Report on Analog Electronics Subsystem

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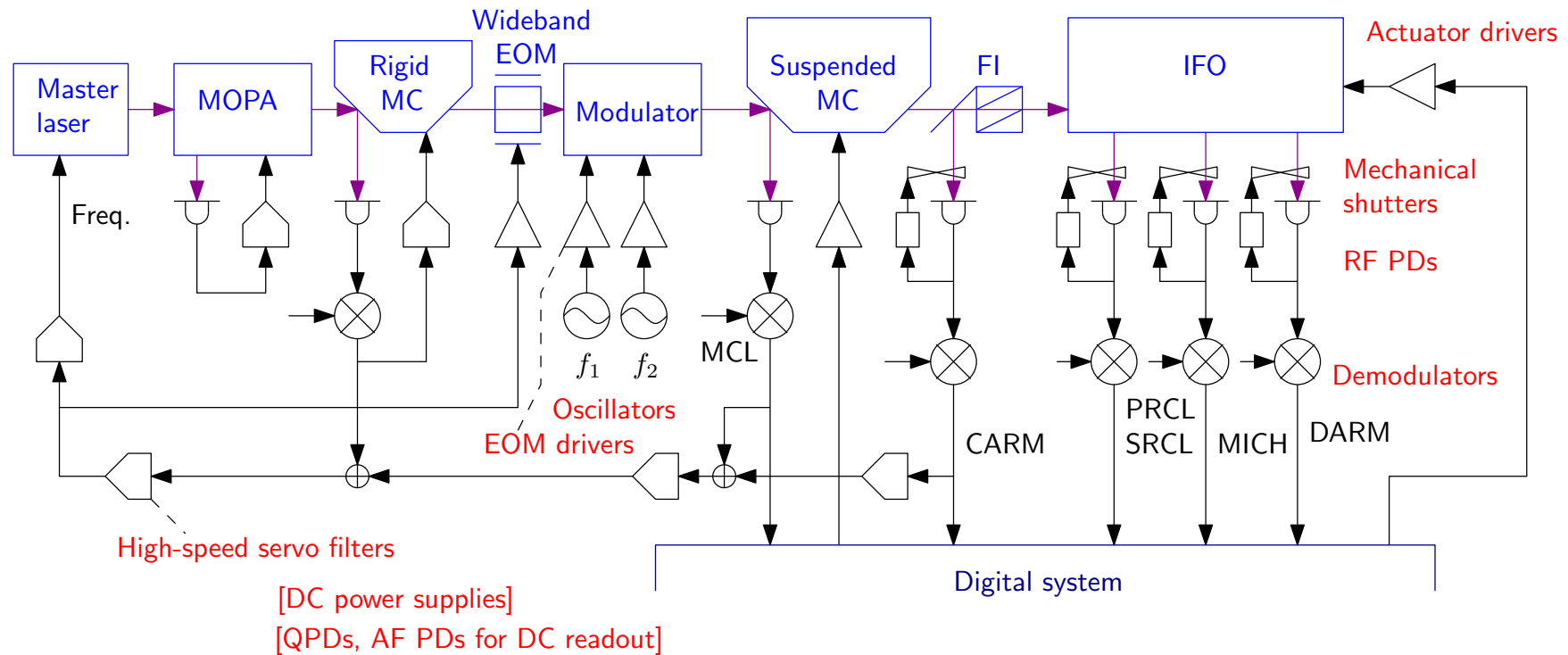

