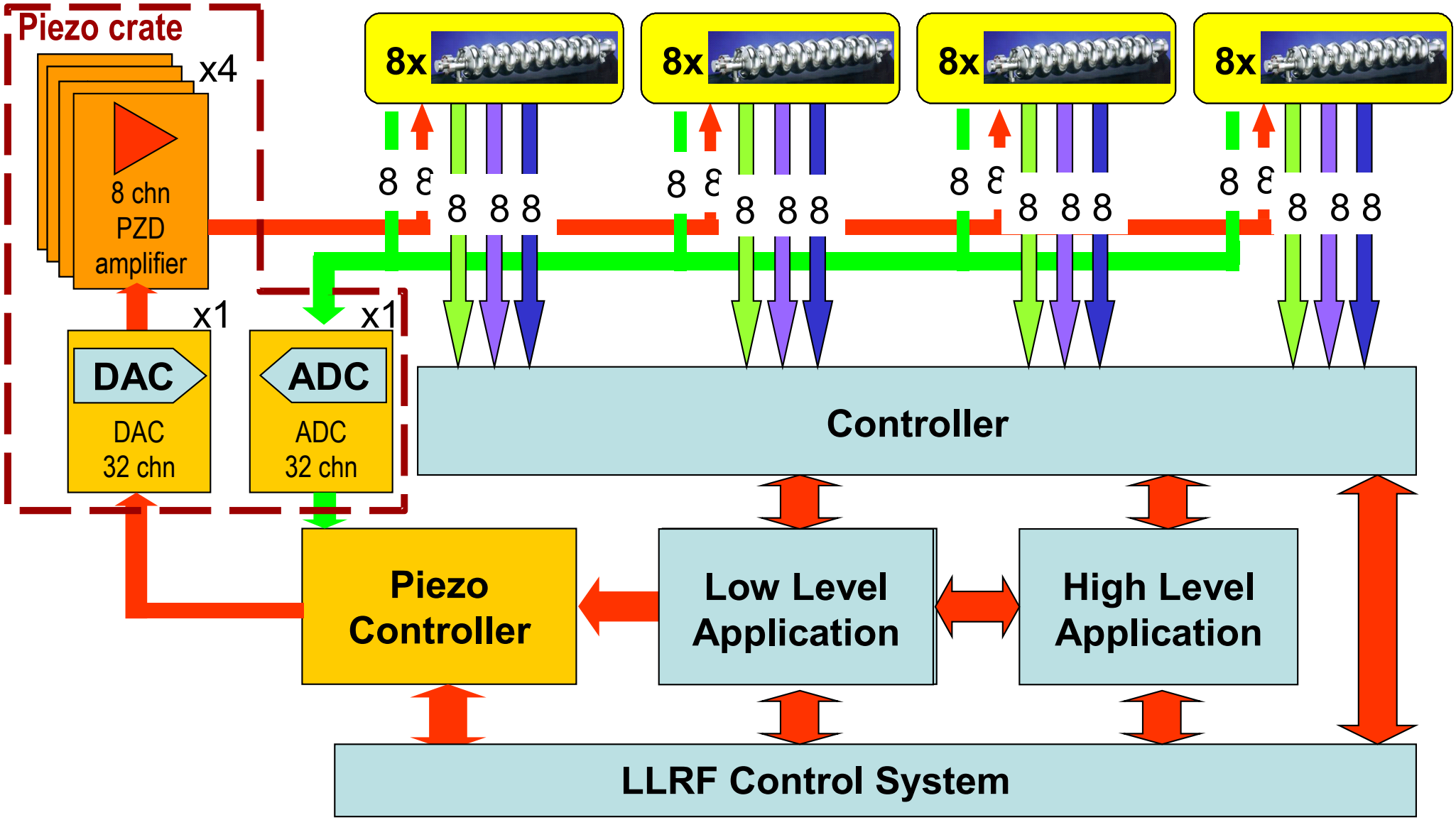
Piezos installed in ACC3,5,6

Producent ratings	Noliac	PI ceramic
Model:	SCMAS/S1/A/10/10/30/200/42/6000	P-888.90
Cells:	8	8
Voltage:	< 200 V	< 120 V
Blocking force:	6 kN	3 kN
Size:	10 mm x10 mm x 30 mm	10 mm x10 mm x 35 mm
Capacitance:	6 μF	12 μF

