High Voltage Piezo Driver RTM

and its application

3rd MicroTCA Workshop for
Industry and Research
08 -11 December 2014

Dr. Konrad Przygoda - DESY

for the LLRF Team

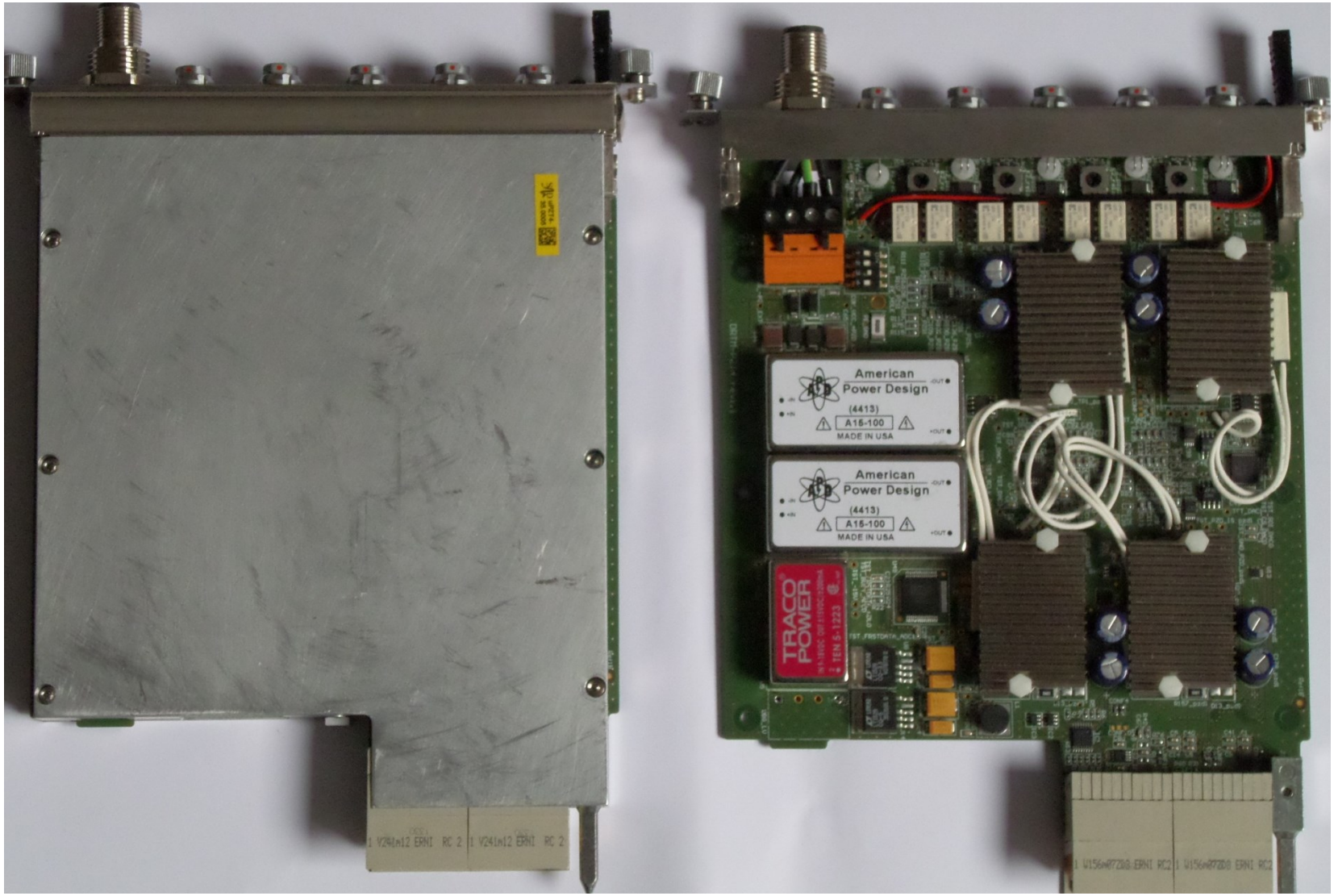
Hamburg, 11.12.2014

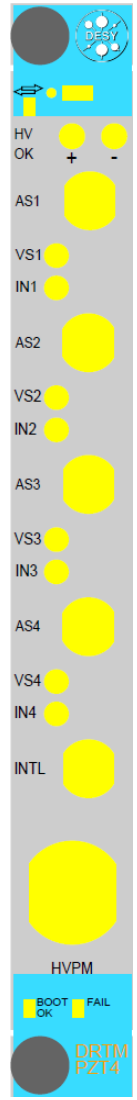
This project is supported by Grant No. HVF-0016
"MTCA.4 for Industry" awarded by the Helmholtz
Validation Fund.

Datasheet

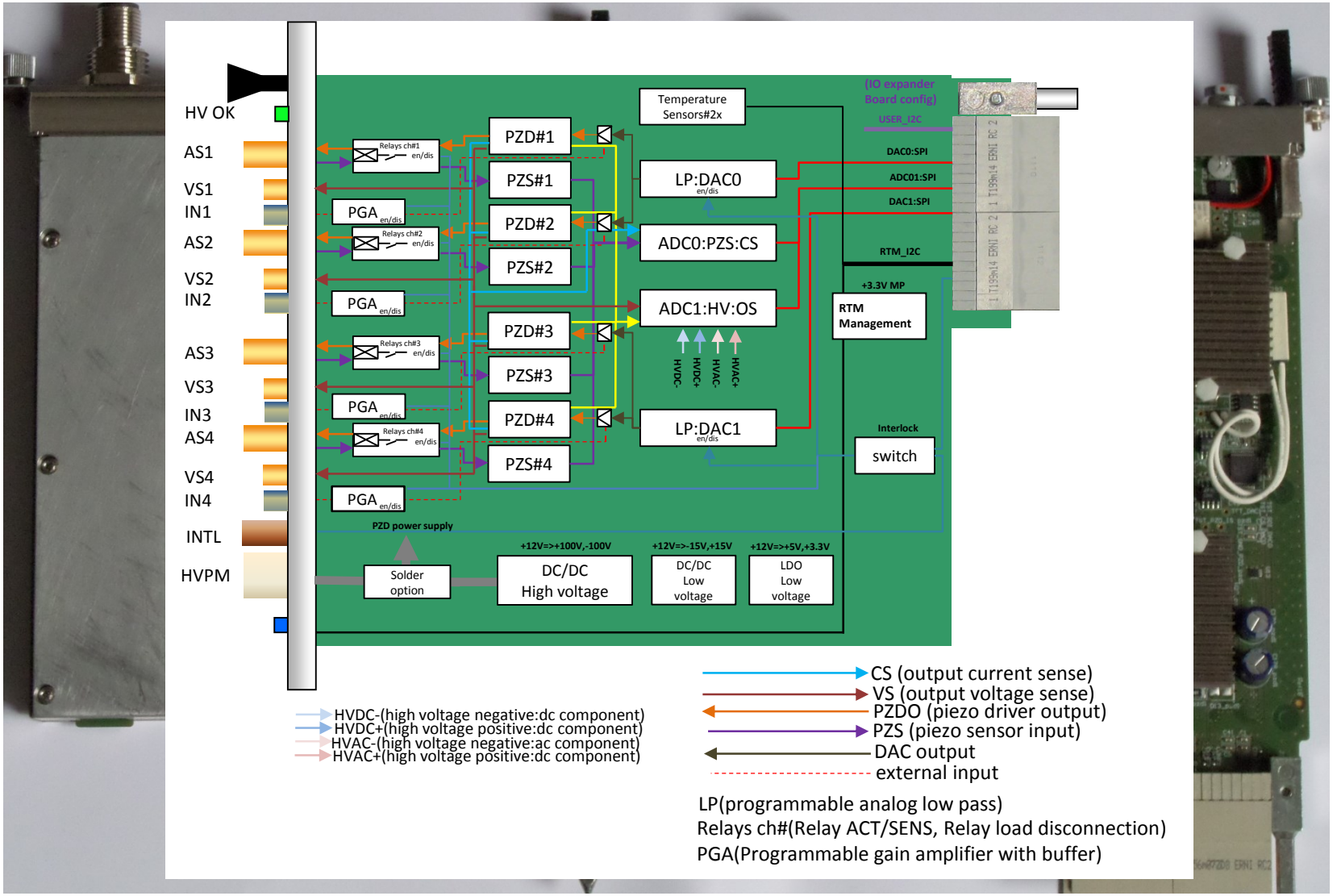
- Double width, mid-size, Rear Transition Module (RTM)
- Zone 3 compatibility: D1.0, D1.1, D1.2
- Power consumption: max. 30 W
- High voltage power supply
  - Internal: ±100 V (generated from 12 V Payload Power)
  - External: max. ±150 V (solder option)
- No. of output channels (Actuator): 4x (bip. ±80 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)

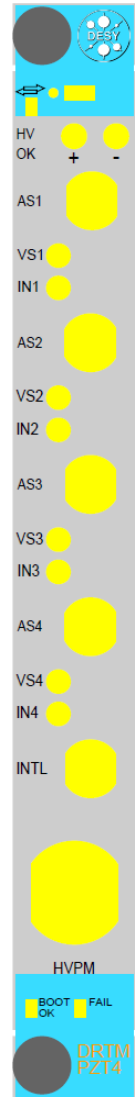
DRTM-PZT4 (1)


American
Power Design
(4413)
A15-100
MADE IN USA
American
Power Design
(4413)
A15-100
MADE IN USA
TRACO
POWER


DESY
HV
OK
+
-
AS1
VS1
IN1
AS2
VS2
IN2
AS3
VS3
IN3
AS4
VS4
IN4
INTL
HVPM
BOOT
OK
FAIL
DRTM
PZT4

DRTM-PZT4 (2)


HV OK
AS1
VS1
IN1
AS2
VS2
IN2
AS3
VS3
IN3
AS4
VS4
IN4
INTL
HVPM
Relays ch#1 en/dis
Relays ch#2 en/dis
Relays ch#3 en/dis
Relays ch#4 en/dis
PGA en/dis
PZD#1
PZS#1
PZD#2
PZS#2
PZD#3
PZS#3
PZD#4
PZS#4
Temperature Sensors#2x
LP:DAC0 en/dis
ADC0:PZS:CS
ADC1:HV:OS
LP:DAC1 en/dis
HVDC-
HVDC+
HVAC-
HVAC+
(IO expander Board config)
USER_I2C
DAC0:SPI
ADC01:SPI
DAC1:SPI
RTM_I2C
+3.3V MP
RTM Management
Interlock
switch
PZD power supply
Solder option
+12V=>+100V,-100V
DC/DC High voltage
+12V=>-15V,+15V
DC/DC Low voltage
+12V=>+5V,+3.3V
LDO Low voltage
HVDC-(high voltage negative:dc component)
HVDC+(high voltage positive:dc component)
HVAC-(high voltage negative:ac component)
HVAC+(high voltage positive:dc component)
CS (output current sense)
VS (output voltage sense)
PZDO (piezo driver output)
PZS (piezo sensor input)
DAC output
external input
LP(programmable analog low pass)
Relays ch#(Relay ACT/SENS, Relay load disconnection)
PGA(Programmable gain amplifier with buffer)


