MICROTCA.4 PIEZO DRIVER "DRTM-PZT4“ AND ITS APPLICATIONS.

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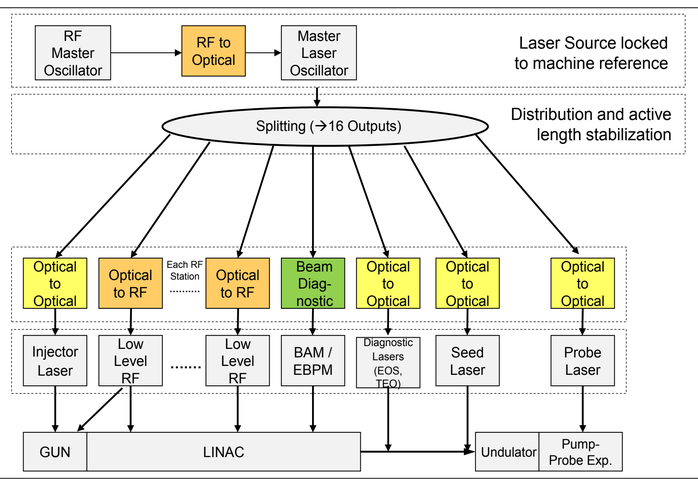
Abstract MicroTCA.4 Piezo Driver "DRTM-PZT4" has been developed to support laser synchronization and special diagnostic (SD) applications foreseen for XFEL facility. The Piezo Driver is capable of driving 4 piezo actuators with voltages up to ±80 V. The solid state power amplifiers are driven using 18-bit DACs and sampling rates of 1 MSPS. The bandwidth of the driver is remotely tuneable using programmable low pass filters. The DRTM-PZT4 unit provides the information of piezo output voltage and current. Three independent test setups have been built to test 4-channel Piezo Driver performance. In the paper we are presenting EOD laser lock to 1.3 GHz FLASH master oscillator using bipolar piezo stretcher (fine tuning). The piezo motor based course tuning has been applied for the long term laser stability measurements. The unipolar piezo actuator operation has been demonstrated for the Origami Onefive laser locked to 1.3 GHz LAB MO. The preliminary results of active stabilization of 3.6 km fibre link laboratory setup are shown.

Introduction

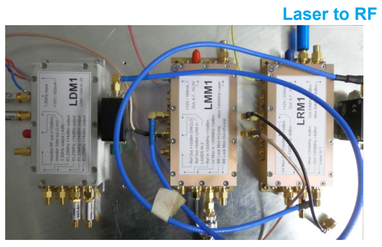
In accelerator facilities, especially free-electron lasers (FEL), the use of mode locked lasers is most common approach, e.g. for electro-optical diagnostics (EOD), as photo-cathode lasers, seeding, Beam Arrival and Beam Position Monitors (BAM, BPM) or pump-probe experiments. The repetition rate of the laser train pulses is typically a sub-harmonic of the main RF synchronization signal. At European XFEL the main reference signal is at 1.3 GHz while the lasers run in a range between 54 MHz and 216 MHz. In order to synchronize the laser to the accelerator reference a piezo element within a laser cavity is applied. The main approach is to use a loop filter (digital or analog) driving a high output voltage and current power amplifier in order to minimize a phase difference between reference and the laser. The accelerator reference signal needs to be also distributed over different places of the machine. The main idea is to encode the reference timing information in the precise rate of an optical pulse trains using master laser oscillator (MLO). The MLO optical signal is next transmitted to different accelerator locations (e.g. RF Gun, main linac or undulator sections) using fibre laser connections. The fibre lasers needs to be actively stabilized using stretcher in a fibre due to temperature drifts and microphonics. The typical active fibre link stabilization is done using balanced optical cross-correlator (OXC) that compares the optical signal of the transmitter (e.g. MLO) and receiver (e.g. Probe Laser) and minimize its phase difference using analog or digital feedback loop.