Piezos Capacitance

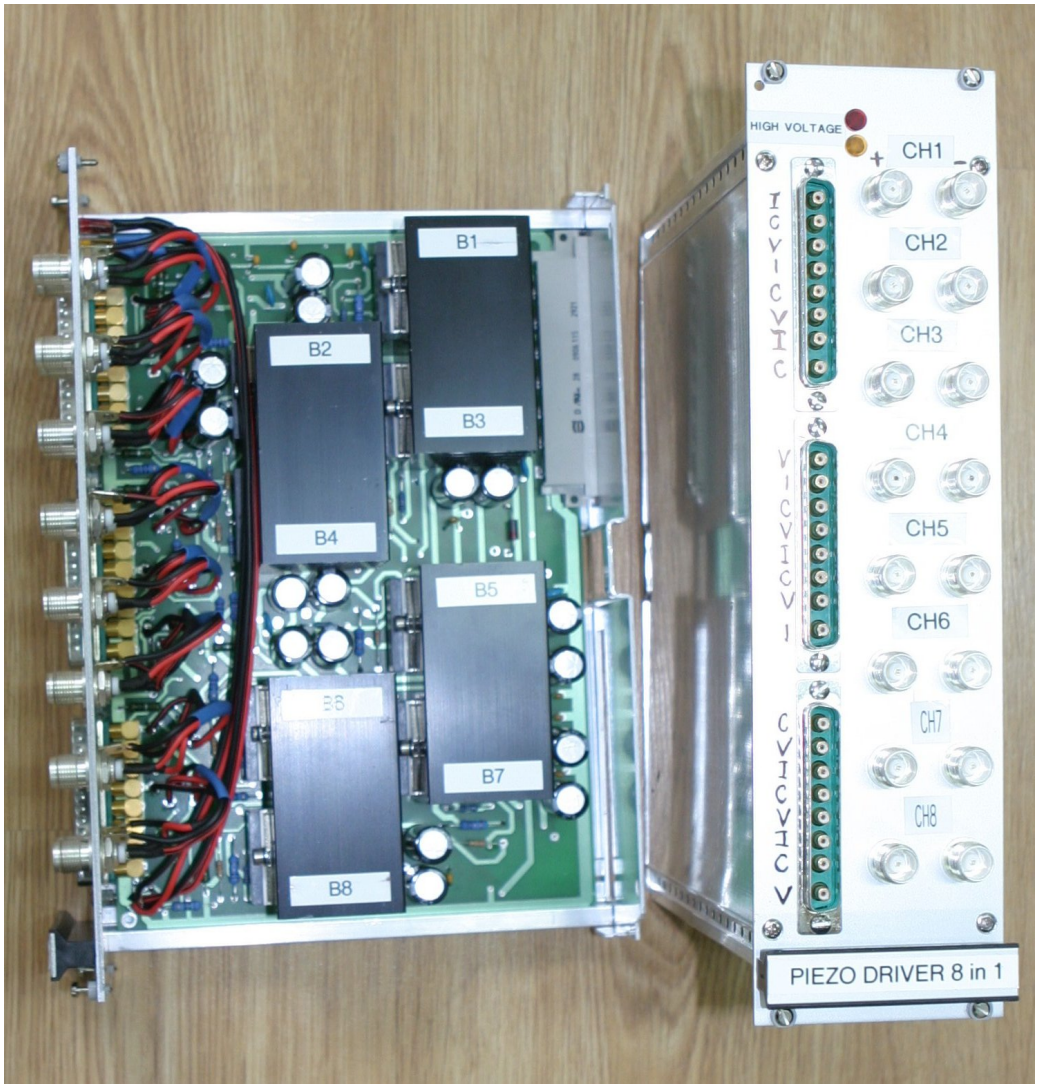
cavity	piezo	model	ACC3/M7	model	ACC5/M5	model	ACC6/M6
1	1	PI	4,93uF	Noliac	2,1uF	PI	4,13uF
	2	-	Unavailable	-	Unavailable	PI	4,45uF
2	1	PI	4,61uF	Noliac	2,22uF	PI	4,4uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF
3	1	PI	4,91uF	Noliac	2,28uF	PI	4,21uF
	2	-	Unavailable	-	Unavailable	PI	4,1uF
4	1	PI	4,6uF	Noliac	3,12uF	PI	3,86uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF
5	1	Noliac	2,6uF	Noliac	2,2uF	PI	4,22uF
	2	-	Unavailable	-	Unavailable	PI	4,28uF
6	1	Noliac	2,13uF	Noliac	2,13uF	PI	3,73uF
	2	-	Unavailable	-	Unavailable	PI	4,41uF
7	1	Noliac	2,22uF	Noliac	2,19uF	PI	4,69uF
	2	-	Unavailable	-	Unavailable	PI	4,41uF
8	1	Noliac	2,21uF	Noliac	2,17uF	PI	4,31uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF

Piezo control for XFEL

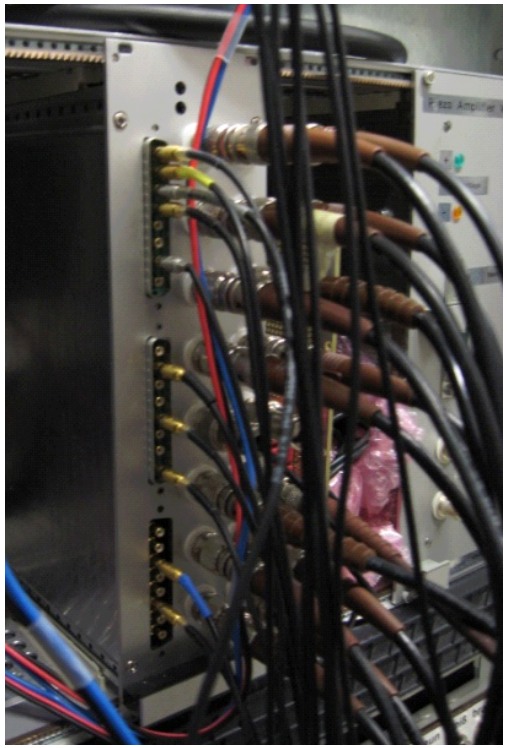


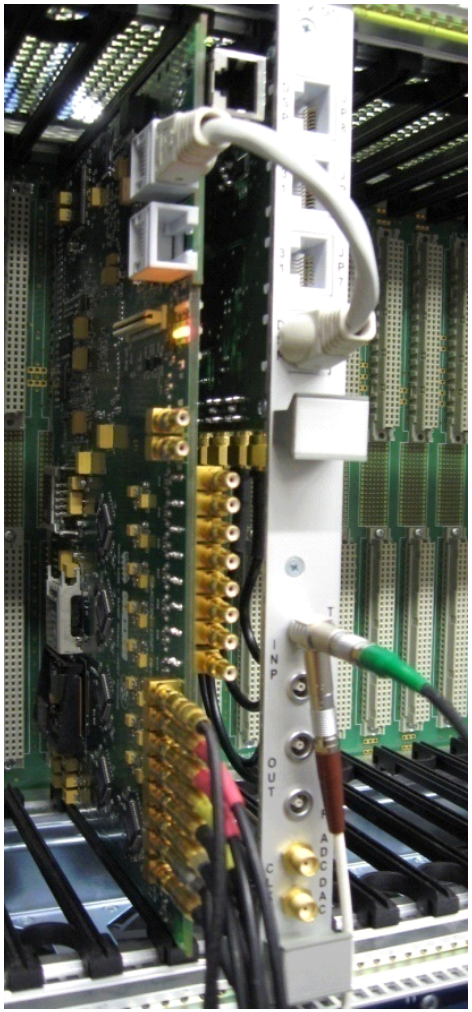
Main parameters of Piezodriver

- Suitable for both types of piezostacks up to 5μF:
  - Physik Instrumente (P-888.90 PIC255); C_{2K} 4,4 μF
  - NOLIAC (SCMAS/S1/A/10/10/20 /200/42/6000); C_{2K} 2,4 μF
- Maximal supply voltage up to ± 150 V (nominal operating voltage ±80V)
- Input voltage ± 1 V
- Amplifier gain Gu= 100V/V,
- Operational temperature Tc < 75°C (Tj <125 °C)
- Pass-band frequency up to 5 kHz (for load 5μF)
- Monitoring of output voltage and current
- Single channel PZD with Apex PB51
- 8 channels on single board
- Up to 4 periods of sinus wave 80V, 200 Hz in 5μF load, 10 Hz repetition rate (thermal limit)