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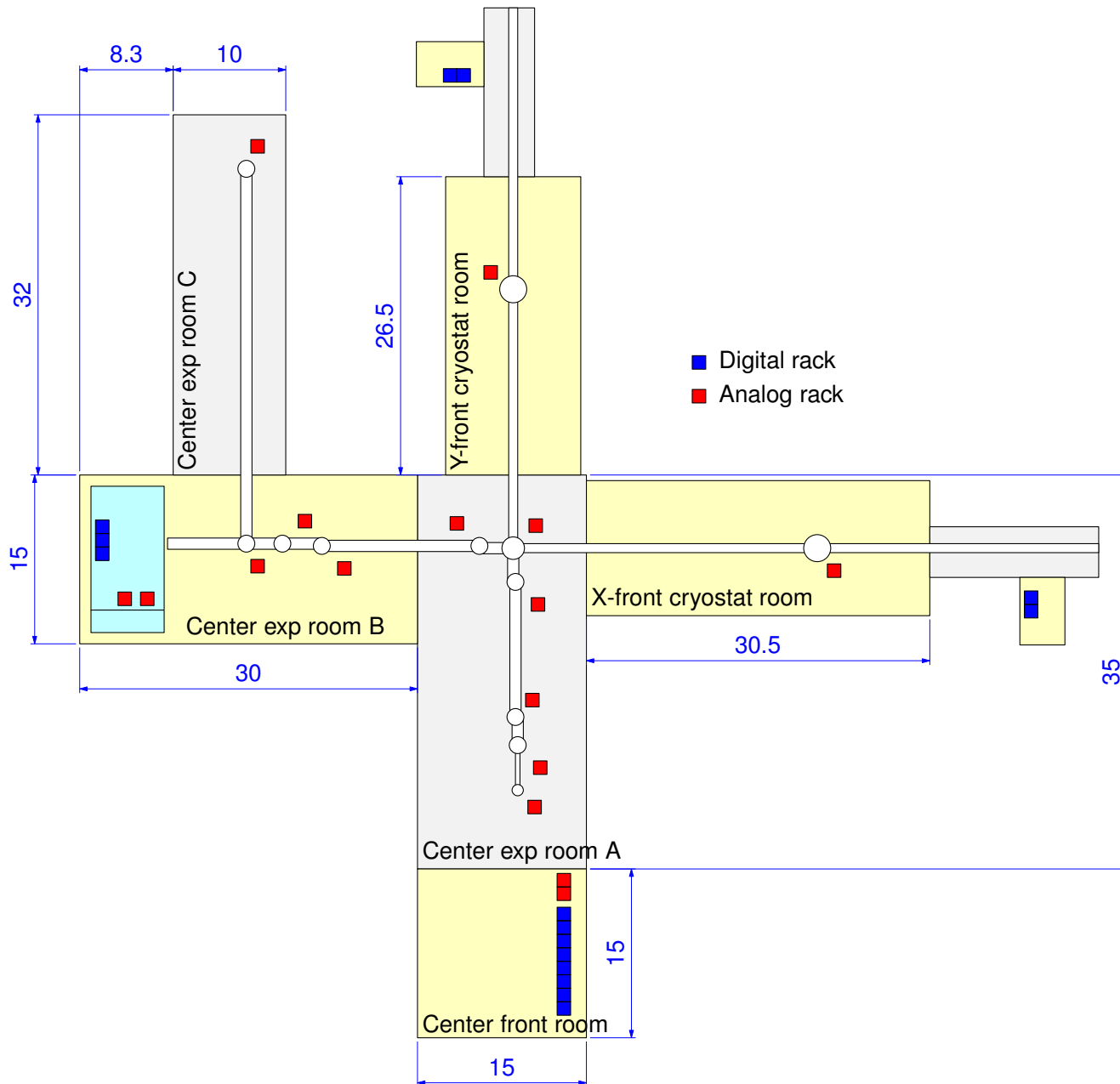
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Tasks of Analog Electronics Subsystem


Components to be provided:

- DC power supplies
- Photo detectors
- Actuator drivers
- RF oscillators, drivers and demodulators
- Conditioning filters for ADC/DAC
- High-speed servo filters out of the digital control subsystem

- (locations of optical benches are not determined yet)
- Analog racks should be separate sufficiently far from AC transformer and AC motors used in vacuum or cryogenic instruments.

