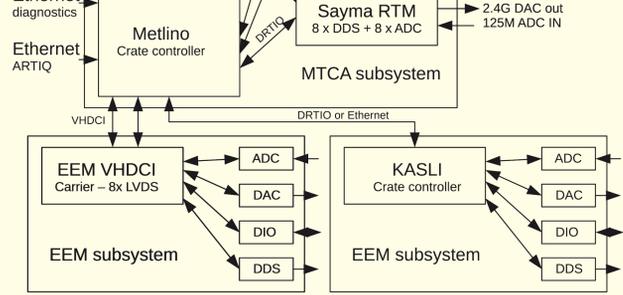


## Introduction

The Sinara hardware platform is a modular open source (CERN OHL 1.2) measurement and control system dedicated to quantum applications that require hard real time performance. It is based on standard, industry-proven MTCA.4 and Eurocard Extension Modules (EEM). The hardware modules can be combined in several configurations, starting from low cost single box device attached to PC up to experiment control systems covering all needs of complex laboratory setup.



Simplified architecture of Sinara platform

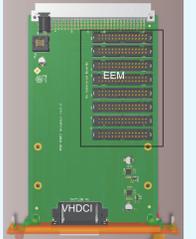
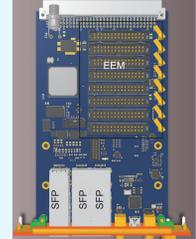
The hardware is controlled and managed by the ARTIQ software developed by M-Labs. The software is open-source, high-level programming language that enables describing complex experiments with nanosecond timing resolution and sub-microsecond latency.

The system currently consists of over 20 different modules and other ones are under development. Some of them are already available commercially, rest are expected Q4 2017. Project repository: <https://github.com/m-labs/sinara/>

## Eurocard Extension Modules

Eurocard subsystem was designed as lower cost extension to MTCA subsystem that still gives 1ns accuracy but do not require low jitter RF distribution. However it still enables ns determinism and high speed data transfer. The EEM cassette can be driven by Metlino controller or work stand-alone using embedded Kasli controller. No backplane is used and modules are connected directly with controller using LVDS signalling over IDC ribbon cable. The EEM system can be optionally equipped with backplane. EEM standard is open and simple enough for academic labs to build the boards. Software/gateway drivers are built in ARTIQ. Vision is that ARTIQ code base serves as driver repository.

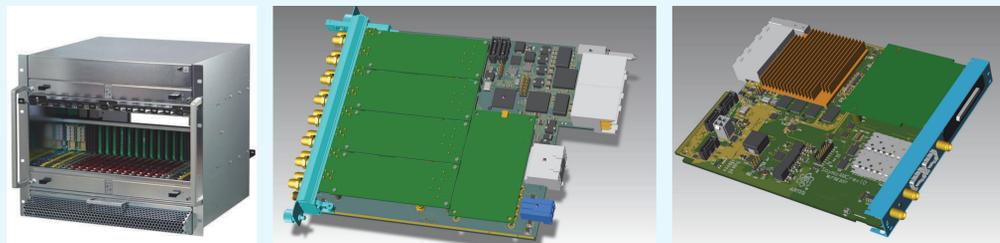
- Connectivity:
- SFP modules
  - 5Gbit/s
  - Break ground loop
  - bichromatic
  - clock & data recovery



EEM hardware: SFP module, Eurocard cassette with modules, Kasli controller, VHDCI beakout / carrier

## MTCA.4 hardware

- Sayma is a high-performance arbitrary waveform generator, featuring 8 2.4GSPS DACs and 8 125MSPS ADCs. It is based on recent MTCA.4 architecture. It consists of several modules:
- Digital AMC module featuring Kintex UltraScale FPGA, FMC extension, two SDRAM banks and SFP ports.
  - Complementary RTM module with 8 channel DAC and ADC, clock distribution and 4 analog I/O mezzanines.
  - I/O mezzanines.
  - Metlino hub with ability to control 3U Eurocrate extensions and FMC extension.
  - RF clock generation and distribution module.
  - Power module with per-card V/I monitoring.
  - Chassis control with JTAG, temperature, fan control.