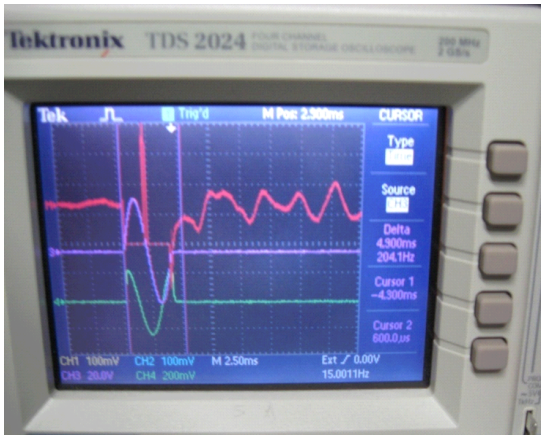


FLASH tests

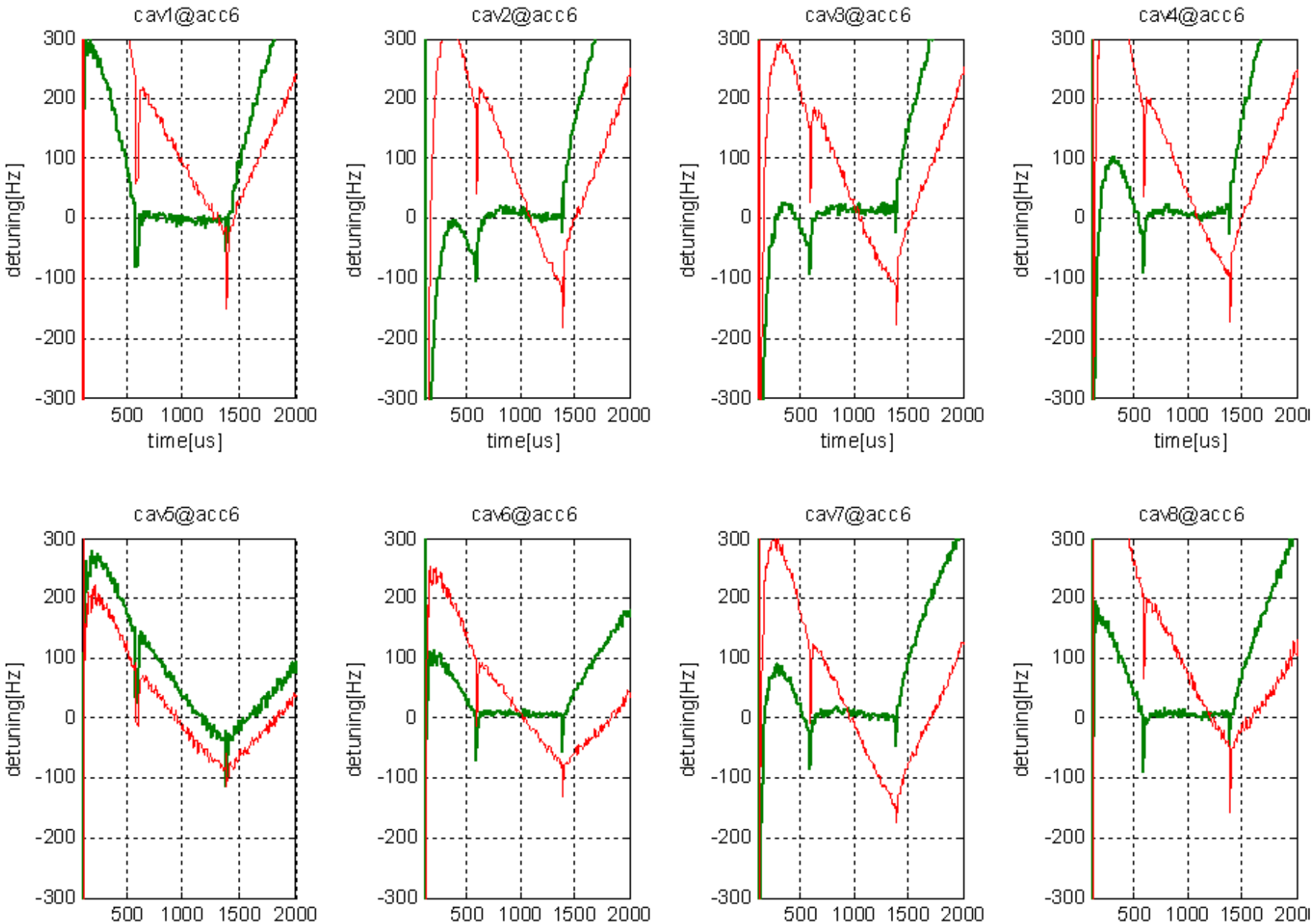



INP
OUT
ADC DAC


ACC-6 Piezotuner
grün
gelb
gelb grün gelb


Tektronix TDS 2024
Tek
Trig'd
M Pos: 2.500ms
CURSOR
Type
Source
Delta
4.300ms
204.1Hz
Cursor 1
-4.300ms
Cursor 2
600.0µs
Ch1 100mV
Ch2 100mV
M 2.50ms
Ext 0.00V
15.0011Hz