DESY
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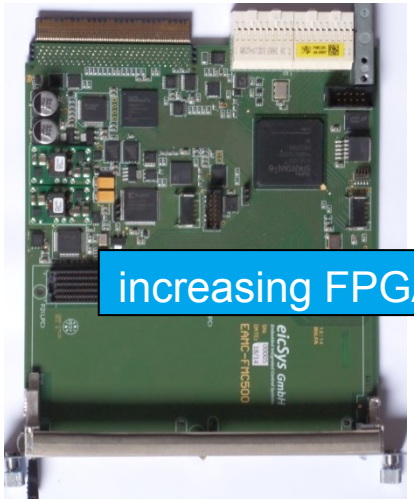
FAIL
DRTM PZT4

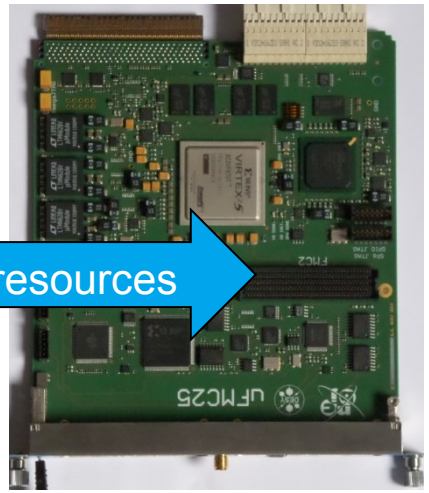
Supported AMCs

DAMC-02

DAMC-FMC20



DAMC-FMC25

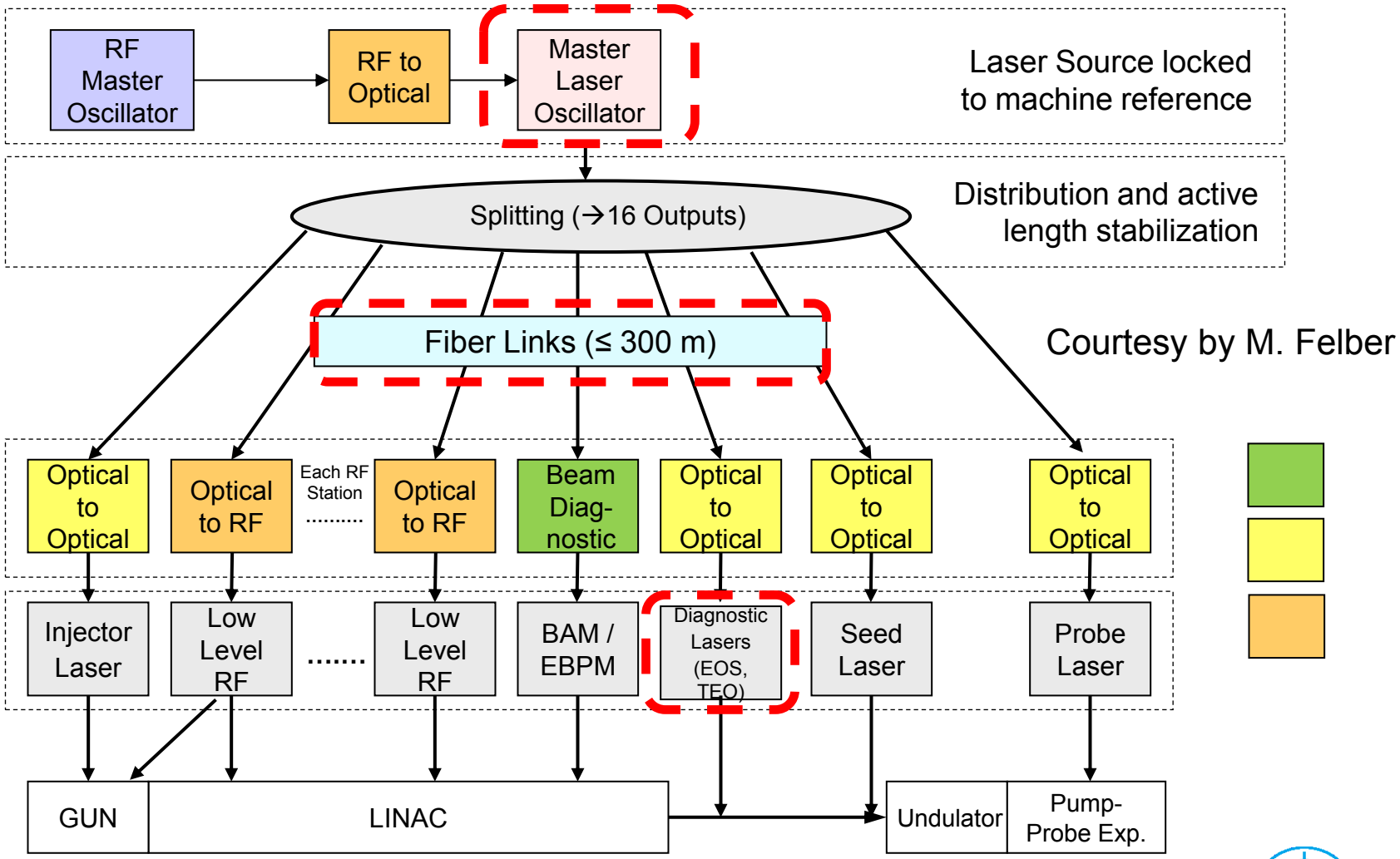


DAMC-TCK7

increasing FPGA resources

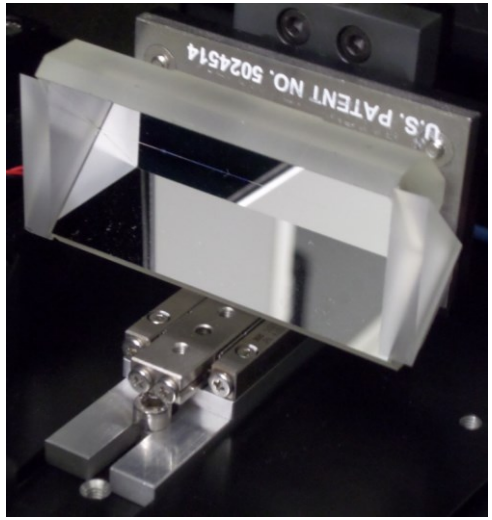
Foreseen Application

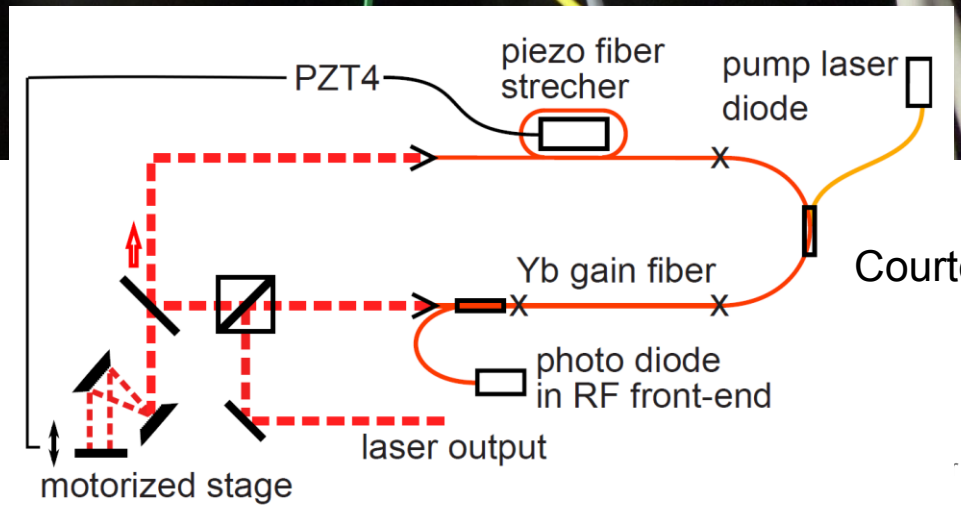
The reference timing information is encoded in the precise repetition rate of an optical pulse train



Electro-optical Bunch Length Measurements (1)

- 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)

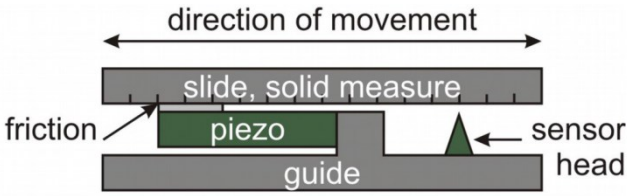


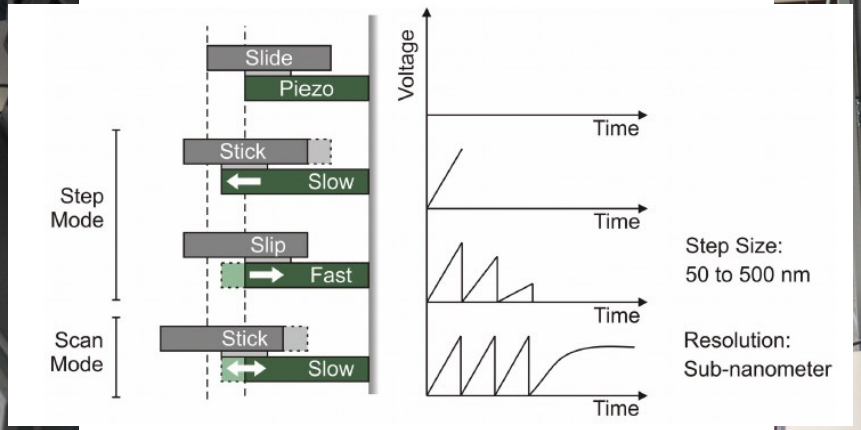


Courtesy by B. Steffen, P. Peier

Piezo Motor Driver (1)