Location of analog rack: X-end area
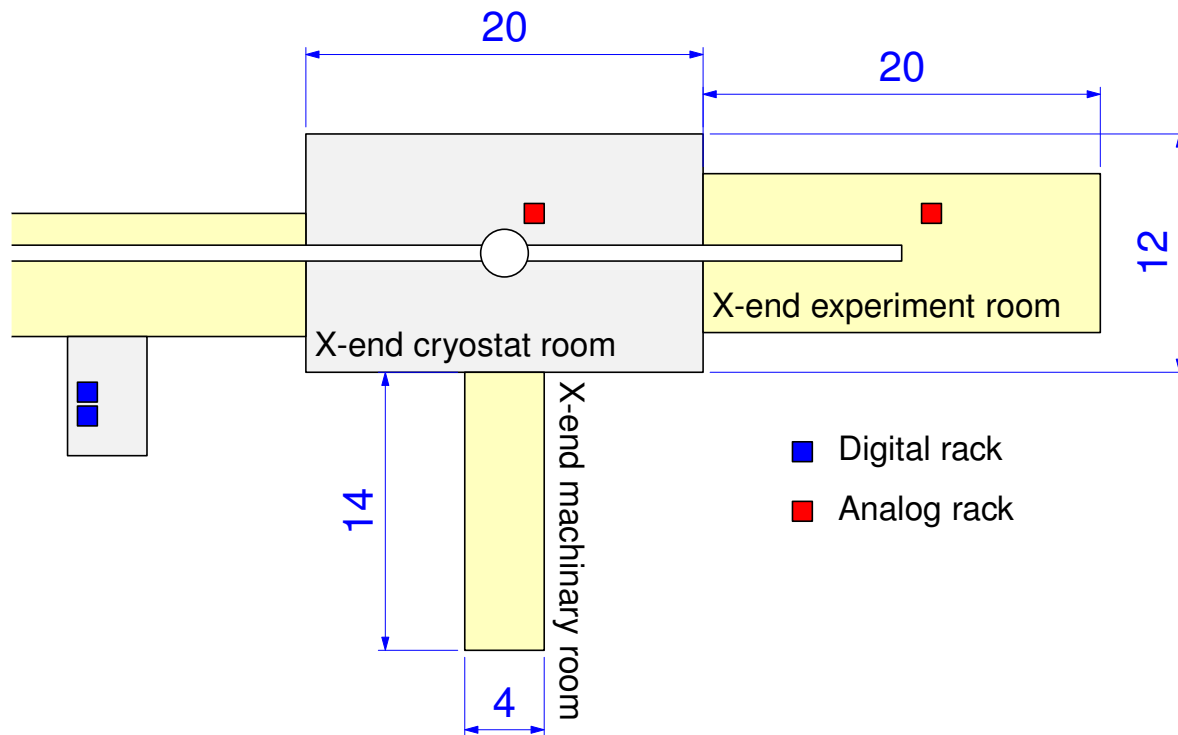
- We need the same consideration as that in the center area.

Components list (1/6) with requirements :
DC Power supplies

- Bipolar 24 V power supply [iLCGT]

- 24-to-15 V (or to-18 V) series regulator [iLCGT]

- 180 V high-voltage supply for QPD bias [iLCGT]

- High-voltage supply for coil driver [iLCGT, voltage: TBD]

- High-voltage supply for piezo actuator [iLCGT, voltage: 150 V (TBD)]

- High-current switching mode supply for LD driver [iLCGT]

- High-current supply for TEC (Peltier) driver [iLCGT]

Components list (2/6): Photo detectors

- RF PDs for length sensing [iLCGT, in air, in vacuum, 100 mW, ϕ3 mm, 45 MHz or 16.875 MHz]
- AF PDs for intensity stabilization [iLCGT, in air, in vacuum]
- RF QPDs for wave-front sensing [iLCGT, 45 MHz or 16.875 MHz]
- AF QPDs for beam position sensing [iLCGT]
- Photo detectors for DC readout [bLCGT, 100 mW, ϕ3 mm]
- Optical lever sensors [iLCGT]
- CCD imaging monitors [iLCGT]

(Common requirement: quantum efficiency >0.9)

Base design:

- TAMA300 RF PD
  [N. Mio et al., Jpn. J. Appl. Phys. **40**, p.426 (2001)]
- High-power, low-noise resonant PD
  [H. Grote, Rev. Sci. Instrum. **78**, 054704 (2007)]

Components list (3/6): Actuator drivers

- Piezo actuator drivers [iLCGT, 150 V]
- Wideband EOM drivers [iLCGT, few MHz bandwidth]
- Picomotor(R)/step motor drivers [iLCGT]
- Drivers for Ultrasonic motor (waveplate holder etc.) [iLCGT]
- Coil drivers for ITM-ETM [iLCGT]
- Coil drivers for SAS IP control [iLCGT]
- TEC (Peltier) driver [iLCGT]
- Electrostatic actuator driver [bLCGT]