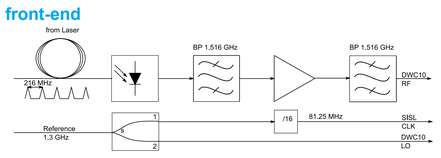


“DRTM-PZT4” PIEZO DRIVER APPLICATIONS

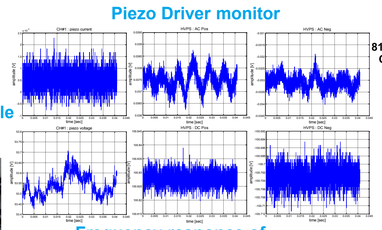
Master Laser Oscilator synchronization test stand

Laser to RF front-end

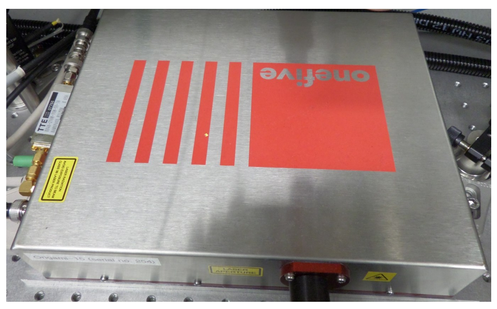




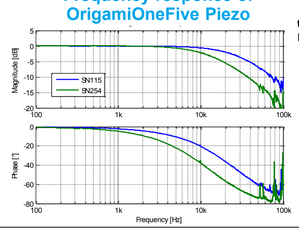
Piezo Driver monitor



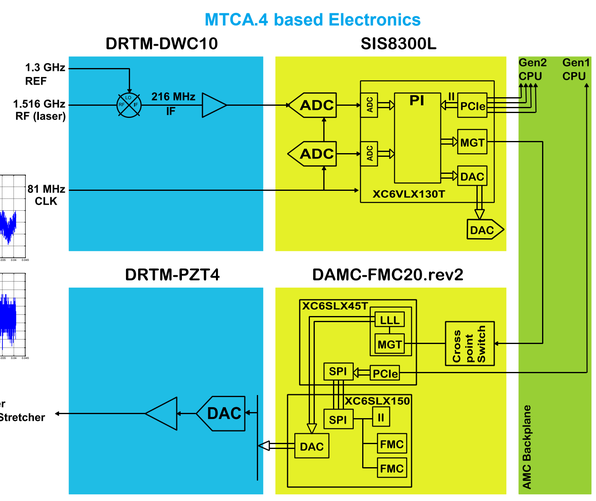
Origami-15 onefive ultra-low-noise femtosecond laser module (wavelength of 1553 nm with repetition rate of 216 MHz)



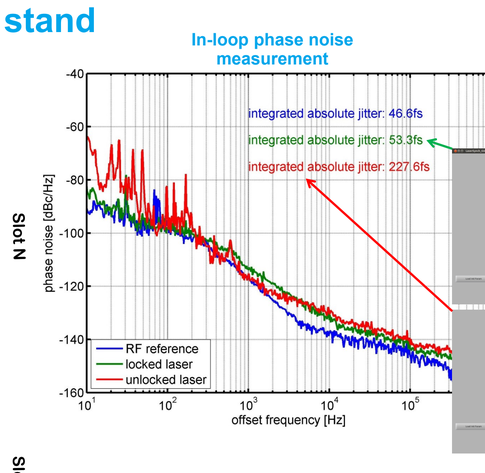
Frequency responce of OrigamiOneFive Piezo