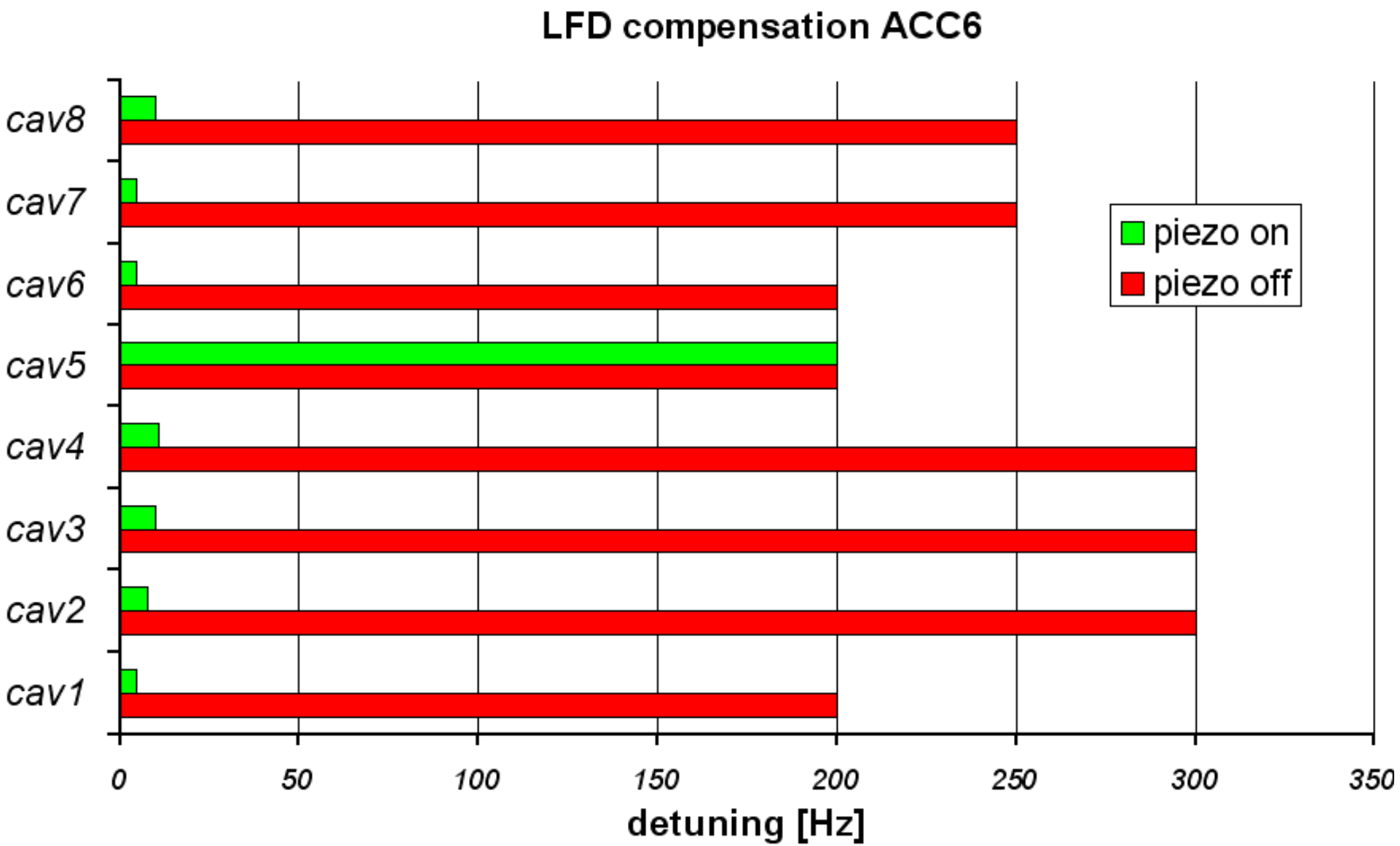
ACC6 (SP = 15 MV/m, Pforw = 220kW, rep = 5 Hz)