Components list (4/6): RF System

- Stable RF oscillators [iLCGT]
- Low phase-noise oscillators [bLCGT]
- Distributors [iLCGT]
- RF resonant EOM drivers [iLCGT]
- I&Q demodulators [iLCGT, $1\,\mathrm{nV}/\sqrt{\mathrm{Hz}}$, $100\,\mathrm{mV}$ range]
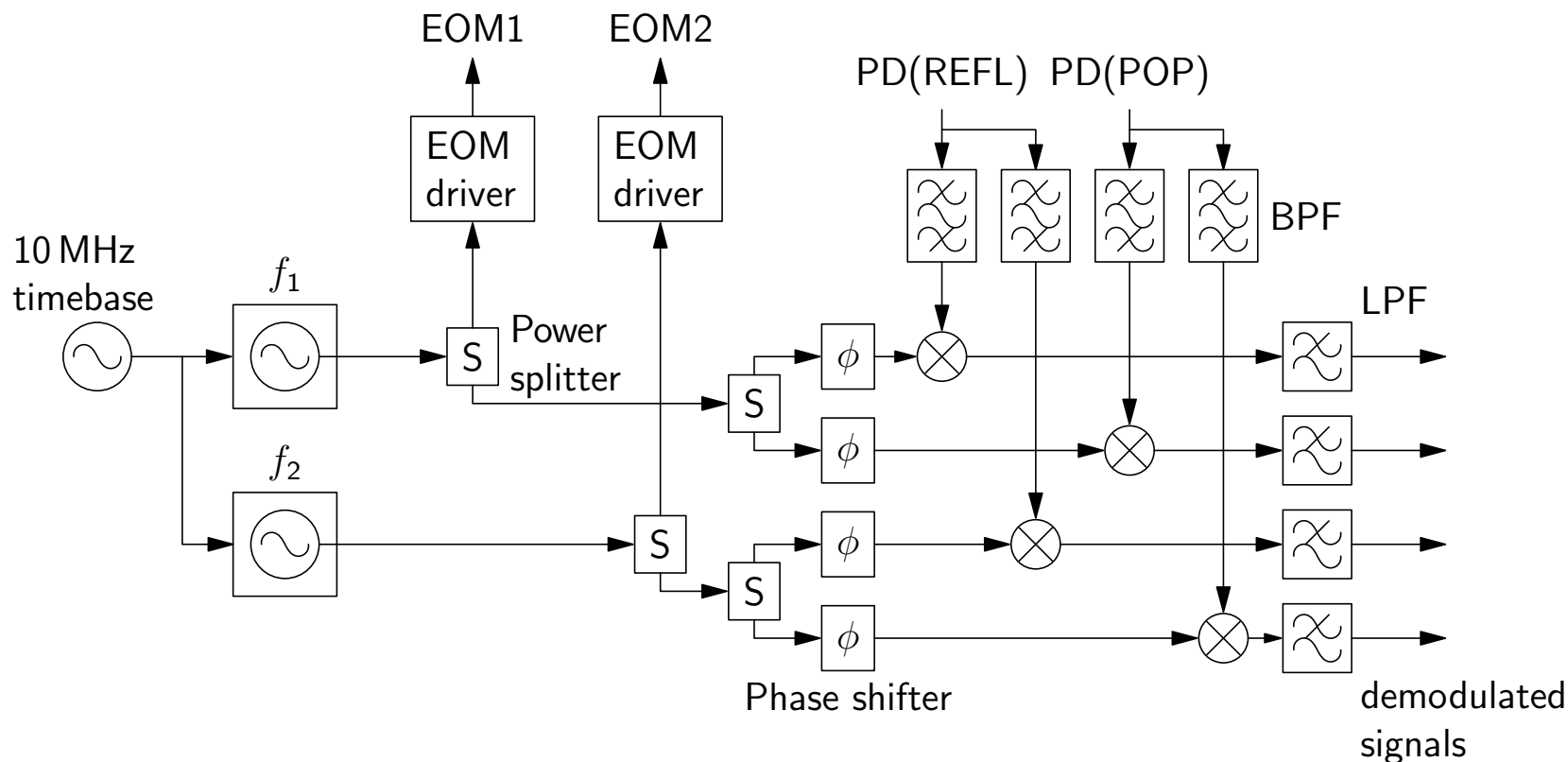
# Components list (5/6): Conditioning filters for ADC/DAC

- Whitening and de-whitening amplifiers [iLCGT]
- Anti-aliasing filters in front of ADC [iLCGT]
- Anti-imaging filters for DAC output [iLCGT]

Components list (6/6): High-speed servo control filters

- Servo filters with differential input/output [iLCGT]
  - ▶ Laser frequency stabilization (NPRO piezo, wideband EOM, ...)
  - ▶ Laser intensity stabilization (LD current, EOAM)
  - ▶ Beamsplitter control for coherent addition in MOPA
  - ▶ PLL locking between fundamental and green lasers
- Feed-around summing amplifier with differential input/output [iLCGT]
- RMS threshold detector with digital interface [iLCGT]

DC power supply: overview

- ± 24 V bipolar DC power supply [Kikusui PAN35-30A]
- DC 24 V distributors
- 24-to-18 V series regulators [LM7818/7918]
- 24-to-15 V series regulators [LM7815/7915]
- 180 V (TBD) DC power supply for PD bias, piezo actuator, coil driver, electrostatic actuator, ...

