Modular Low-Noise Piezoamplifier Driver for SRF Applications

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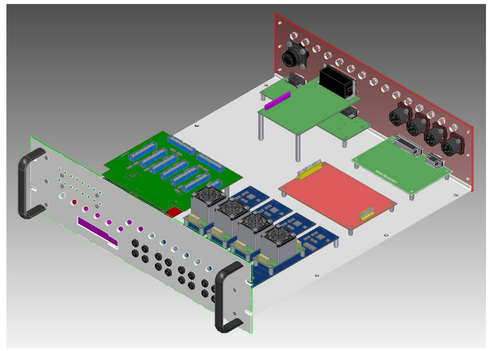
LCLS-II Resonance Control

Controlling the resonant frequency of superconducting cavities can be difficult due to their high sensitvity to mechanical and pressure variations. In addition, the cooling process itself as well as RF heating and deformation leads to resonant frequency shifts that need to be mechanicalyl compensated for. Stepper motors are often used for gross adjustment, but they also introduce significant noise in to the cavity system. Piezo transducers provide a way to perturb the cavity with minimal disruption.

For the LCLS-II project, a modular piezoamplifier driver was developed using off-the-shelf components in conjunction with a custom carrier board. This allows for a low-noise system that provides real-time monitoring of piezotransducer health.

The modules are designed to be easily serviceable and use audio-style connectors for monitor and drive ports on the chassis.



Parts Selection and Design

Driver: PiezoDrive PDu150 (COTS)

DAC: (2x) Analog Devices AD5781

ADC: Analog Devices AD7608

Monitoring Amplifiers: Analog Devices AD629

The digital control signals are isolated from the rest of the board to minimize crosstalk and ground bounce in the audio band.

System Design Noise Calculations

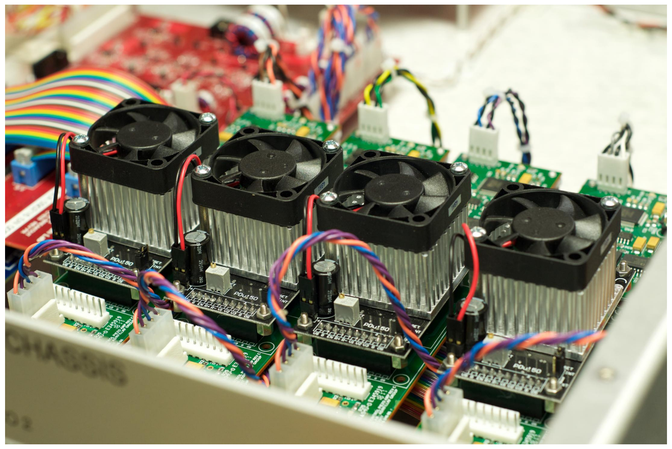
Driver: 15 µVrms LF, 16 µV HF

DAC: 1.1 µVp-p LF, 7.5 nV/√Hz noise spectral density HF

ADC: 90 dB SNR @ 1 kHz, +- 40LSB tUE

Monitoring Amplifiers: 15 µVp-p LF, 550 nV/√Hz HF

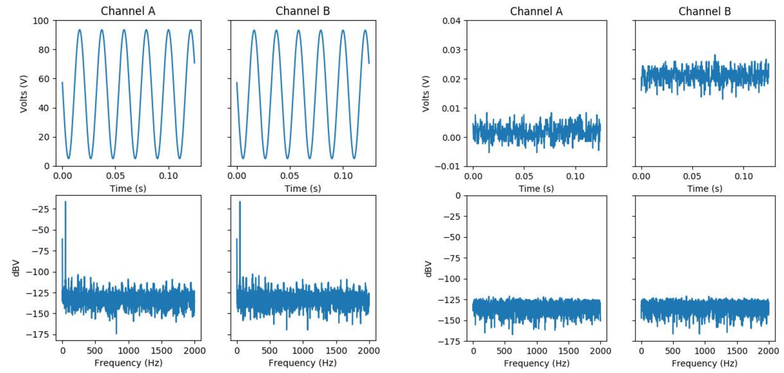
Largest noise source is the amplifier itself, and measurements show even lower noise measurements.



Piezo modules mounted in LCLS-II Resonance Control chassis

For more information, see P-93, 'LLRF Resonance Control System for LCLS2 Cavities'

System Performance



ADC readings with and without signal (NCO-generated)

Readings taken using the on-board ADC. Measurements taken with an SRS780 show the same performance characteristics.

Piezo Driver

Load Capacitance	HF Noise	Total Noise
10 nF	450 uV	450 uV
30 nF	170 uV	170 uV
100 nF	60 uV	62 uV
300 nF	34 uV	37 uV
1 uF	21 uV	26 uV
3 uF	16 uV	23 uV
10 uF	16 uV	22 uV
30 uF	18 uV	23 uV

Table 3. HF Noise (10 Hz to 1 MHz) and total noise

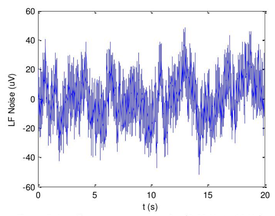


Figure 5. Low frequency output noise (0.03 Hz to 10 Hz)

Piezo Amplifier Noise Characteristics

The noise characteristics are such that an LCLS-II, TESLA-style cavity sees <1/10 Hz/√Hz noise.

The amplifier offers 3 output channels, of which only two are used. In order to provide a spare channel, the third channel is unused for future repairs and maintainability.