Typical piezo capacitance:
C_L=64 nF

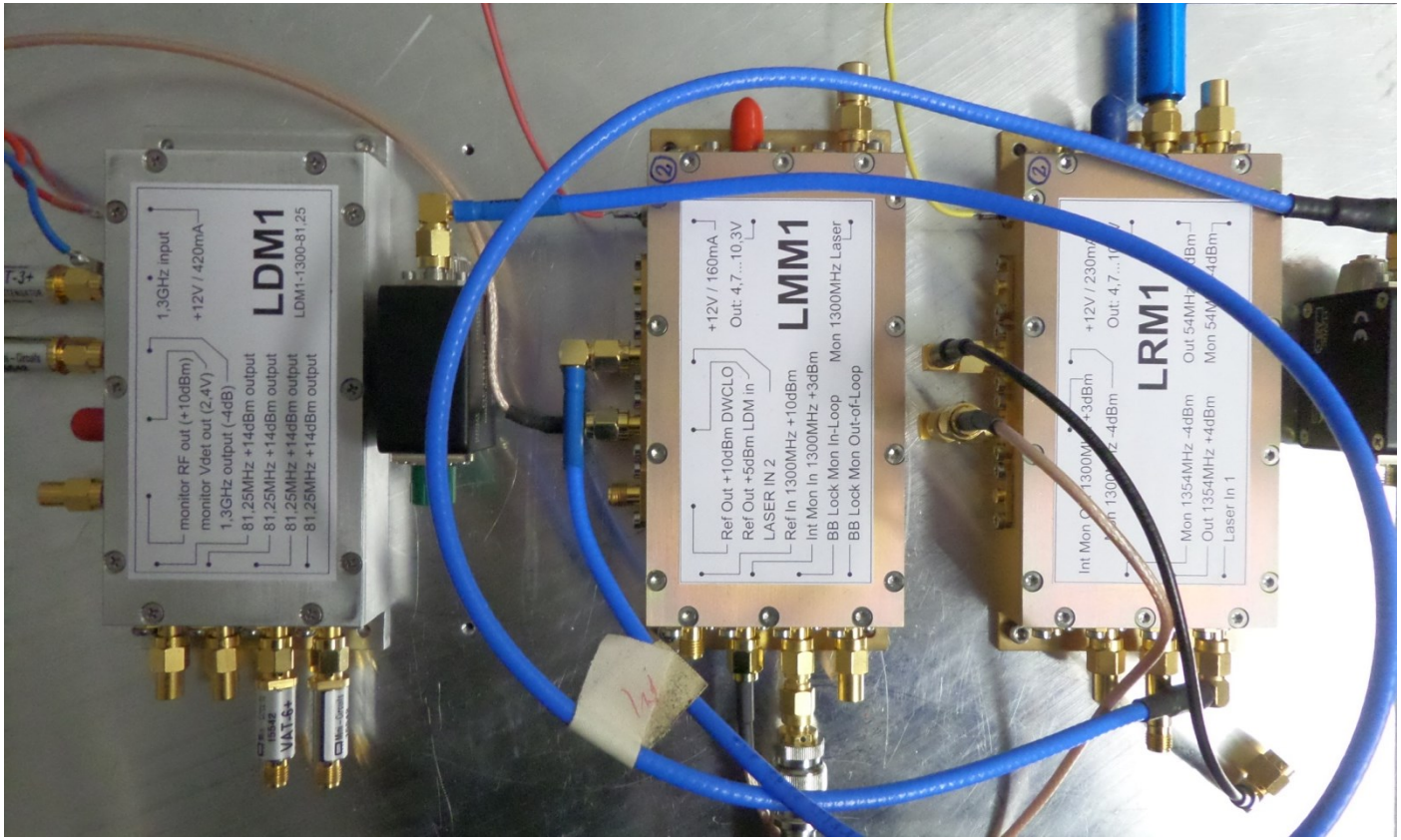




http://www.smaract.de/

Electro-optical Bunch Length Measurements (2)

- Application compenents part#2:
  - RF front-end supported by photodetector and set of bandpass, low pass RF filters



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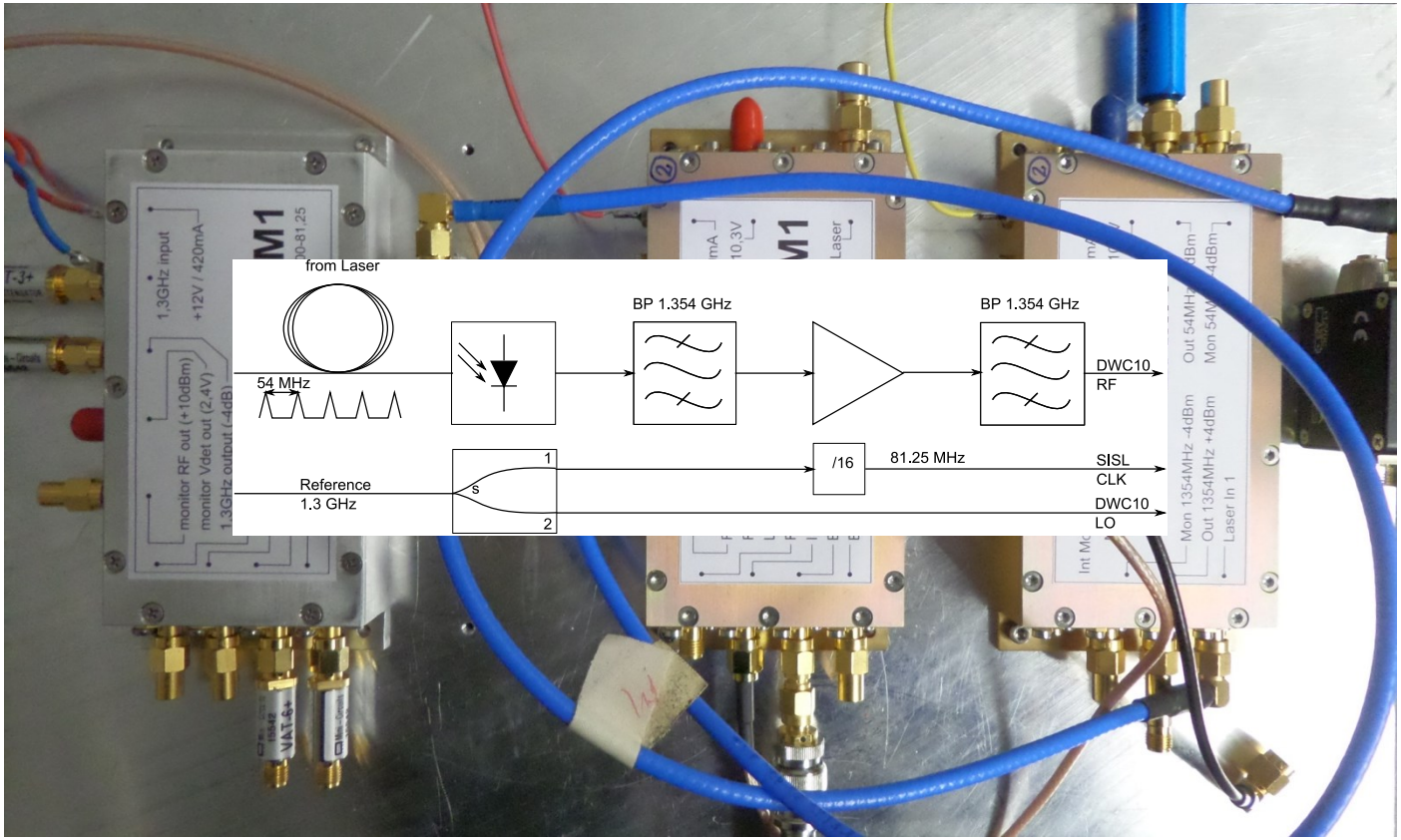
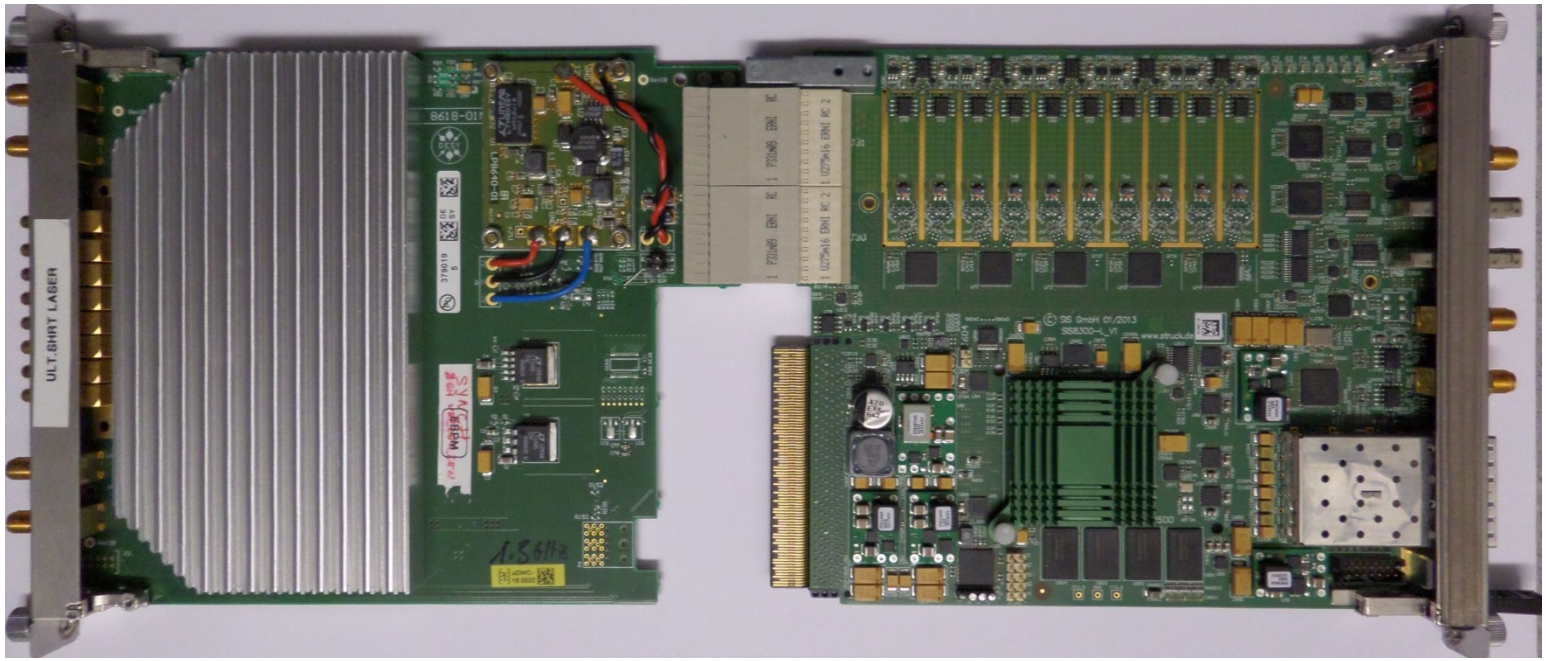