Outside center room

Center room

3

± 24,V supply

Distributor
10x dc circuit breaker
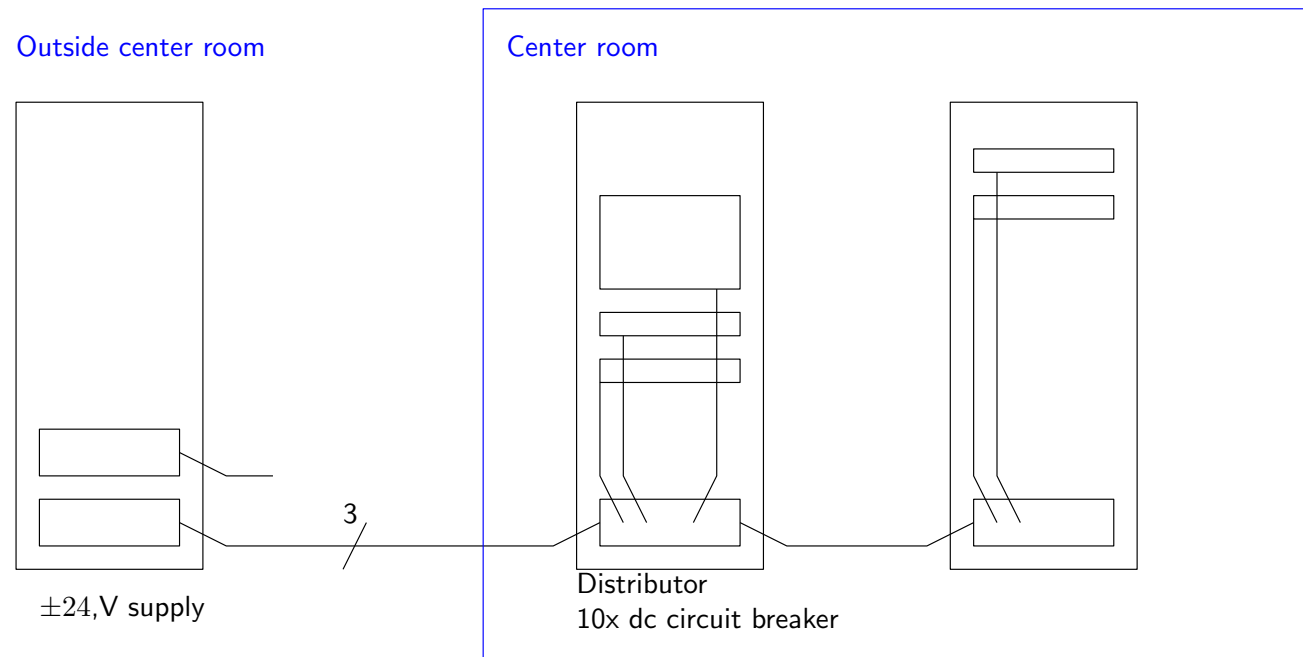
DC power supply: connectors and cables

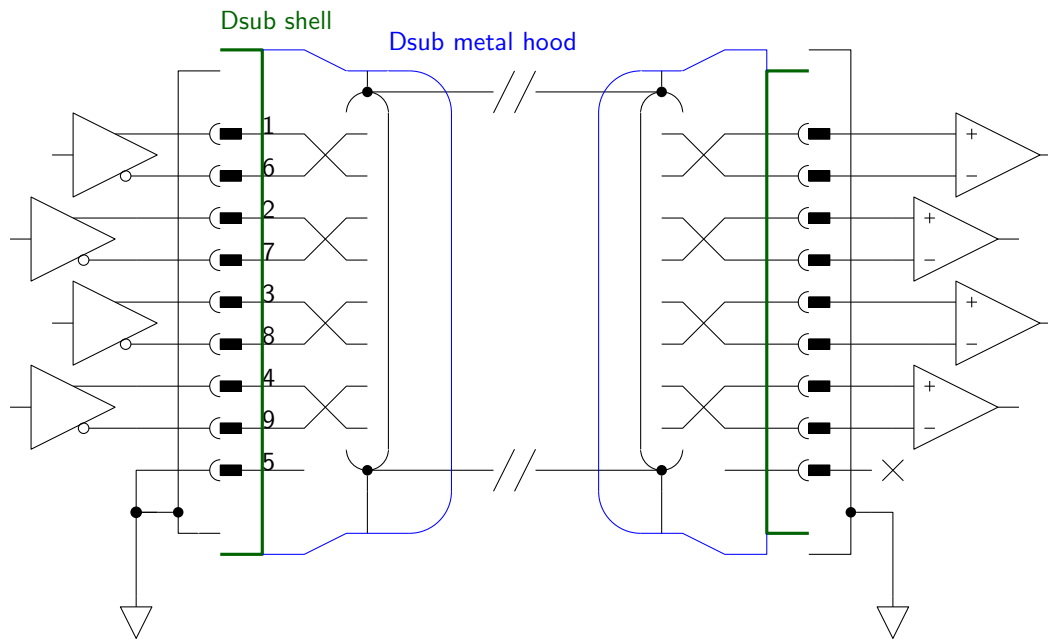Special care (mainly ground loop management) is required to reduce AC line noise.

