High Voltage Piezo Driver RTM and its application

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This project is supported by Grant No. HVF-0016 "MTCA.4 for Industry" awarded by the Helmholtz Validation Fund.
Double width, mid-size, Rear Transition Module (RTM)

Zone 3 compatibility: D1.0, D1.1, D1.2

Power consumption: max. 30 W

High voltage power supply
- Internal: ±100 V (generated from 12 V Payload Power)
- External: max. ±150 V (solder option)

No. of output channels (Actuator): 4x (bip. ±80 V, unip. 0..80 V)
- DAC, 18-bit, 1 MSPS or ext. input (remotely)
- Programmable low pass filter: (1÷150) kHz (remotely)
- Switching relays for actuator and sensor functionality (remotely)

No. of input channels (Sensor): 4x (bip. ±1 V)
- ADC, 18-bit, 100 kSPS

Interlock signal support (hardware protection)
Supported AMCs

DAMC-02  DAMC-FMC20  DAMC-FMC25  DAMC-TCK7

increasing FPGA resources
Foreseen Application

The reference timing information is encoded in the precise repetition rate of an optical pulse train.

- RF Master Oscillator
- RF to Optical
- Master Laser Oscillator
- Splitting (→ 16 Outputs)
- Distribution and active length stabilization
- Laser Source locked to machine reference
- Fiber Links (≤ 300 m)
- Courtesy by M. Felber

Flowchart:
- Optical to RF
- Optical to RF
- Optical to RF
- Beam Diagnostic
- Optical to Optical
- Optical to Optical
- Optical to Optical
- Optical to Optical
- Optical to Optical
- Each RF Station
- Low Level RF
- Low Level RF
- BAM / EBPM
- Diagnostic Lasers (EOS, TEO)
- Seed Laser
- Probe Laser
- GUN
- LINAC
- Undulator
- Pump-Probe Exp.

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Application components part#1

- Ytterbium-Fiber Laser (wavelength of 1030 nm with repetition rate of 54 MHz) that consists of a ring oscillator with a fiber and a free space part supported by piezo stretcher and motorized stage (based on piezo motor driver)

Courtesy by B. Steffen, P. Peier
Typical piezo capacitance: $C_L = 64 \text{ nF}$

http://www.smaract.de/
Electro-optical Bunch Length Measurements (2)

- Application components part#2:
  - RF front-end supported by photodetector and set of bandpass, low pass RF filters
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Electro-optical Bunch Length Measurements (3)

> Application components part#3:
  - RTM Downconverter for 1.3 GHz LO
  - AMC Digitizer/Controller/Transmitter (ADC sampling at 81.25 MHz, low latency link rate 3.125 Gbs)
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- RTM Downconverter for 1.3 GHz LO, 54 MHz IF
- AMC Digitizer/Controller/Transmitter (ADC sampling at 81.25 MHz, low latency link rate 3.125 Gbs)
Electro-optical Bunch Length Measurements (4)

> Application components part#4:

- AMC Receiver/Controller (low latency link rate 3.125 Gbs, DAC sampling at 1 MHz)
- RTM Piezo Driver
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Application components part#4:

- AMC Receiver/Controller (low latency link rate 3.125 Gbs, DAC sampling at 1 MHz)
- RTM Piezo Driver
Electro-optical Bunch Length Measurements (5)

> Application components part#5:

- MTCA.4 crate (2U starter kit from Power Bridge)
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- MTCA.4 crate (2U starter kit from Power Bridge)
DRTM-PZT4 Setup for EOD Application

Piezo capacitance $C_L=33 \, \text{nF}$ (bipolar up to $\pm200 \, \text{V}$),

$1^{st}$ piezo resonance $30\div40 \, \text{kHz}$

 Courtesy by M. Felber

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Phase noise measurements (2)

- PZT4 output channel connected to piezo fiber stretcher
  (coarse tuning) (out-of-loop)
Master Laser Oscillator Synchronization (1)

> Application components part#1

- Origami-15 onefive ultra-low-noise femtosecond laser module (wavelength of 1553 nm with repetition rate of 216 MHz) that consists of mode-locked erbium-doped fiber laser and a free space part supported by piezo stretcher and motorized stage (based on temperature stabilized controller)
Master Laser Oscillator Synchronization (3)

> Application components part#3:

- MTCA.4 crate (6U from Elma)
DRTM-PZT4 Setup for MLO Application

- Piezo capacitance $C_L = 100 \text{ nF}$ (unipolar 0 ÷ 120 V),
- lock range up to few kHz

Courtesy by M. Felber
Phase noise measurements

> PZT4 output channel connected to piezo fiber stretcher (in-loop)

integrated absolute jitter: 46.6fs
integrated absolute jitter: 53.3fs
integrated absolute jitter: 227.6fs

Courtesy by U. Mavric
Application components part#1

- The idea is to distribute RF synchronized laser pulses over large scale machine using long fiber links, the transmitted (MLO) and received (e.g. PPL) optical pulses are compared in phase using balanced optical cross-correlator (OXC) (e.g. due to temperature drifts, microphonics) and next stabilized using digital loop controller.

Fiber Link Stabilization (2)

> Application components part#2:

- MTCA.4 crate (6U from Elma)
Piezo capacitance 
\( C_L = 88 \text{ nF} \) (bipolar \( \pm 400 \text{ V} \)),

1st piezo resonance
\( 18 \div 20 \text{ kHz} \)

Courtesy by M. Felber
3.6 km Fiber Link Stabilization

![PID Startup Graph](image)

Courtesy by M. Heuer
Conclusions

> 5x RTM Piezo Driver boards manufactured by DESY (3x of them permanently installed and used)

> Main applications foreseen for synchronization and special diagnostics tested and proved to be satisfied for the end-users:

  - EOD laser synchronization (1)
  - piezo motor based (2) coarse tuning;
  - MLO (3) laser synchronization
  - fiber link stabilization (4)

> Both unipolar and bipolar piezo stretchers operable

> Product licensed to industry
THANK YOU FOR ATTENTION