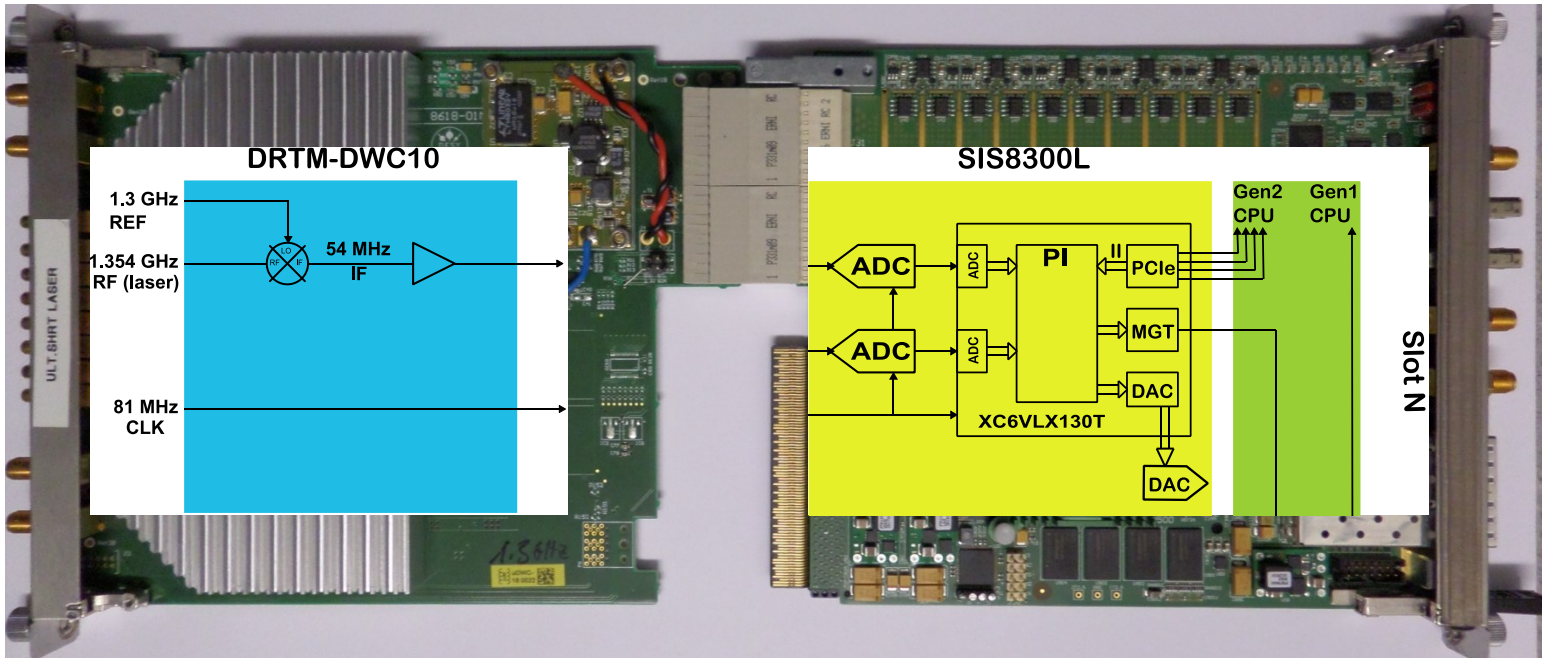
Electro-optical Bunch Length Measurements (3)

- Application compenents 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)



Electro-optical Bunch Length Measurements (3)

- Application compenents part#3:
  - 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 compenents part#4:
  - AMC Receiver/Controller (low latency link rate 3.125 Gbs, DAC sampling at 1 MHz)
  - RTM Piezo Driver

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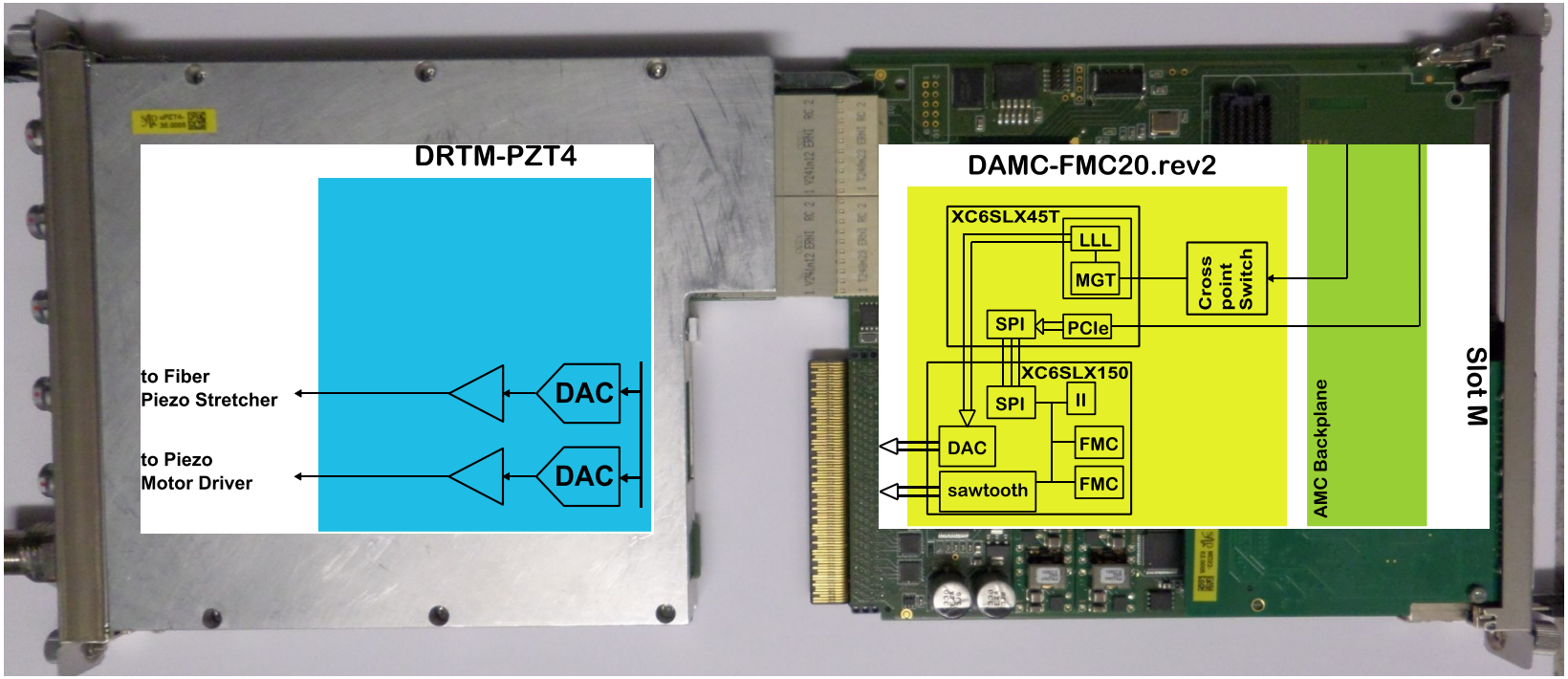
- Application compenents part#4:
  - AMC Receiver/Controller (low latency link rate 3.125 Gbs, DAC sampling at 1 MHz)
  - RTM Piezo Driver



Electro-optical Bunch Length Measurements (5)

- Application compenents part#5:
  - MTCA.4 crate (2U starter kit from Power Bridge)

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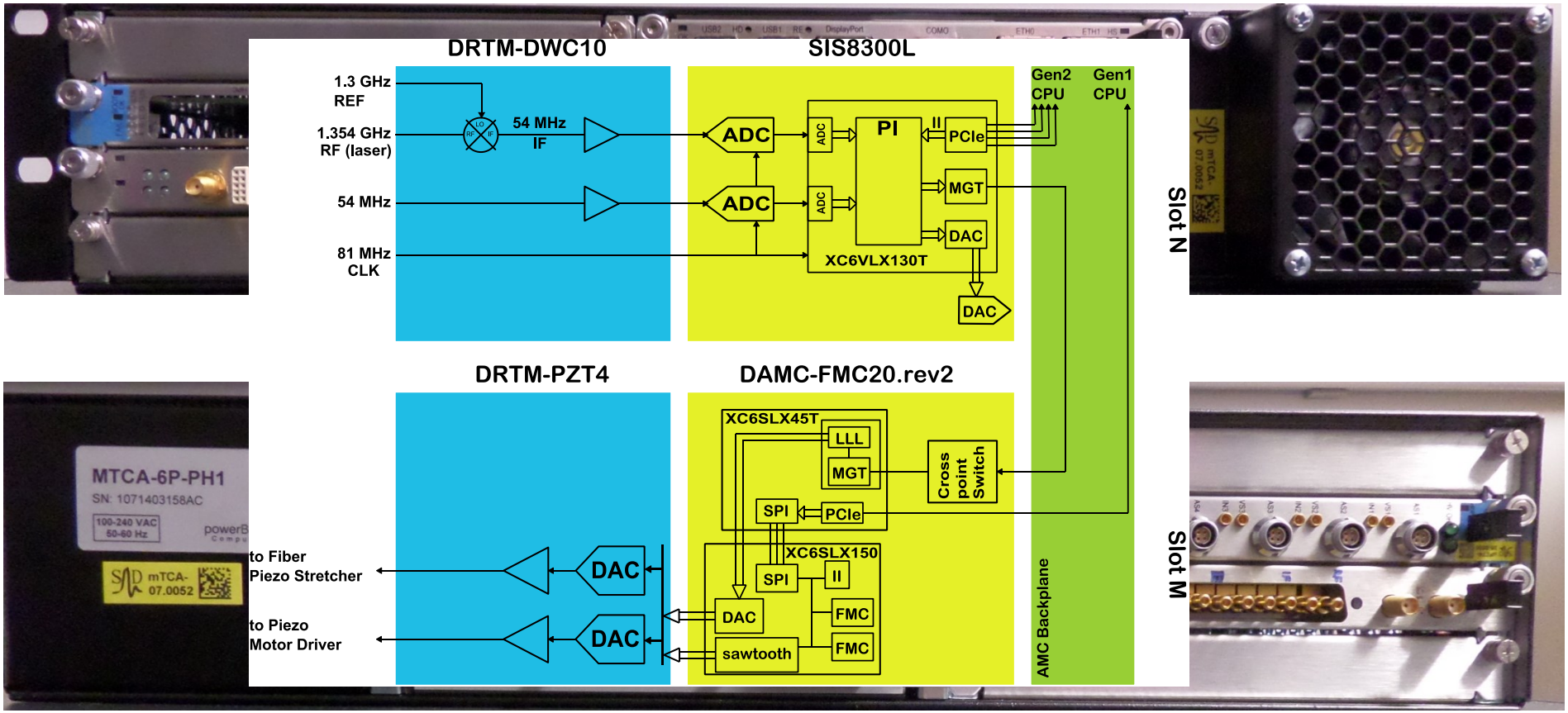
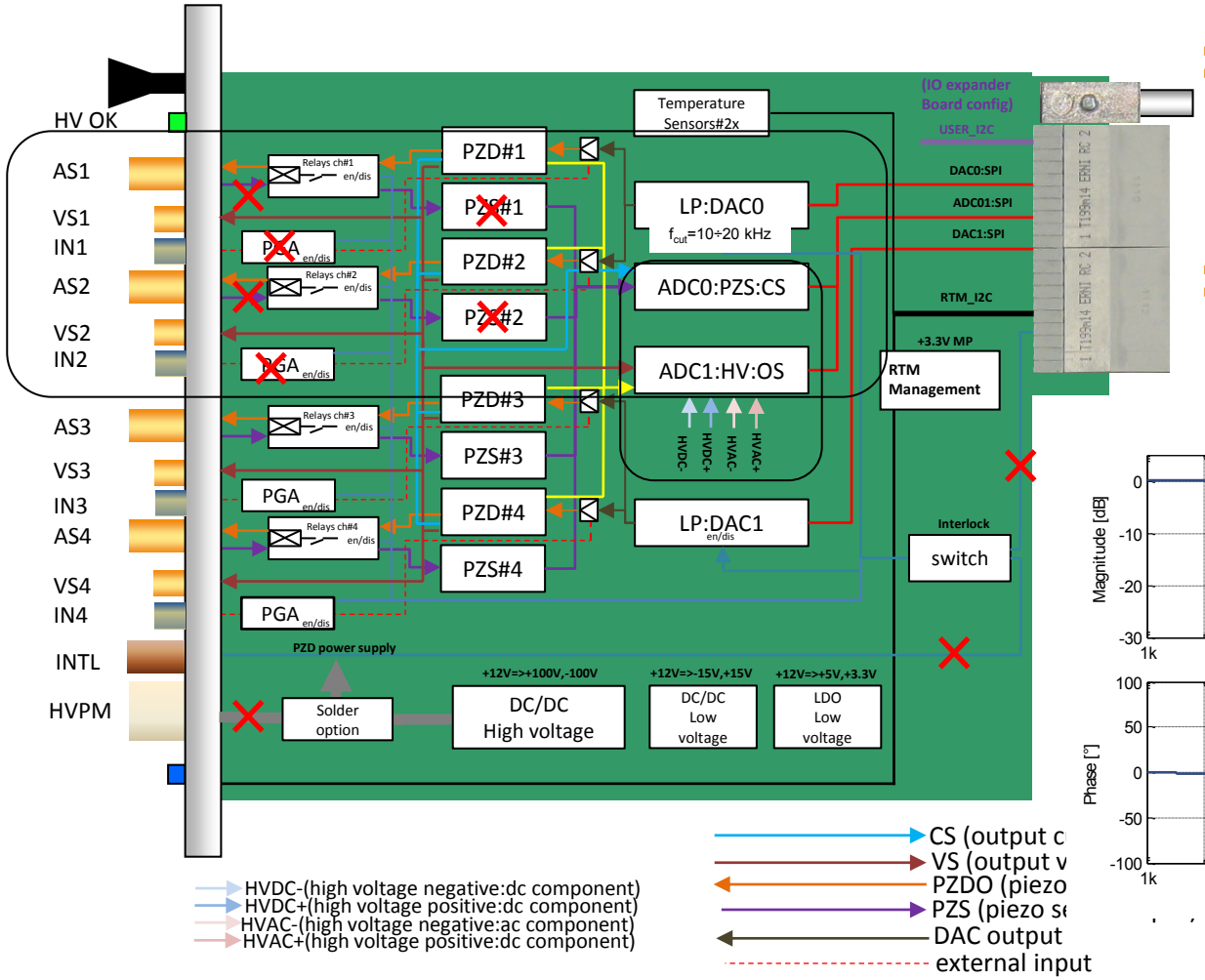
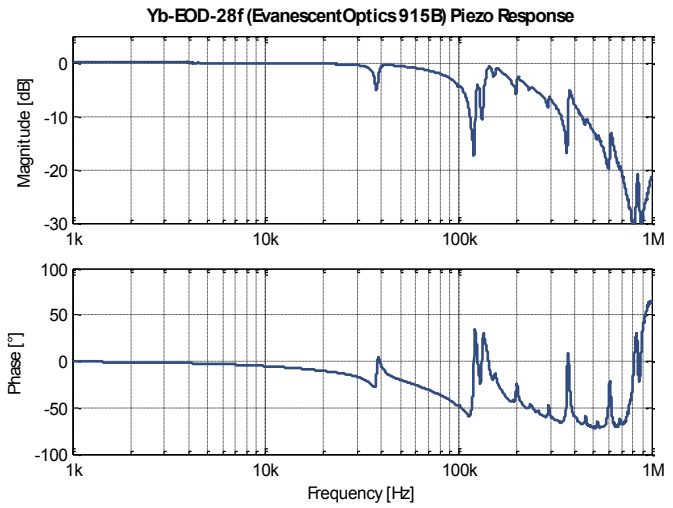