- Unshielded 3-wire cable with D-sub 3W3 connector
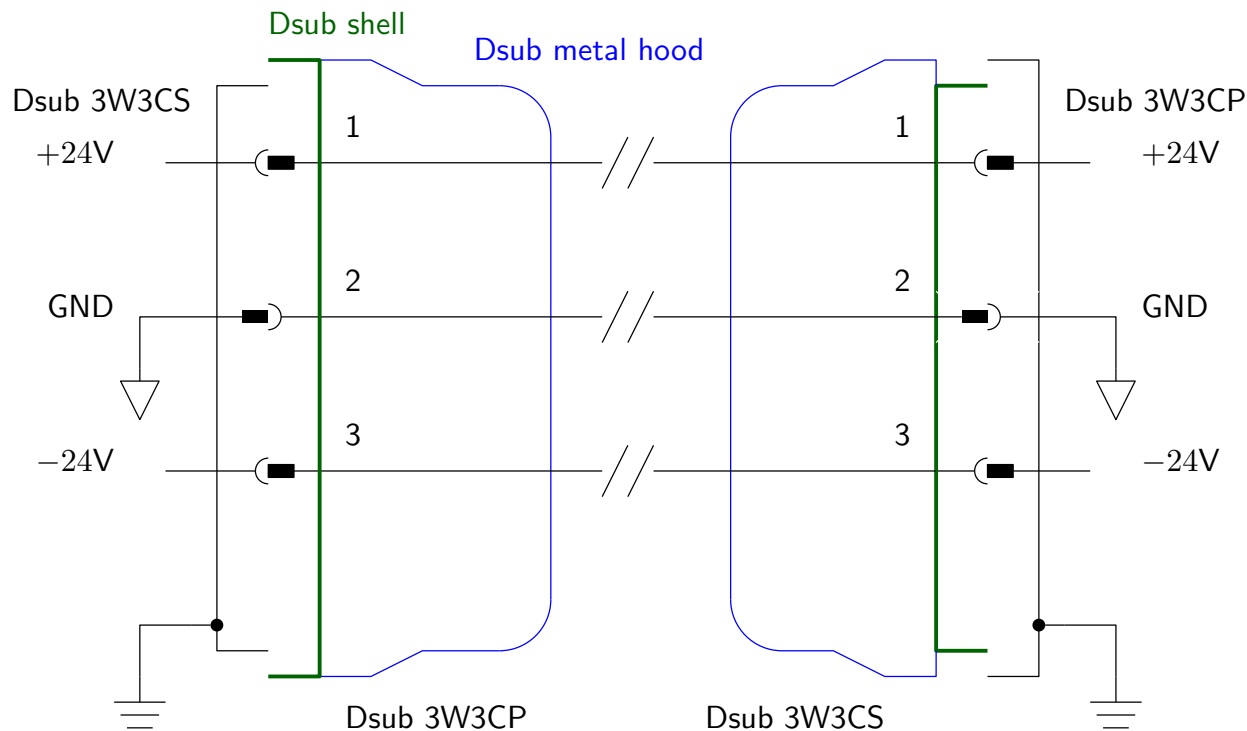
Policy on AF signal transfer

Do not transfer signals between modules with single-ended cable! Use STP (shielded twist pair) lines.