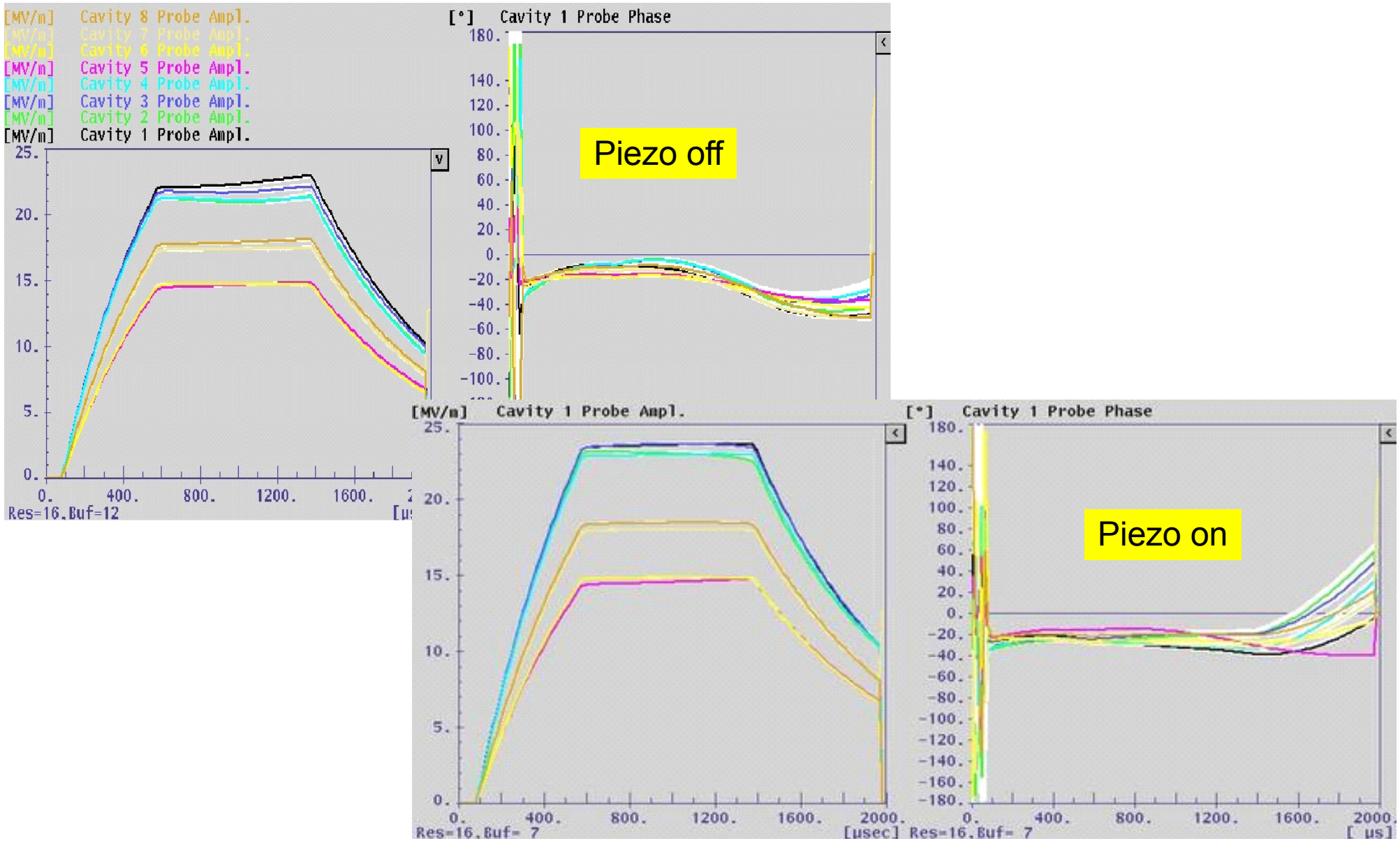
Cav. (1-3)
Amp: 34V
Dly: - 4.1 ms

Cav. (4-8)
Amp: 23V
Dly: - 4 ms

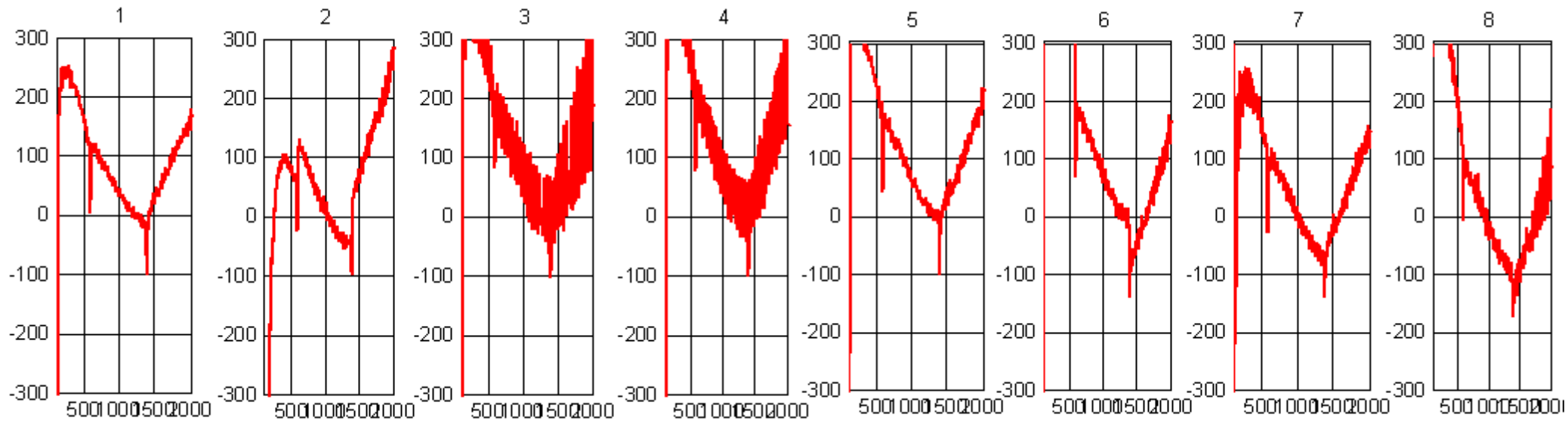
ACC6 – LFD compensation results

