

High-power Piezoelectric Tuner Driver for Lorentz Force Compensation

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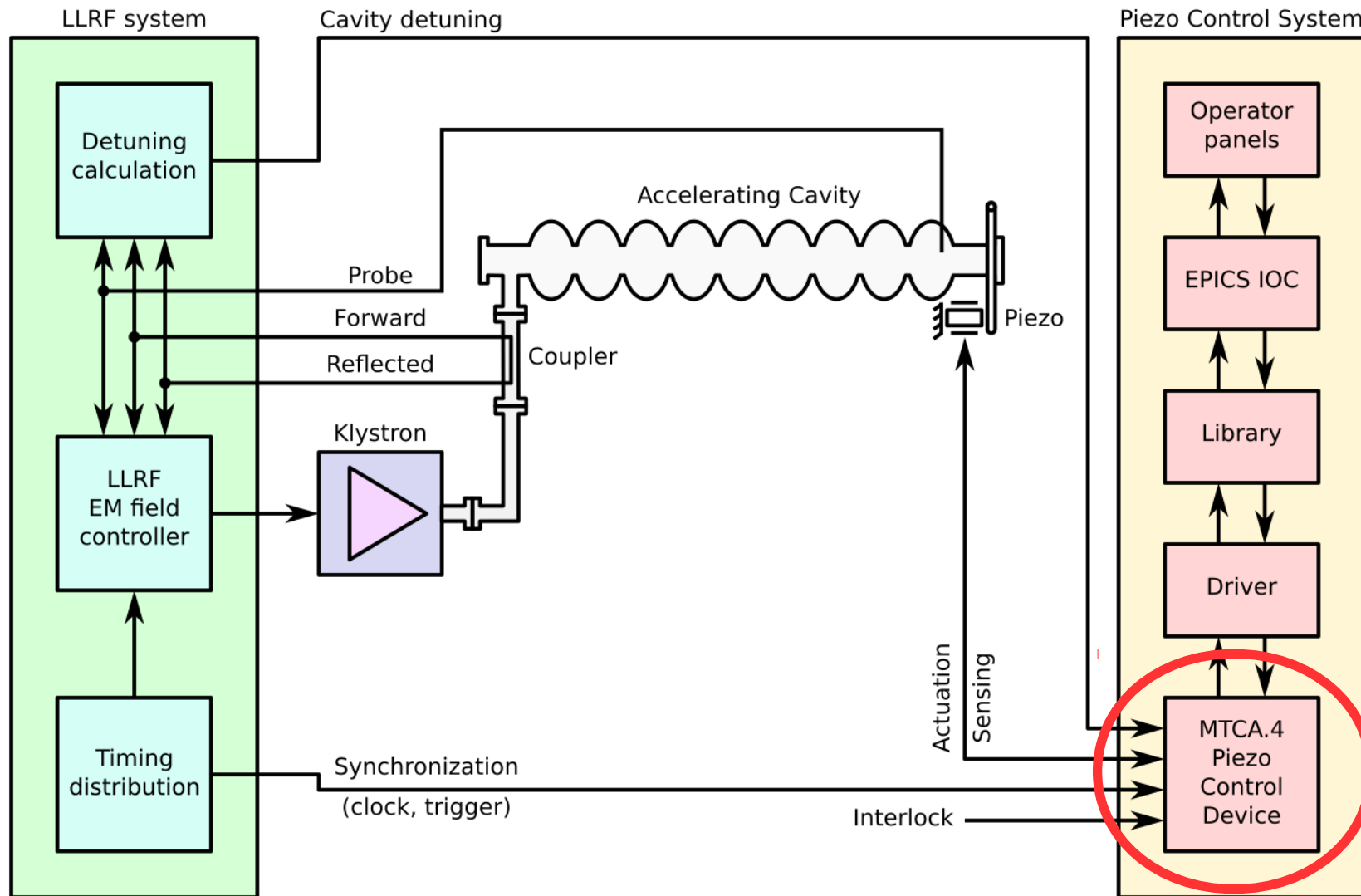
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High Power Piezo Driver - Motivation

- ▶ This work is being done in frame of the Polish in-kind delivered by the Polish Electronic Group (PEG) within in-kind agreement signed between PEG and ESS on 2016-11-08, (together with Schedule AIK 8.2, signed 09.2017, ESS-0060409)
- ▶ Department of Microelectronics and Computer Science, Lodz University of Technology as a member of PEG consortium is responsible for piezo driver system delivery for elliptical cavities of ESS linac.
- ▶ Pioneering research to design the first High-power piezo driver dedicated for MicroTCA.4 systems