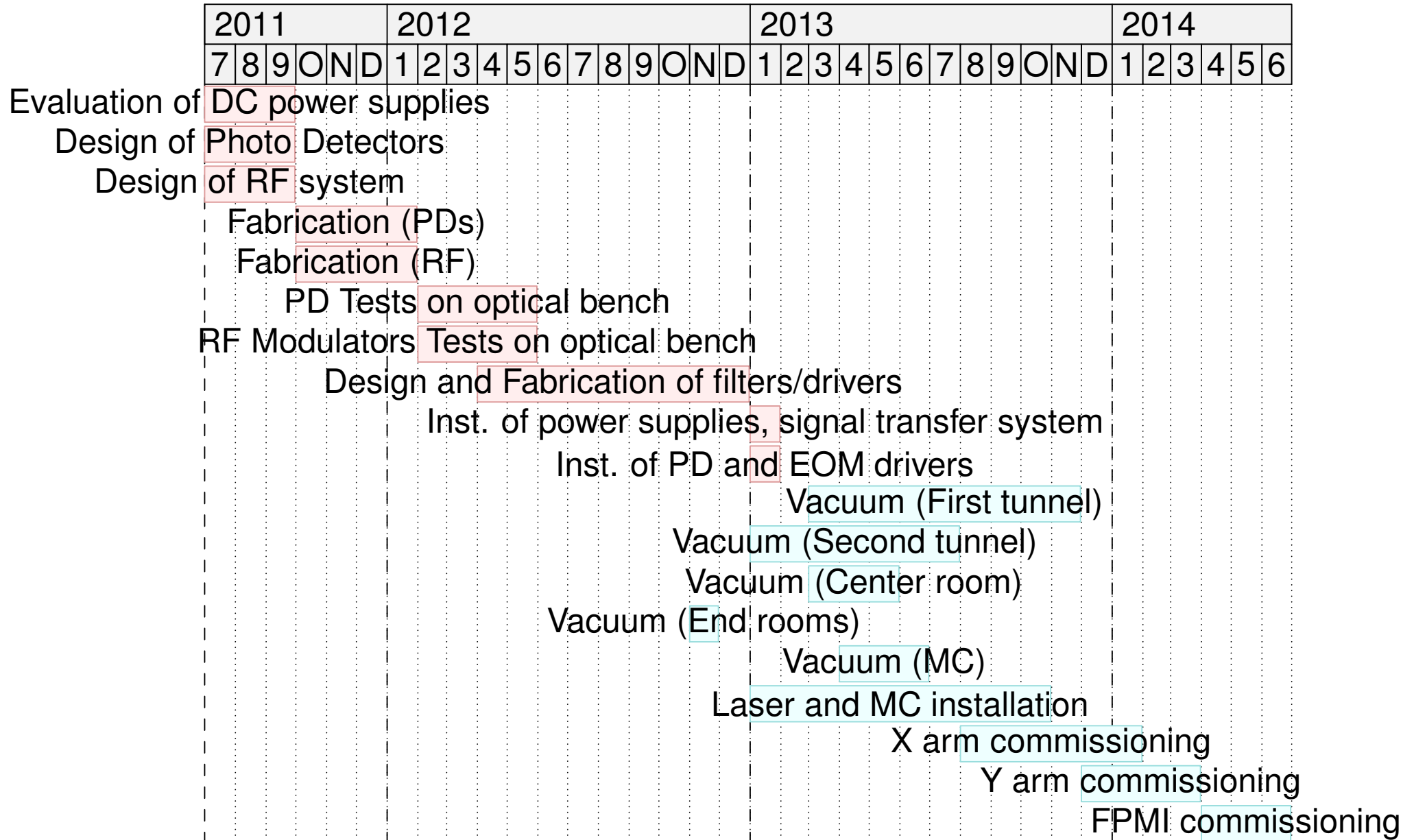optional shield isolation adapter are used to avoid ground loops along STP shield.

STP cable with D-sub connector
- grounded at both end via receptacle shells

Chassis form for circuits: 19-inch cabinet and NIM crates/modules

- 19-inch cabinets will be used for almost all the circuits.
  - ▶ Operation under $\pm24\,$V or $\pm18\,$V DC power supply.
  - ▶ Take care for passive air flow cooling.
    Do not use cooling fans in analog rack!
- Use of NIM (Nuclear Instrumentation Module) will be allowed.
  - ▶ Specification document: DOE/ER-0547T at `http://www.osti.gov/`
  - ▶ Vertical PCB arrangement $\rightarrow$ effective air cooling
  - ▶ Custom crates which do not have AC 100 V transformer will be introduced. This crates provide DC $\pm24\,$V and $\pm12\,$V supply to the module via backplane connector.