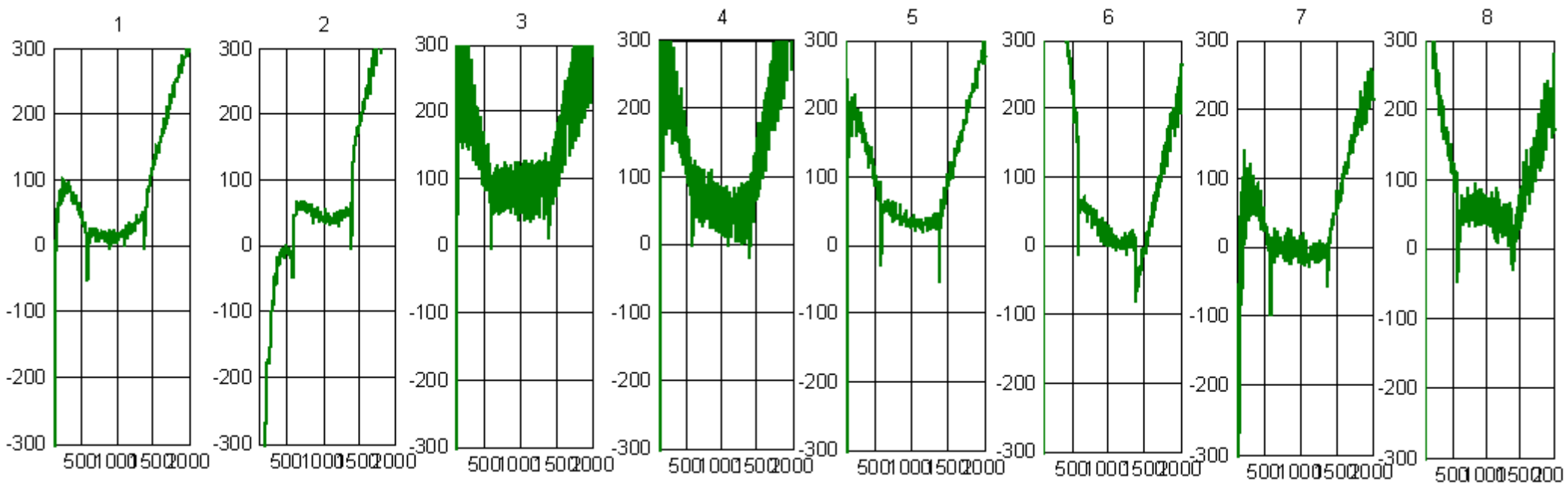


ACC6 – LFD compensation results

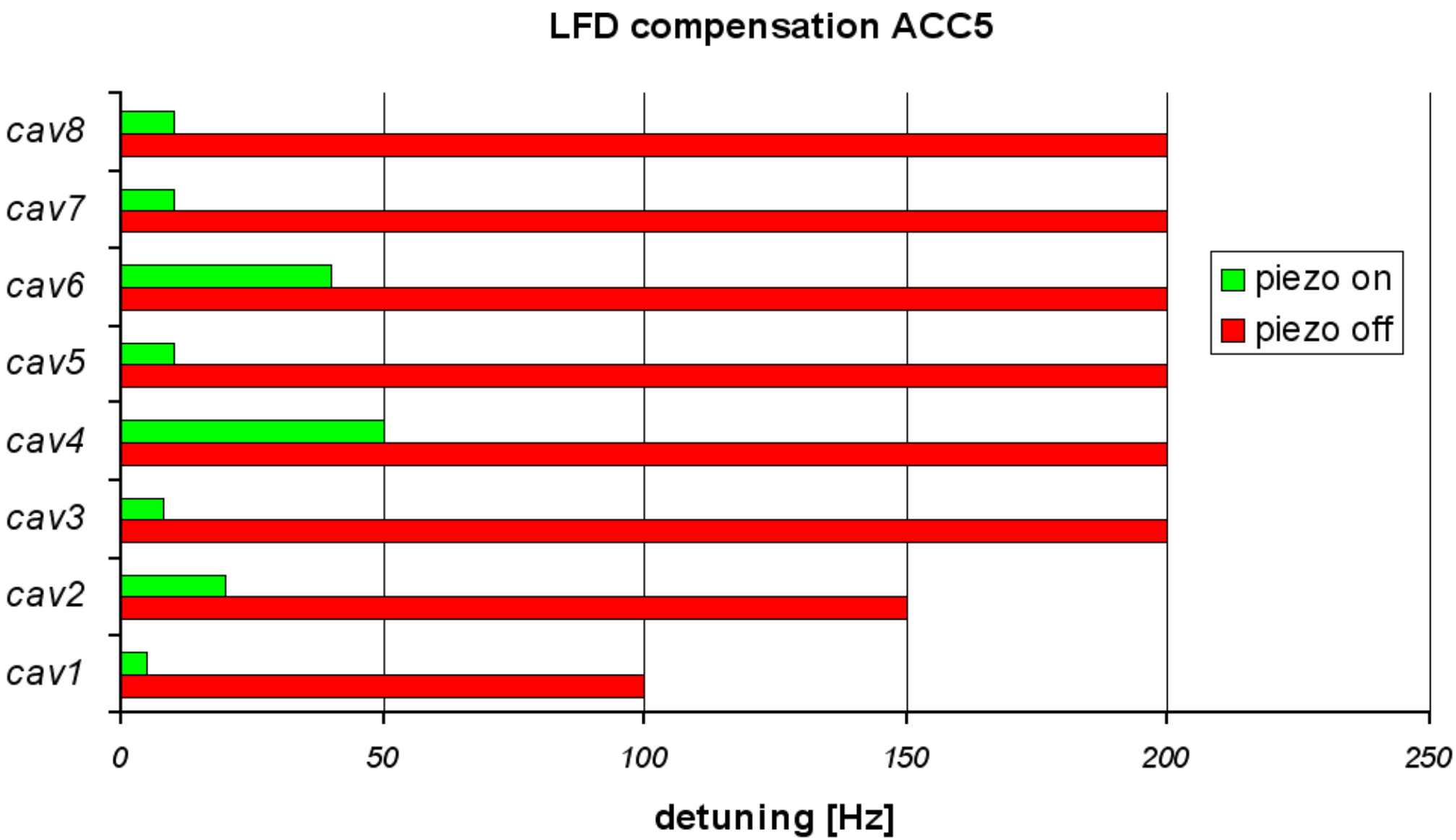


ACC5 (SP = 15 MV/m, Pforw = 90 kW, rep = 5 Hz)