DRTM-PZT4 Setup for EOD Application



- Piezo capacitance C_L=33 nF (bipolar up to ±200 V),
- 1st piezo resonance 30÷40 kHz)



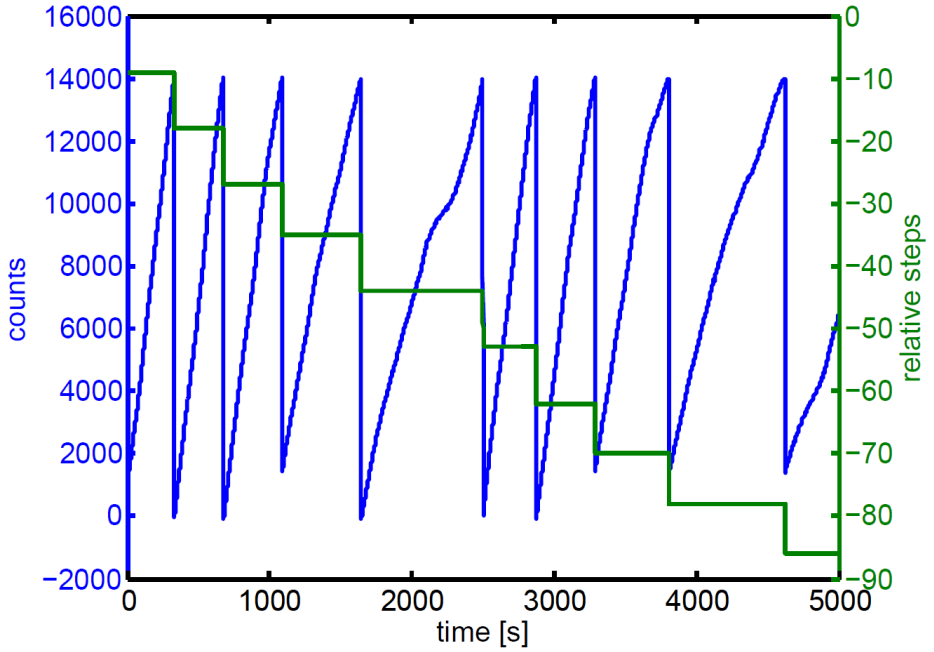
Courtesy by M. Felber

LP(programmable analog low pass)
Relays ch#(Relay ACT/SENS, Relay load disconnection)
PGA(Programmable gain amplifier with buffer)

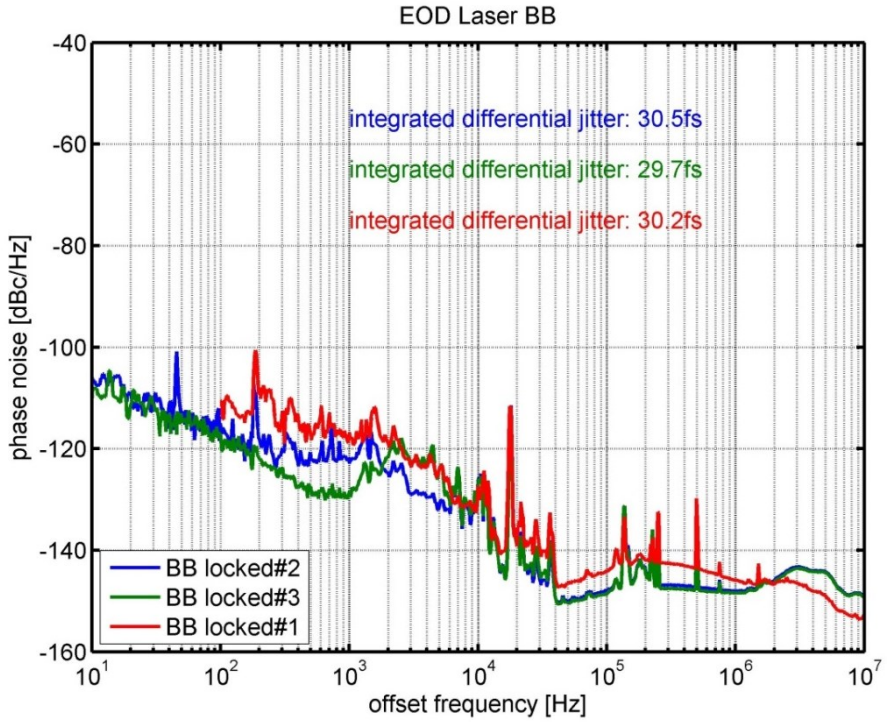
Phase noise measurements (2)

- PZT4 output channel connected to piezo fiber stretcher

(coarse tuning)

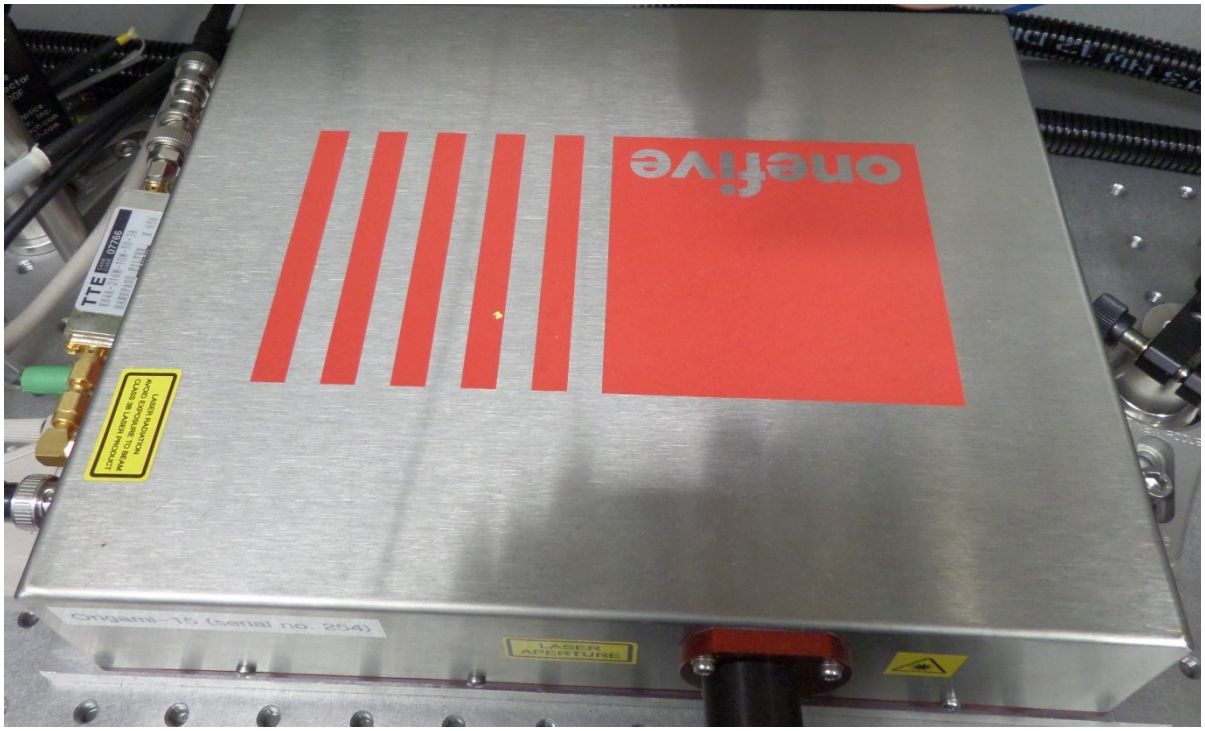


(out-of-loop)