Schedule

	2011						2012												2013												2014					
	7	8	9	O	N	D	1	2	3	4	5	6	7	8	9	O	N	D	1	2	3	4	5	6	7	8	9	O	N	D	1	2	3	4	5	6

Evaluation of DC power supplies
Design of Photo Detectors
Design of RF system
Fabrication (PDs)
Fabrication (RF)
PD Tests on optical bench
RF Modulators Tests on optical bench
Design and Fabrication of filters/drivers
Inst. of power supplies, signal transfer system
Inst. of PD and EOM drivers
Vacuum (First tunnel)
Vacuum (Second tunnel)
Vacuum (Center room)
Vacuum (End rooms)
Vacuum (MC)
Laser and MC installation
X arm commissioning
Y arm commissioning
FPMI commissioning

First article test

Example of AA/AI (anti-alias/anti-imaging) filter:
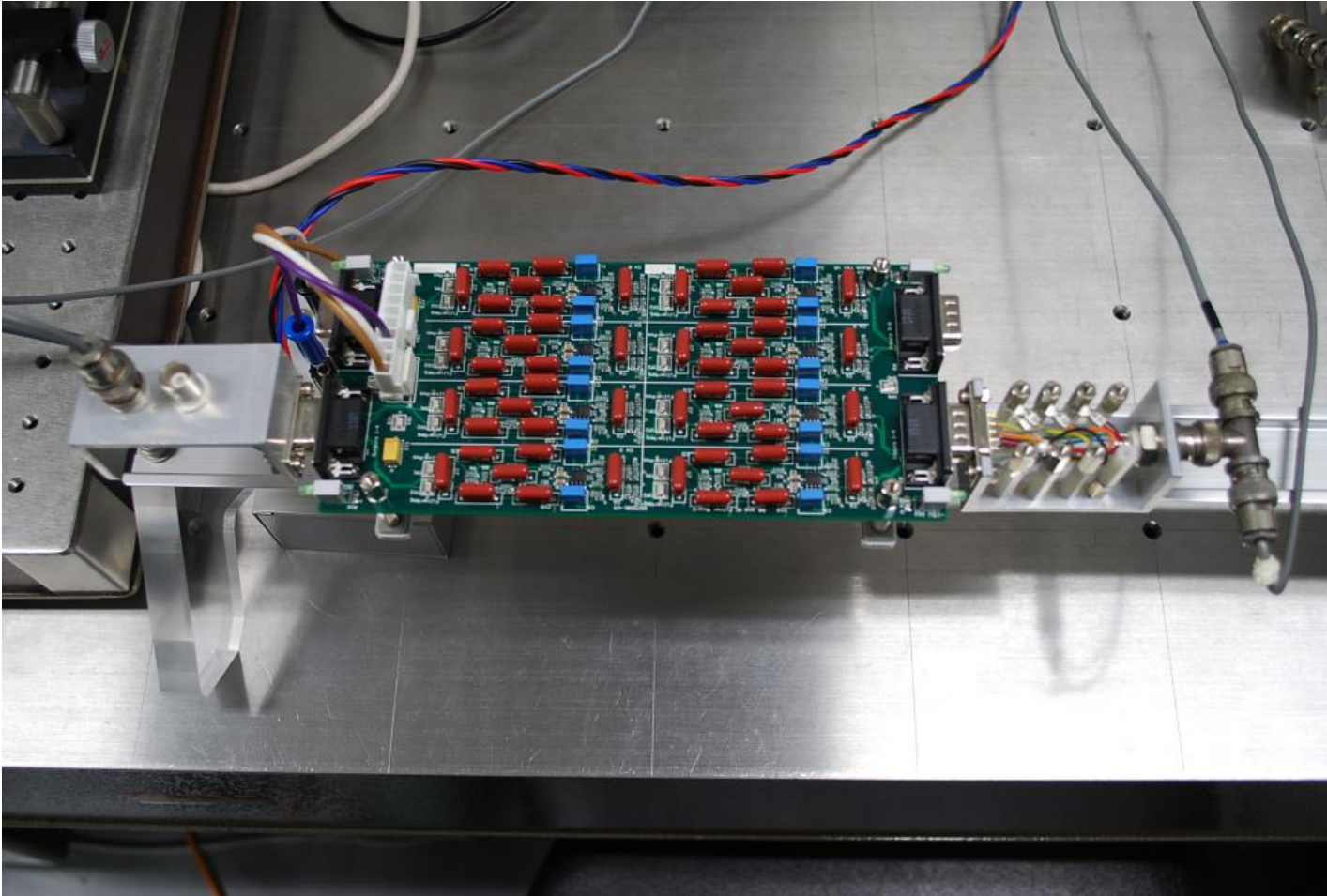
Fully-differential low-pass filter, 8 channels per a board

Risk management

- AC 60 Hz line noise
  $\rightarrow$ policy compliance for AC transformer, AC motor and grounding treatment

- RF cross-talk noise
  $\rightarrow$ design policy for cabling and routing on circuit board

- Acoustic coupling via capacitors, cables and oscillator crystals
  $\rightarrow$ policy for component selection

- The data cannot be analyzed without the configuration state of analog electronics.
  $\rightarrow$ SVN Change-log management