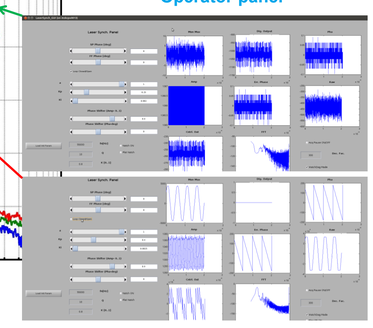
MTCA.4 based Electronics



In-loop phase noise measurement

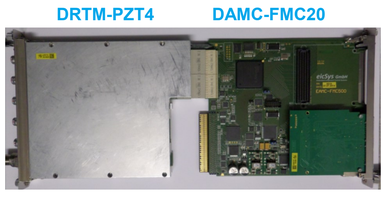


Operator panel

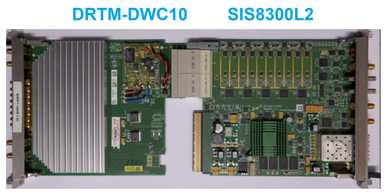


Slot N

DRTM-PZT4



DAMC-FMC20

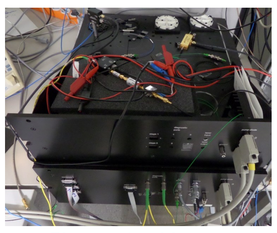


DRTM-DWC10

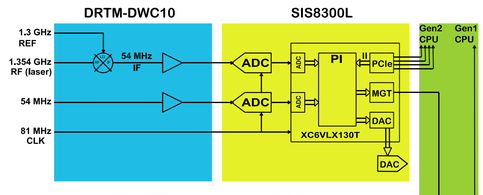
SIS8300L2

Electro-optical bunch lenght diagnostic laser synchronization test stand

Ytterbium-Fiber Laser (wavelength of 1030 nm with repetition rate of 54 MHz)