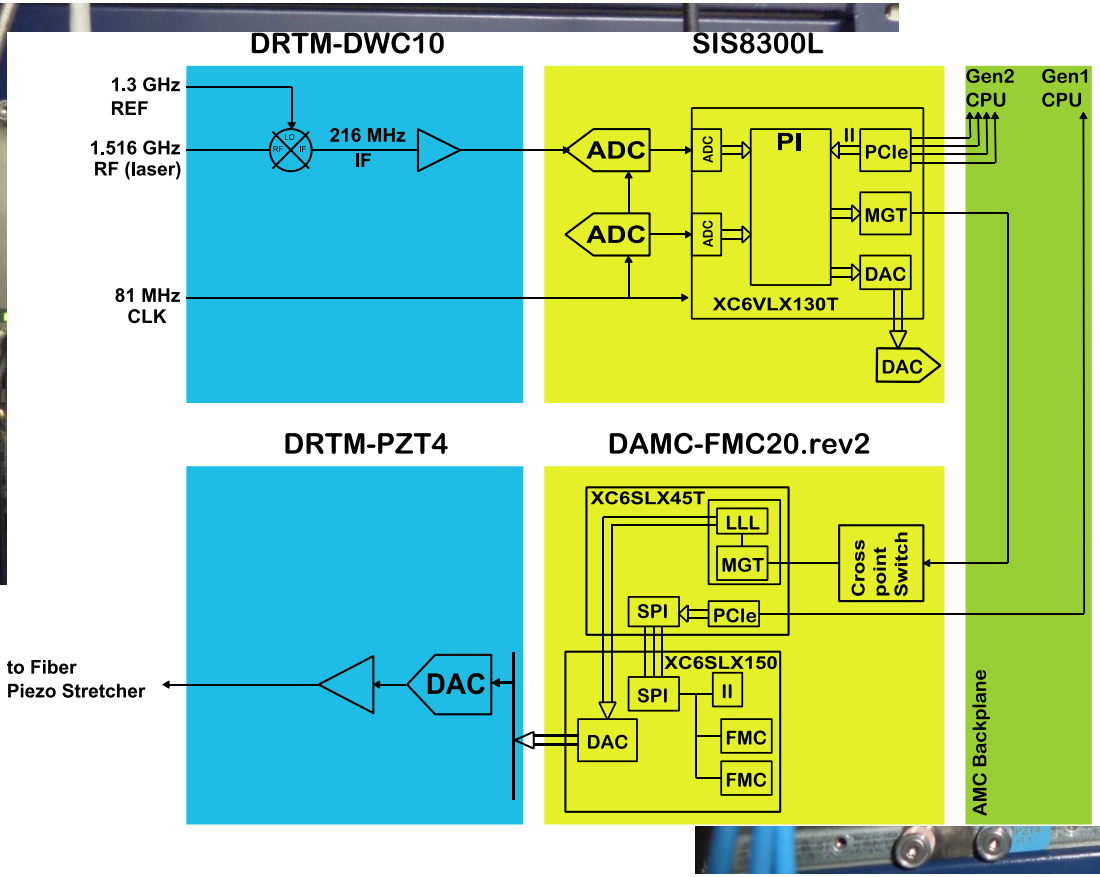
Master Laser Oscillator Synchronization (1)

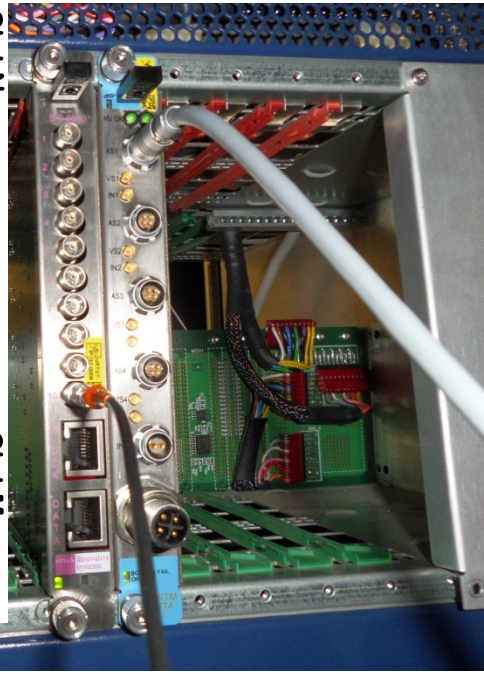
- Application components part#1
  - Origami-15 onefive ultra-low-noise femtosecond laser module (wavelength of 1553 nm with repetition rate of 216 MHz) that consists of mode-locked erbium-doped fiber laser and a free space part supported by piezo stretcher and motorized stage (based on temperature stabilized controller)



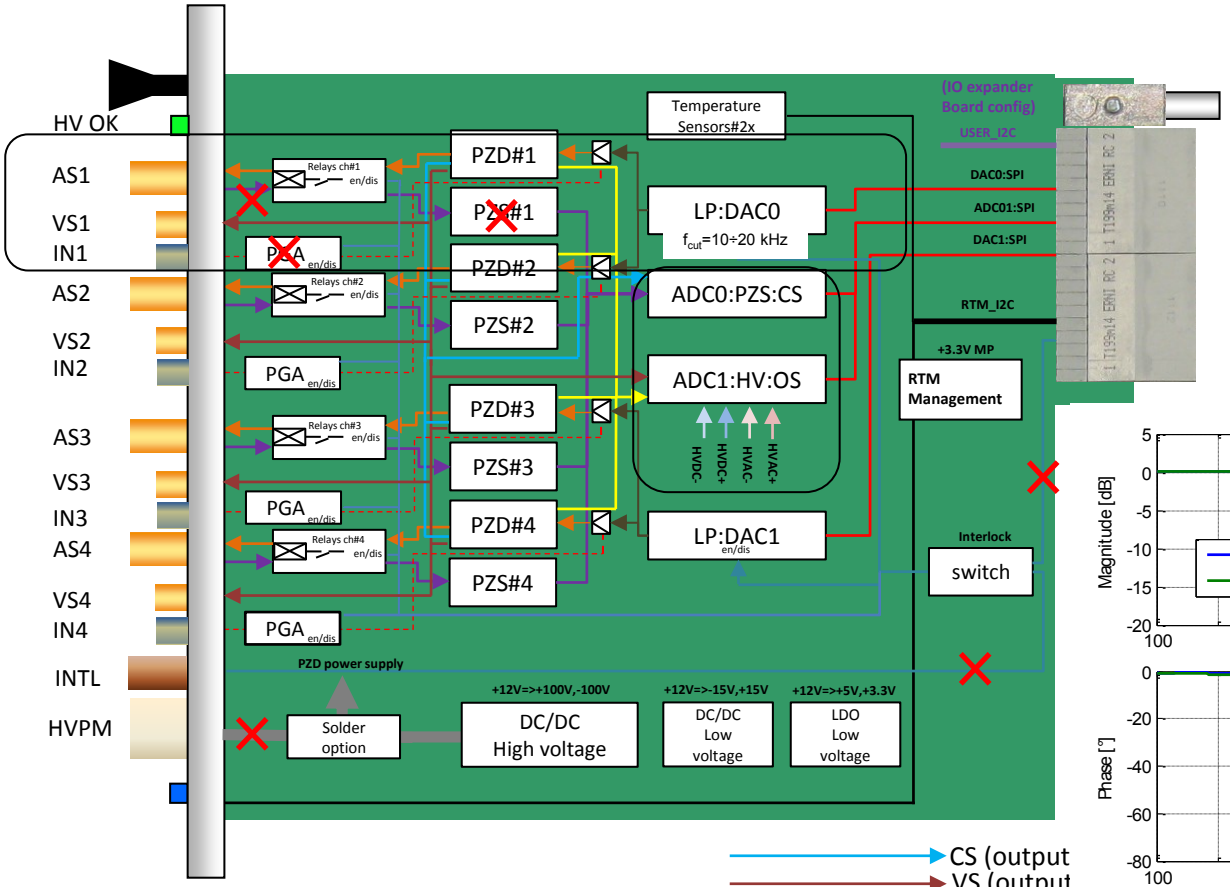
Master Laser Oscillator Synchronization (3)

- Application compenents part#3:
  - MTCA.4 crate (6U from Elma)

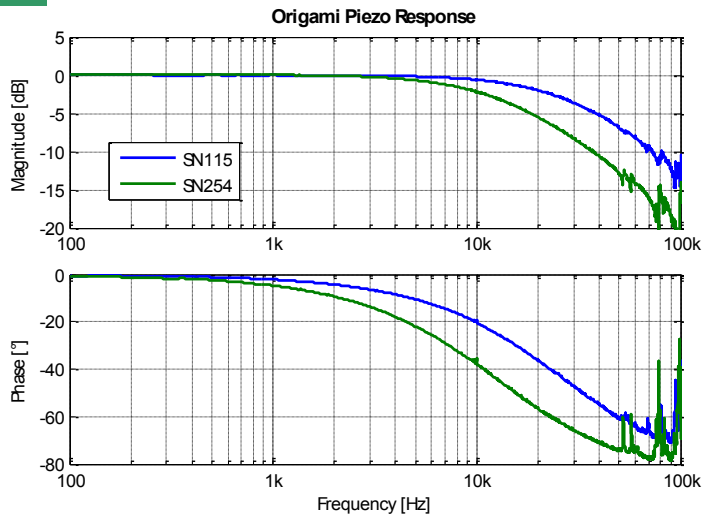




DRTM-PZT4 Setup for MLO Application



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



HVDC-(high voltage negative:dc component)
HVDC+(high voltage positive:dc component)
HVAC-(high voltage negative:ac component)
HVAC+(high voltage positive:dc component)