Sayma MTCA hardware: Crate, Sayma RTM with modules, Sayma AMC

## Digital I/O EEM

Universal Input/Output Modules supporting various connector types and signalling standards were developed. 3U BNC and SMA modules support 8 (50Ohm/1k) TTL channels and are galvanically isolated, RJ45 LVDS have 16 bidirectional channels with no isolation. They are directly tied to FPGA (Metlino, Sayma, Kasli or devboard) for low latency.

- Specification for 3U BNC and SMA 8 channels, isolated in groups of 4
- Min pulse width: 3ns
  - IO standard: TTL@50Ohm
  - Galvanic isolation: 1kV
  - Channel delay (LVDS to TTL): 20ns
  - Connectors: BNC or SMA

- Specification for 3U IDC 8 channels
- Min pulse width: 3ns
  - IO standard: LVTTTL (3.3V)
  - Connectors: IDC



Round trip delay: 50 ns. Setup: 3U BNC - 3U VHDCI - 1m of VHDCI cable - 3U VHDCI - 3U BNC

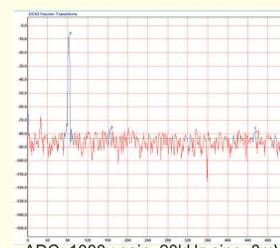
- Specification for 3U LVDS RJ45 16 channels (2 EEM slots)
- Min pulse width: 3ns
  - IO standard: LVDS
  - Galvanic isolation: 1kV
  - Connectors: RJ45, CAT6 compatible

## ADC/DAC EEM

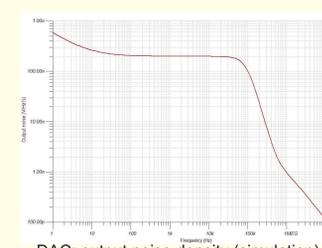
Complementary ADC and DAC boards were developed to support slow control applications as well as time critical implementation of ADC to RF digital servo. Its support is planned in ARTIQ.

- ADC spec:
- 8 channels, 1MS/s, 16bit
  - +/- 0.01, 0.1V, 1V, 10V range
  - CMRR filter
  - BNC input

- DAC spec:
- 32 channels, 100KS/s, 16bit
  - +/- 10V RANGE
  - low noise <1nVrtHz (>1MHz)
  - drift <10ppm



RTM GTX performance at 12 Gbit/s

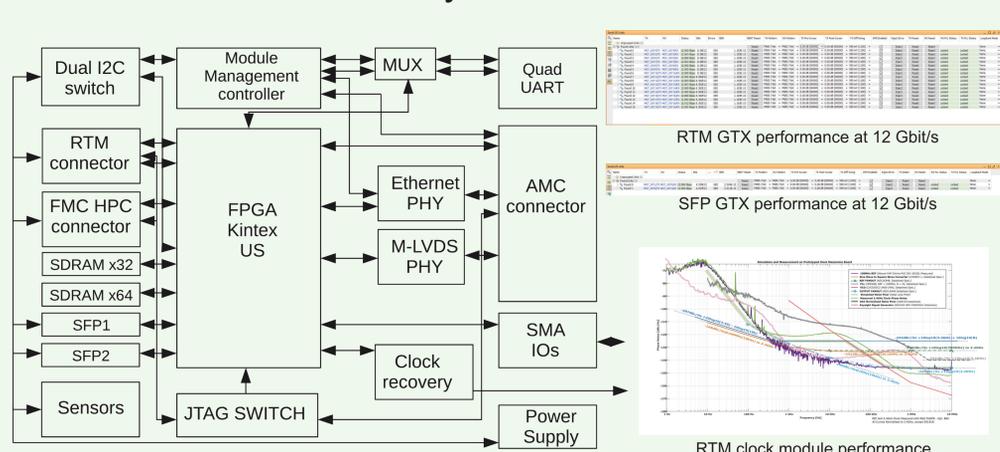


DAC: output noise density (simulation)