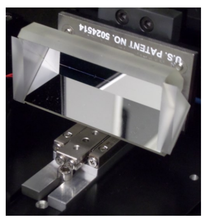


DRTM-DWC10 / SIS8300L

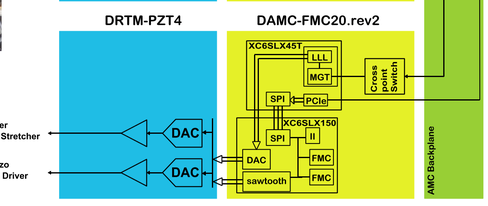


Operator panel

Piezo motor driver



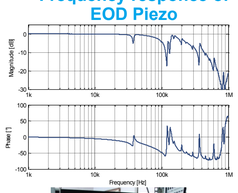
DRTM-PZT4 / DAMC-FMC20.rev2



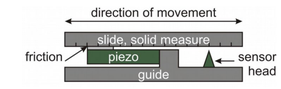
Front side of MTCA.4 2U crate

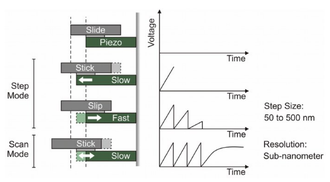
Rear side of MTCA.4 2U crate

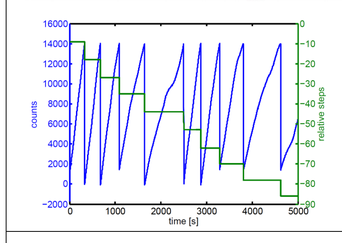
Frequency responce of EOD Piezo



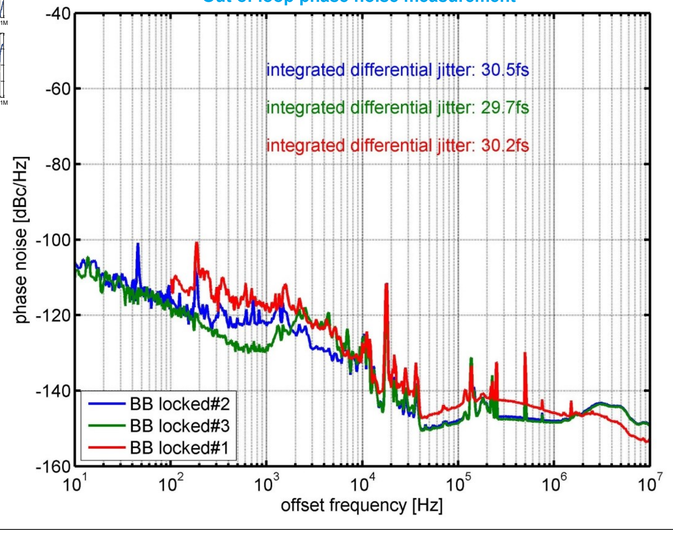
direction of movement





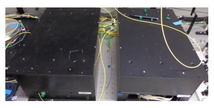


Out of loop phase noise measurement

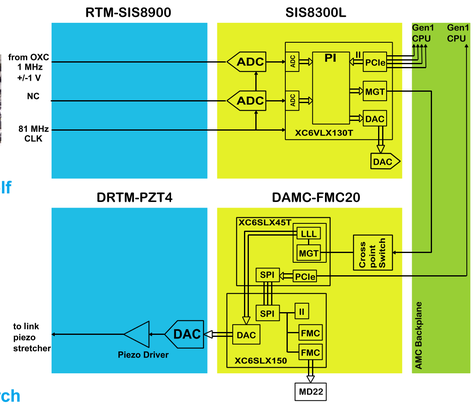


Fiber Link stabilization test stand

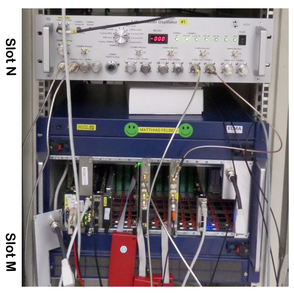
Fiber Piezo-stretcher & supported optics



RTM-SIS8900 / SIS8300L

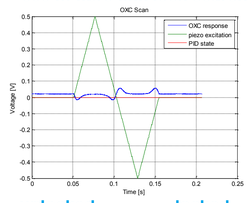


Front side of MTCA.4 shelf

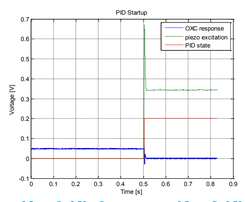


Rear side of MTCA.4 shelf

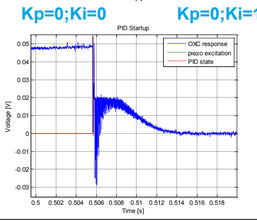
300 m fibre link lock search



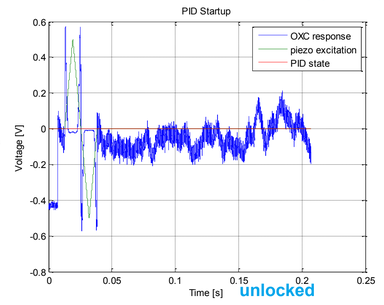
unlocked locked

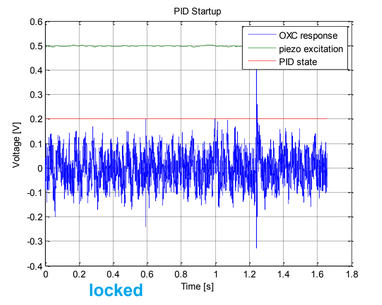


Kp=0;Ki=0 Kp=0;Ki=1e-8



3.6 km fibre link lock





The fibre link stabilization procedure consists of:

a) Course tuning stage (with step motor), where the OXC signal is searched by moving step motor device,
b) Fine tuning stage (with piezo fibre stretcher), where the digital feedback controller (PI algorithm) is activated to drive fast piezo actuator.

Conclusions

The designed MicroTCA.4 “DRTM-PZT4” Piezo Driver has been successfully tested with different conditions (unipolar and bipolar piezo actuators) and various capacitance load (from 30 nF up to 100 nF). The MLO laser oscillator has been locked to 1.3 GHz reference with integrated differential jitter of 50 fs (in loop). The 3.6 km long fibre link has been stabilized to deliver fs optical pulses. The electro-optical bunch laser synchronization performance to 1.3 GHz reference has been measured to be less than 30 fs of integrated differential jitter (out of loop). During long term laser operation it was noticed that several piezo motor driver steps have been generated to relax the piezo driver voltage whenever threshold condition has been reached. The designed RTM Piezo Driver module has been commercialized and its mass production for XFEL facility installation has been lunched.

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