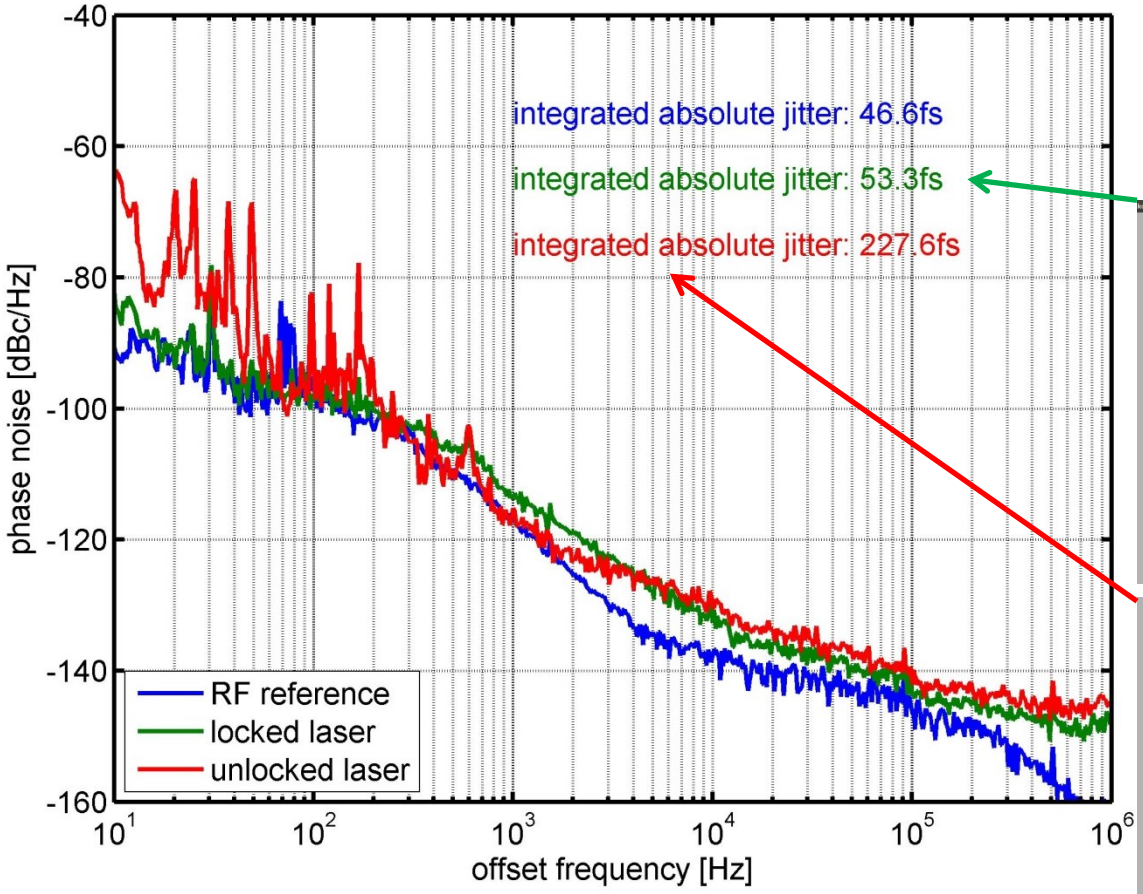
CS (output
VS (output
PZDO (pie
PZS (piezo sensor input)
DAC output
external input

Courtesy by M. Felber

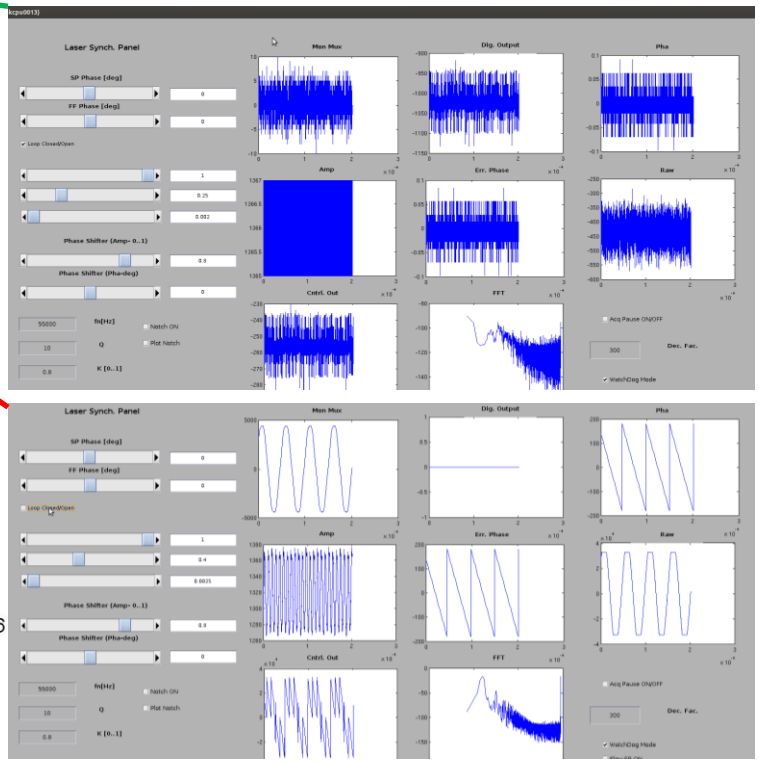
LP(programmable analog low pass)
Relays ch#(Relay ACT/SENS, Relay load disconnection)
PGA(Programmable gain amplifier with buffer)

Phase noise measurements

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

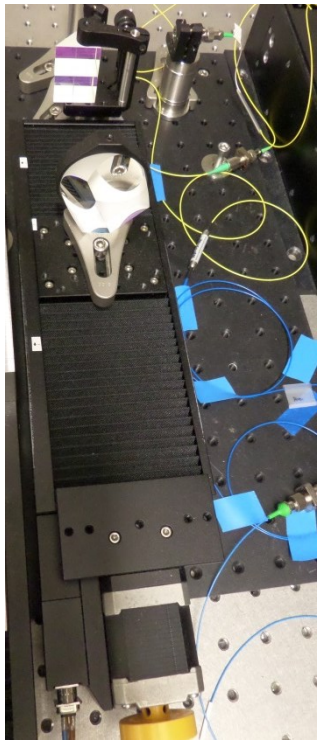


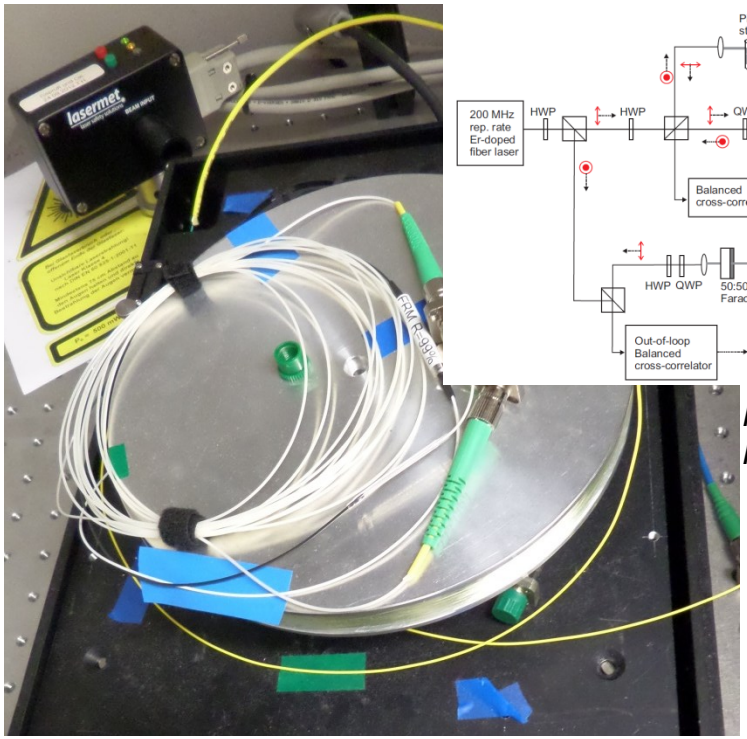
Courtesy by U. Mavric

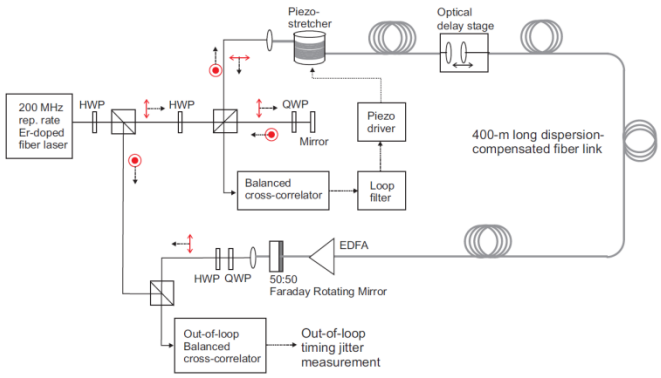


Fiber Link Stabilization (1)