Eurocard Extension Module : 8 channel ADC

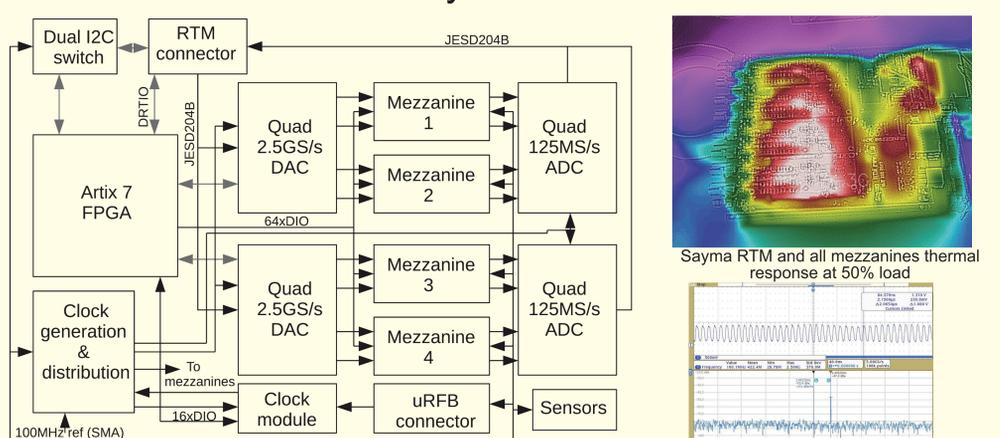
## Sayma AMC



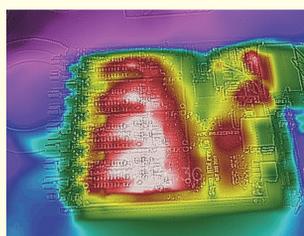
Sayma AMC block schematic

RTM clock module performance

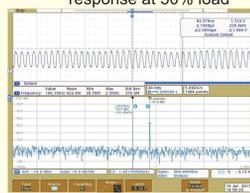
## Sayma RTM



Sayma RTM block schematic



Sayma RTM and all mezzanines thermal response at 50% load

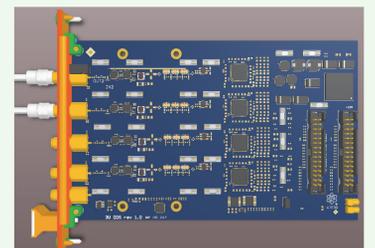


RF generation from reference

## RF DDS EEM (Urukul)

Low-cost DDS-based 4-channel RF source, featuring high-isolation switches, digitally programmable attenuators and pre-amplifiers. Can be used in combination with Kasli and Novogorny ADC to create a low-cost multi-channel AOM driver with intensity servo.

- Features:
- 1GS/s sampling rate.
  - Lowest output frequency: 1 MHz.
  - Highest output frequency (first Nyquist zone): 200 MHz.
  - Nominal output power 10 dBm.
  - Output power range -20 dBm to 10 dBm.
  - Phase offset resolution: 14 bit.
  - Temporal resolution, FTW/POW updates: 100 ns.
  - Temporal resolution RF switch: 100 ns.
  - Phase noise floor: -100dBc/Hz.
  - Uses one or two EEM connectors.

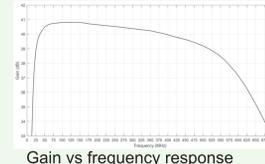


RF DDS module drawing

## 8 channel RF Power Amplifier

RF power amplifier is complementary unit to Sayma and EEM subsystem. 2U package houses 8 exchangeable units, supply, cooling, protection and SCPI over Ethernet control interface.

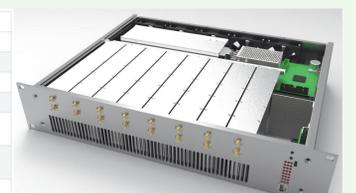
- RF PA spec:
- BW: 40M-500MHz
  - P1dB: 36dB, IP3: 48dB
  - Gain @1dB comp: 40dB
  - PWR: 100-230V AC
  - Crosstalk: < 60dB



Gain vs frequency response

	This design	ZHL-03-SWF+	ZHL-SW-1+
Bandwidth (MHz)	40-500	60-300	50-500
Gain (dB)	40	30	40
P1dB (dBm)	36	36	37
Channel cost (EUR ex VAT)	750	544	1120
Power per channel	<12W (>35% eff.)	67W (2.8A/24VDC)	80W (3.3A/24VDC)
Open-circuit/overload protection	Yes	No	No
Remote monitoring	Yes (ethernet)	No	No

Pre-existing alternatives



8 channel RF Power amplifier drawing