Piezo Compensation System



Functional Specification for Piezo Control System at ESS

- ◆ Provide a control signal for piezo actuators of medium-, high-beta and spoke cavities of ESS accelerator operating in cryogenic temperatures
- ◆ Measure cavity deformation using piezo device as sensor element
- ◆ Support two independent channels with configurable mode of operation:
 - ◆ Piezo actuator and/or
 - ◆ Piezo sensor
- ◆ **Compatible with MicroTCA.4 and MicroTCA.4.1 standard**
- ◆ Provide health monitoring and diagnostics
- ◆ Assure safe operation of piezo actuator

More about High Power Piezo Driver

Poster 514

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📅 12 Jun 2018, 14:40

🕒 1h 30m

📍 Woodlands Conference Center

🗣️ Speaker

👤 Dr Dariusz Makowski (Lodz University of Te...)

Poster presentation

New Standards

Poster 1

HIGH-POWER PIEZOELECTRIC TUNER DRIVER FOR LORENTZ FORCE COMPENSATION
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Introduction
 Superconducting Radio Frequency (SRF) cavities are used in modern accelerators to efficiently accelerate particles. When cavity is supplied with pulsed RF field it undergoes a mechanical strain due to the Lorentz force. The resulting deformation causes dynamic detuning of which magnitude depends on mechanical properties of the cavity, RF pulse rate and their profile. This effect causes considerable loss of acceleration performance. Therefore, it is usually actively compensated, most commonly with fast piezoelectric actuators.

MicroTCA.4
 The MicroTCA.4 standard, developed in 2013 is based on the original PC Industrial Computer Manufacturers Group (PICMG) MicroTCA.0 specification and therefore inherits the main limitations of the base standard concerning power consumption and heat generation in a single slot. The main goal of MicroTCA.4 technology was designing a high-power piezo driver a central task.

Specification
 • Provide a control signal for piezo actuators operating with power of 100 W for each channel
 • Measure cavity deformation with piezo sensor
 • Support two independent channels with configurable mode: Piezo actuator and/or sensor
 • Compatible with MicroTCA.4 and IPMI standards
 • Provide health monitoring and diagnostics
 • Assure safe operation of piezo actuator

Possible Scenarios
 The MicroTCA.0 and MicroTCA.4 standards allow dissipating up to 80 W in a single AMC slot. The Piezo Driver could be designed as AMC device requiring from 22 V available on AMC module. The maximum power will be limited to 80 W.
 When the Rear Transition Module (RTM) is used the power provided to the MicroTCA power supply system is shared between the AMC (50 W) and the RTM device (30 W), in such situation the cooling capabilities are limited to 80 W for AMC and 30 W for RTM. The control division on RTM consumes ca. 10 W. Only 20 W is available for the high-power driver. Therefore a design of a low-kVA-class piezo driver is not possible in this configuration.
 The architecture involving an external power supply was selected. The external power supply can provide much more power than available from MicroTCA internal power supply. However, the cooling is still limited to 80 W on the RTM side. Therefore, the design of a high-power piezo driver suitable for accelerators operating with long RF pulses, such as the ESS machine built in Sweden, requires a high-efficiency amplifier designed as an RTM.

Implementation
 In order to overcome the 30 W cooling limit on RTM a high-efficiency power amplifier is needed. A typical linear class-AB amplifier is clearly not suitable for such applications, due to its poor energy efficiency limited to 50%. A 300-W class-AB amplifier dissipates at least 90 W. Therefore, a high-efficiency class-D amplifier based on a Piezo-Matrix Modulator controller from International Rectifier was applied.