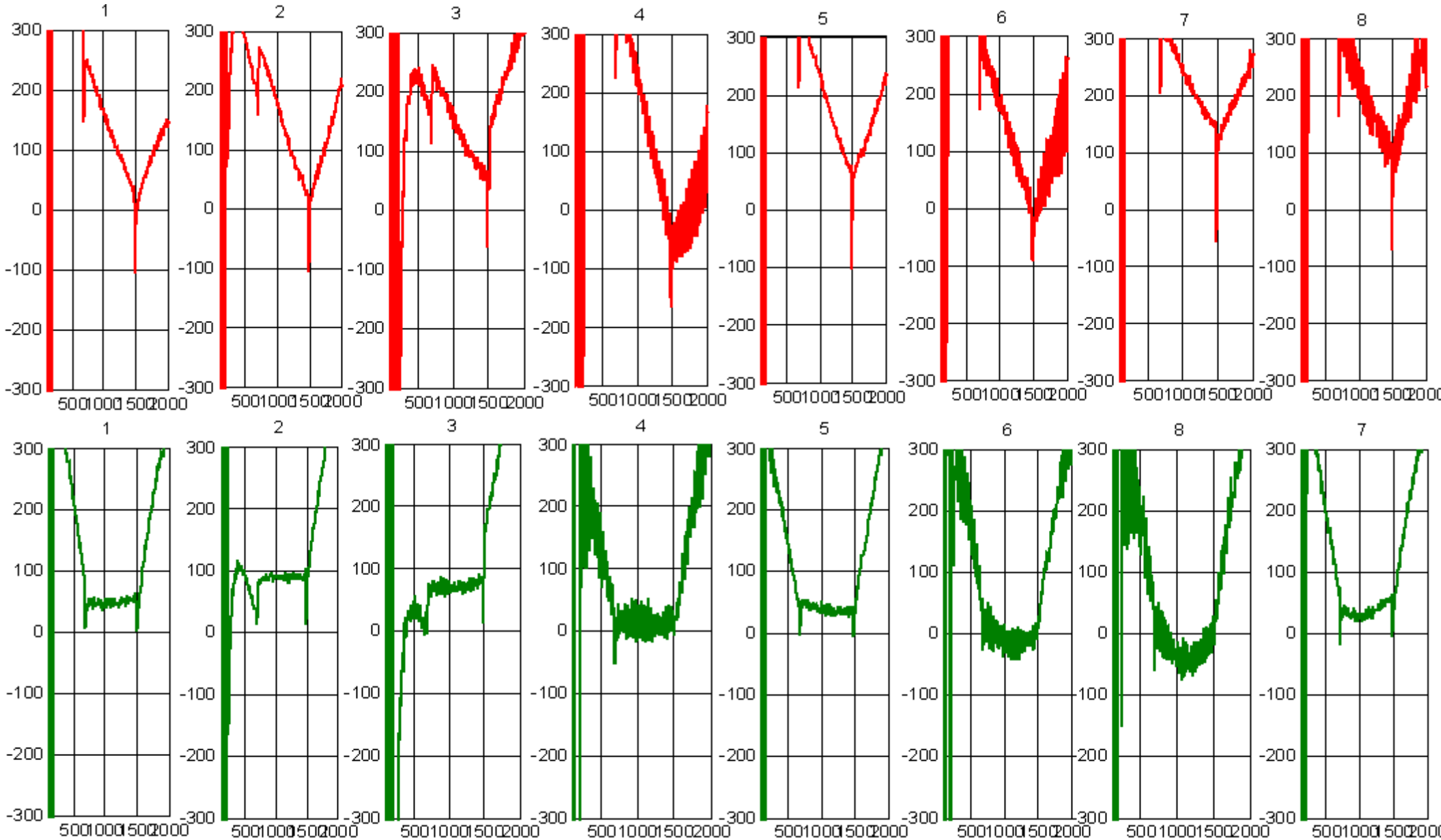




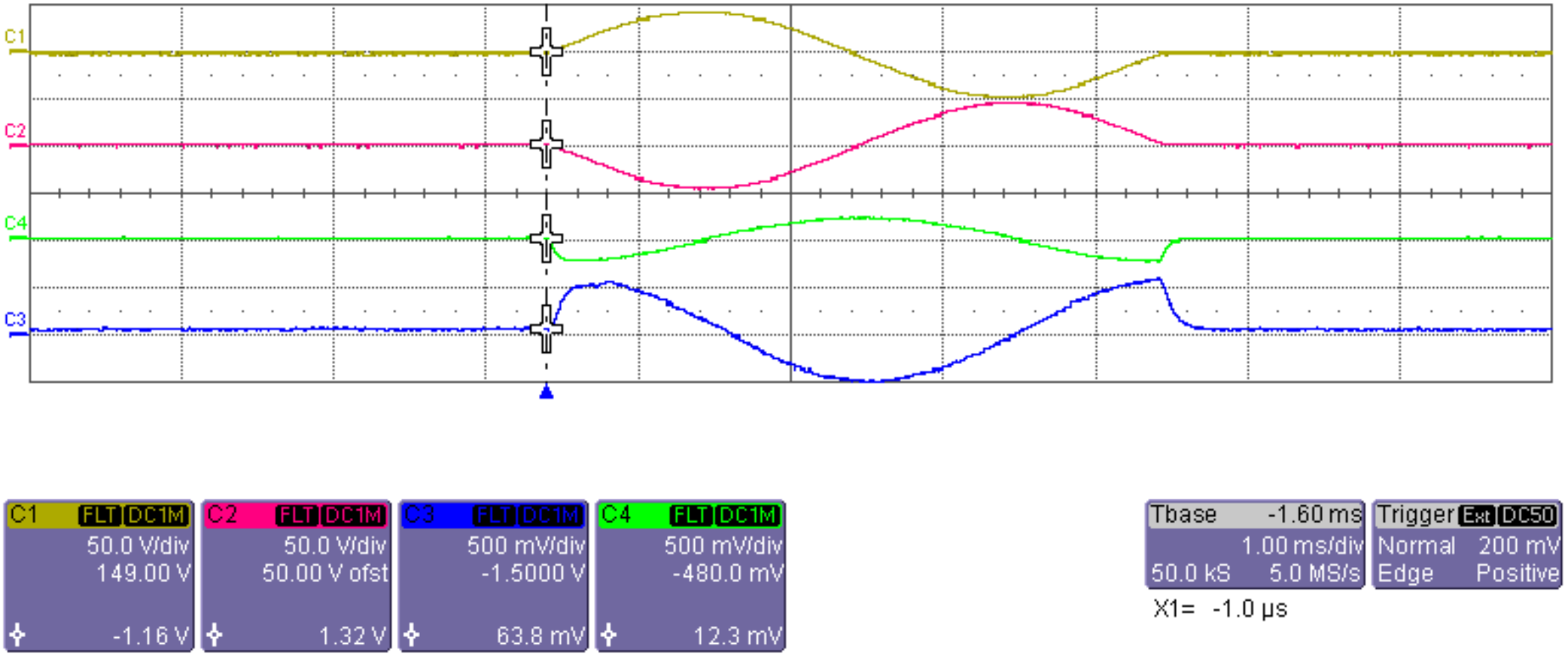
ACC5 – LFD compensation results



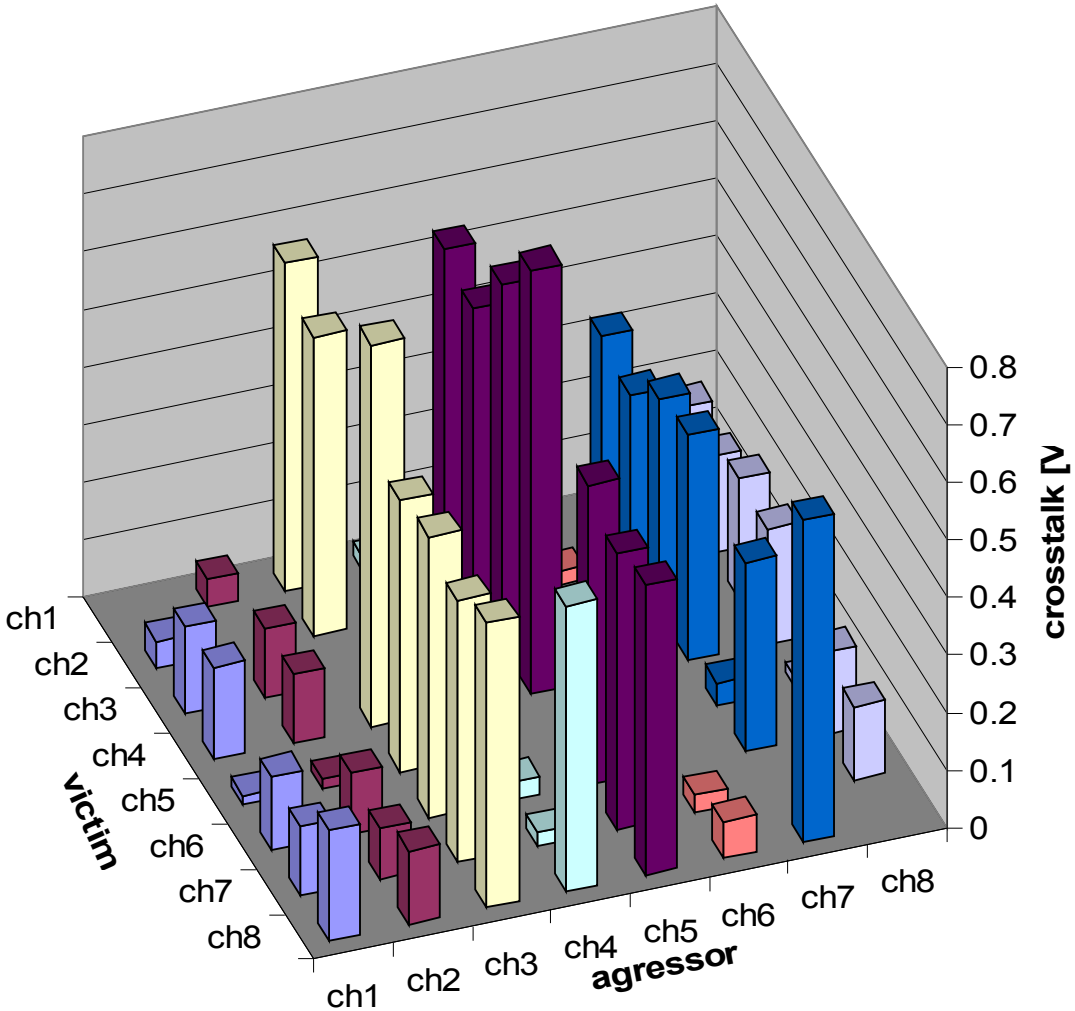
ACC3 (SP = 17 MV/m, Pforw = 220 kW, rep = 5 Hz)



Crosstalk in PiezoDriver

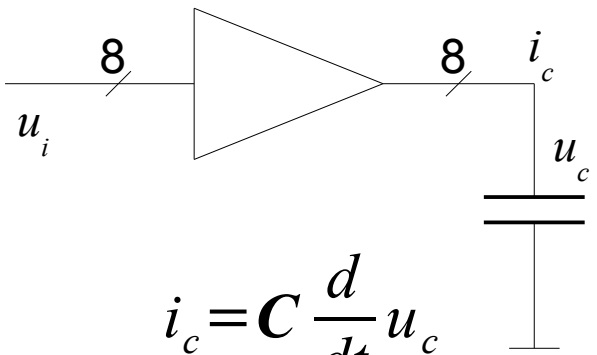


Crosstalk compensation



cross talk matrix

[V]	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8
ch1		0.048	0.152	0.16	0.016	0.128	0.12	0.192
ch2	0.048		0.12	0.12	0.016	0.106	0.088	0.128
ch3	0.57	0.52		0.664	0.472	0.488	0.456	0.496
ch4	0.024	0.048	0.016		0.016	0.032	0.024	0.496
ch5	0.536	0.512	0.632	0.736		0.52	0.48	0.504
ch6	0.024	0.024	0.024	0.024	0.016		0.032	0.064
ch7	0.328	0.304	0.376	0.392	0.04	0.328		0.56
ch8	0.176	0.168	0.208	0.2	0.016	0.144	0.128	



$$i_c = \boldsymbol{C}\frac{d}{dt}u_c$$

$$u_c = \boldsymbol{A}u_i + \boldsymbol{B}i_c$$

$$u_i = \boldsymbol{A}^{-1}u_c - \boldsymbol{A}^{-1}\boldsymbol{BC}\frac{d}{dt}u_c$$

$$u_i = \frac{1}{A}\left(u_c - \boldsymbol{BC}\frac{du_c}{dt}\right)$$

Conclusion

- The tests were succesfull proving the piezos can compensate LFD in new high-gradient accelerating modules
- Future plans
  - redesigning of PZD 8/1 PCB board with more attention to crosstalk between channels
  - integration of temperature sensors
  - design of 32 channel ADC and DAC boards
  - design of HV Power Supply unit