- 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



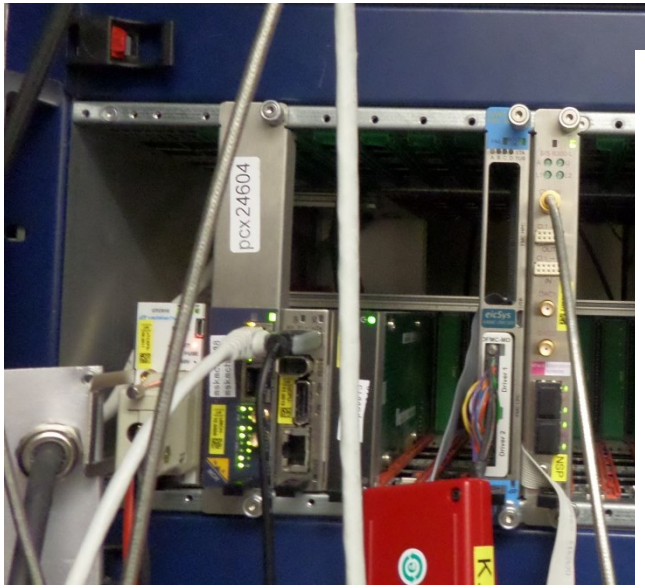


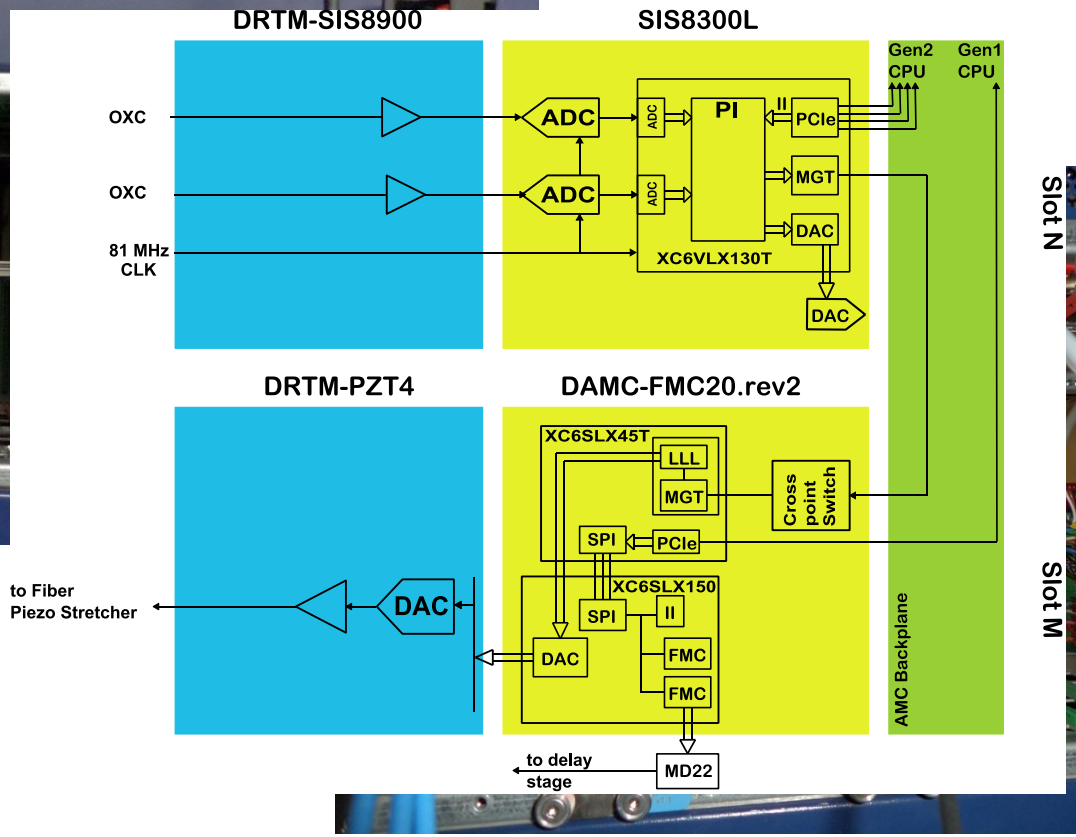


F. Loehl, et al., Proceedings of DIPAC'2007

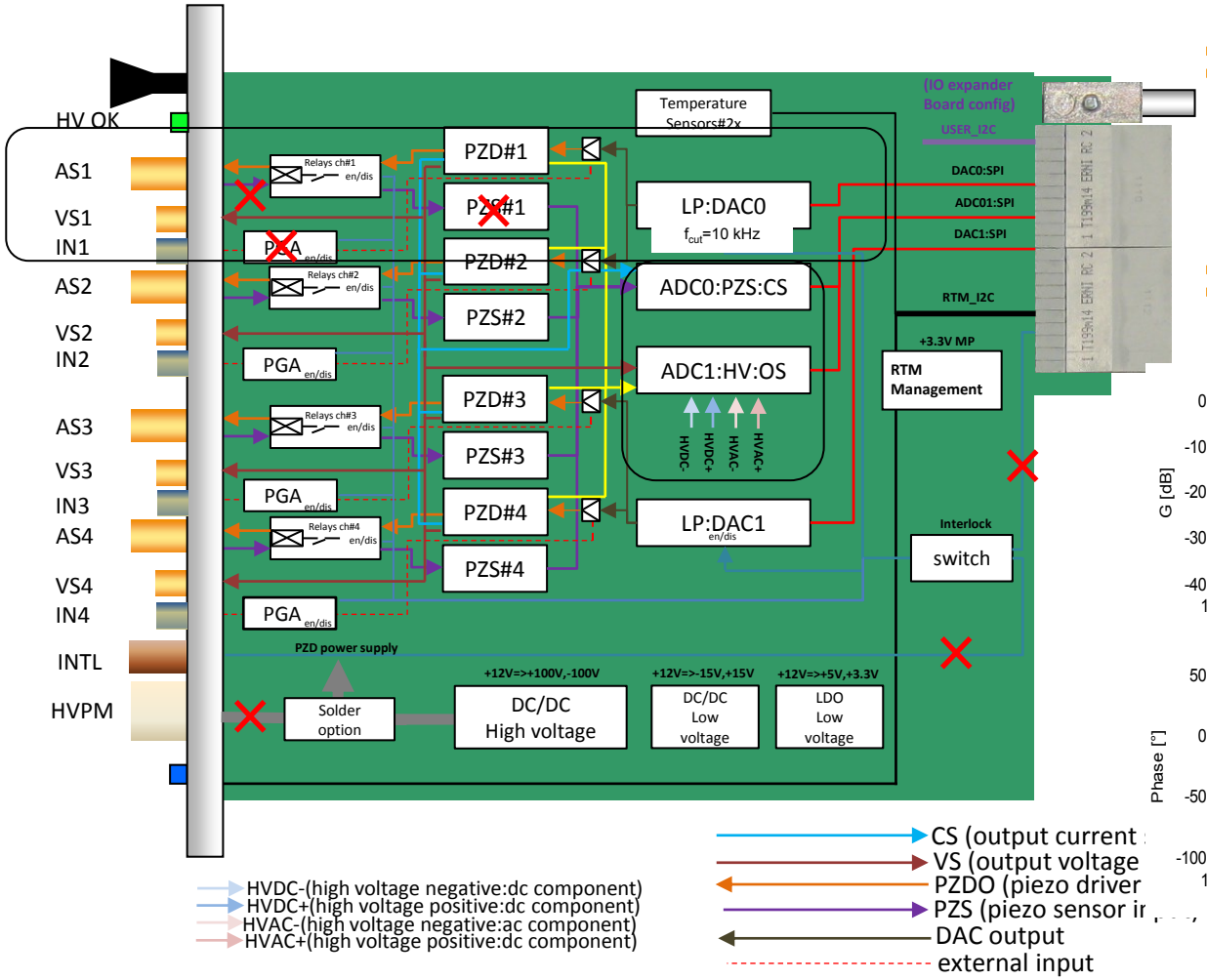
Fiber Link Stabilization (2)

- Application compenents part#2:
  - MTCA.4 crate (6U from Elma)

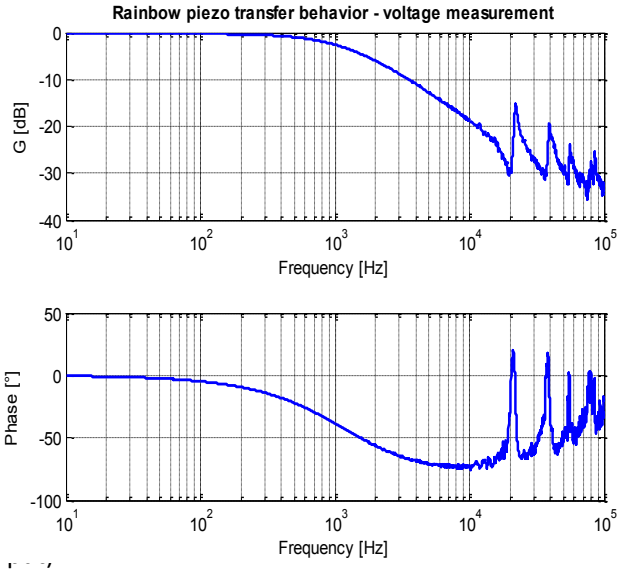




DRTM-PZT4 Setup for Fiber Link Application



- Piezo capacitance C_L=88 nF (bipolar ±400 V),
- 1st piezo resonance 18 ÷ 20 kHz



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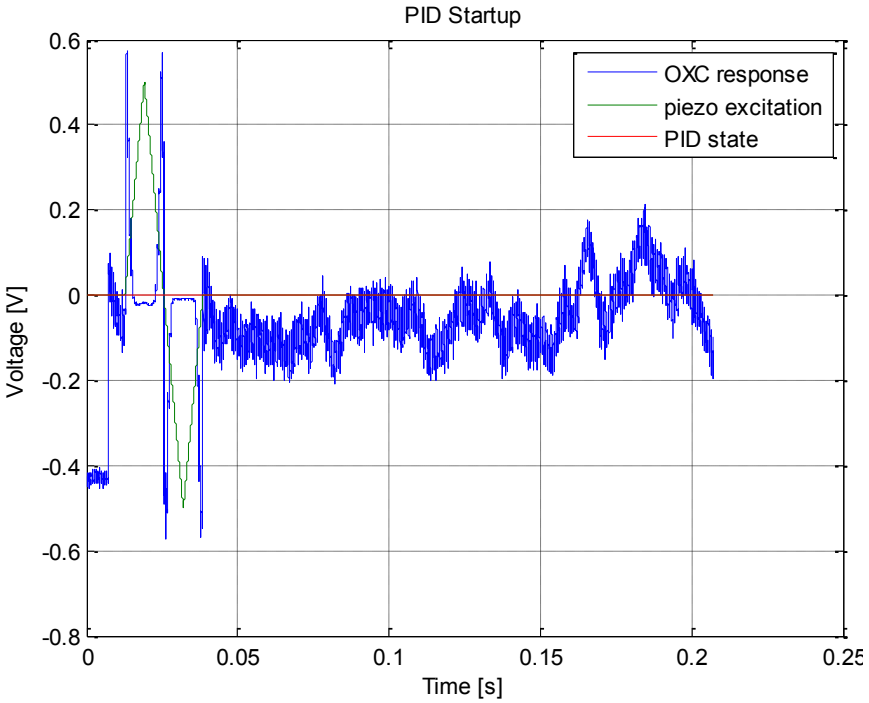
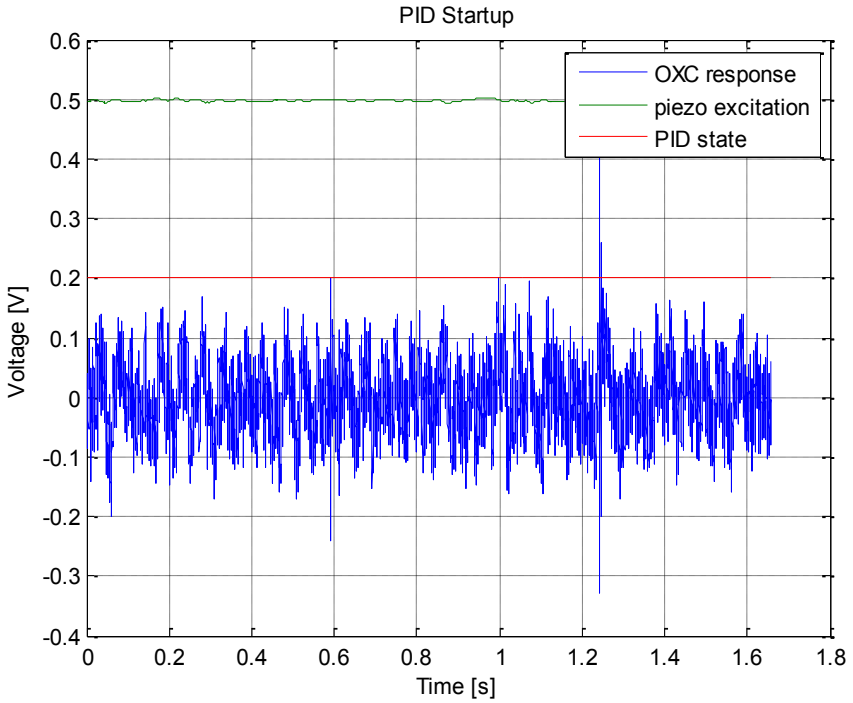
3.6 km Fiber Link Stabilization





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

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THANK YOU FOR ATTENTION