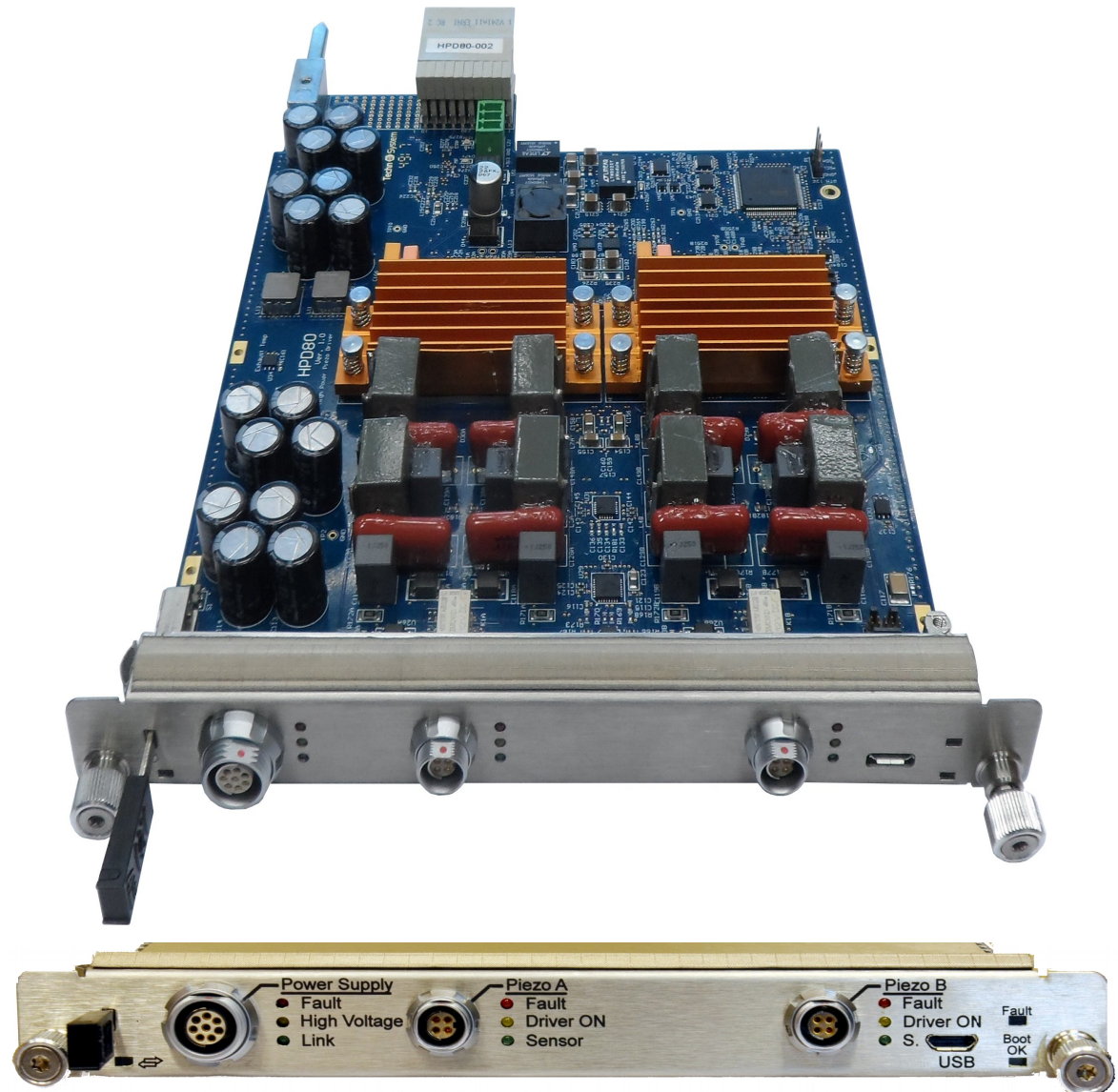
Evaluation
 The output of the driver was first evaluated with various film capacitors ranging from 2.2 μF up to 300 μF. Next, the driver was applied to couple two Maser MAC 2022 H33 piezo actuators/sensors installed in machine vice.
 Piezo actuator is considered for ESS Lorentz force detuning. Piezo sensor and actuator in machine vice.
 Experimental results in continuous Mode. Experimental results in pulsed mode.

Conclusion
 We developed the first high-power piezo driver for MicroTCA.4-based systems that can control the largest piezoelectric actuators with the capacitances up to 300 μF. The driver fulfills all the MicroTCA requirements, in particular the RTM dissipated power level to 30 W.
 The initial tests have shown, that the RTM can cooperate with the AMC module and can drive loads up to 300 μF. We are planning further tests in cavity assemblies in cryostats and accelerators.
 The current high-power version of the driver requires an external power supply. However, if the driver requirements were relaxed, it would also be possible to build a version supplied solely from an AMC module.



Piezo Driver RTM Module

- ◆ 2 channels of high power piezo driver
 - ◆ 2x 35 Watts (MTCA.4 power supply)
 - ◆ 2x 100 Watts (external power supply)
- ◆ Piezo driver and piezo sensor mode
- ◆ Build-in diagnostics (advanced implementation of RMC)
- ◆ Various protection mechanisms for both Piezo channels to protect driver itself and piezo actuator
- ◆ Proposed new digital high-voltage class D1.2-HV (± 50 V) on Zone 3 (MTCA.4 power supply)



Thank you for your attention