uLOG Status Update.

Uroš Mavrič, DESY

Tony Rohlev Dynamique - TSR Engineering

Warsaw, 11.06.2015

HELMHOLTZ ASSOCIATION

DESY

Current Status.

- 6 full units have been delivered -> mechanics unassembled and untested.
- Two weeks of tests -> 3 units have been tested (not fully).

DESY

- Full characterization of the unit. -> golden unit used as a reference for the acceptance.
- RF board layout and schematics changes -> if needed.
- Contract and ordering activities ongoing -> got first questions from V4 for further justifications.
- Development of testing tools and organization of the testing environment
- Installation of the units

Dynamique

- Modification of Altium and mechanics documents (except the RF board Altium file)
- Organizational work with Sanmina PCB House.
- Organizational work with Alfa EMS assembly house.
- Organization of production of mechanical components.
- Shipping/delivery
- Final mechanical assembly
- Testing of all the 48 units

Open Points.

- RF Board:
  - ✔ Adjustment of RF power delivered over the RF backplane to the DWC. Fine adjustments.
- Carrier:
  - SPI/UART communication with the BM has never been tested. The task is being taken care by Dariusz and his colleagues.
- TEC:
  - Testing of the temperature regulation.
  - Settings of the PID values for the XFEL tunnel.
  - What are the best fan speed settings?
  - Is there enough power coming over the BM?
- Testing process:
  - Based on the “2-weeks” experience the testing process might be an issue.
- Production:
  - New PCB manufacturer-> no experience with uLOG but with good reputation.
- Components:
  - All potential “long-lead-time” components have been ordered.

Testing.

- The testing protocol has been defined and agreed by both parties.
- The testing process is split in:
  - Reduced testing -> includes only relevant measurements such as power, basic transmission of all channels, sensors, switches etc.
  - Full testing -> long and detailed testing which is performed on 10 randomly selected modules. It includes all the reduced testing + special measurements such as S11, residual phase noise, isolation, full S-parameter matrix etc.
- The organization of the test process is left to the company. DESY will provide testing equipment and laboratory space.
- Matlab scripts, MMC FW, application FW will be provided by DESY.

Documentation.

- Specs, manual and datasheet on N drive.
- Rev C and D committed to SVN. Rev A and B on N drive.
- Test results on N drive.

Schedule.

- The release/start of production is foreseen in the next 1,2 weeks:

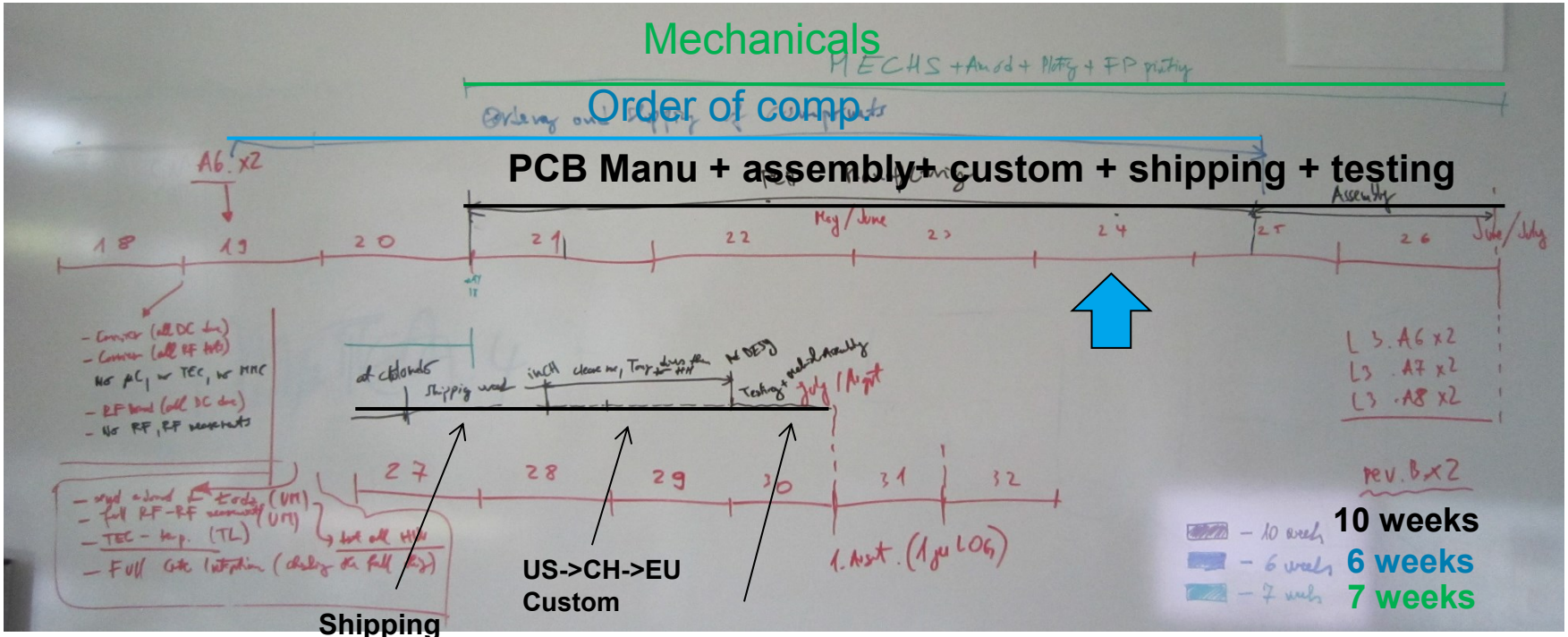
  Pushed by:

  - Beginning of August we need the first uLOG from the new batch.
  - Start of production has to happen before Tony arrives to DESY (for the testing of the 6 units) -> 18th of June.

  Pulled by:

  - Release of the first part of the contract money -> contract issues solved.
  - Full testing of a unit (the three points marked with a red rectangle).
  - Recent issues with bad soldering..needs more investigation.

Time plan.

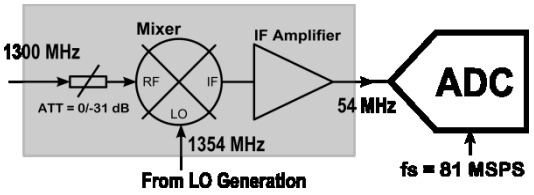

Mechanicals
Order of comp.
PCB Manu + assembly+ custom + shipping + testing
A6 x2
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
May / June
July / August
L3.A6 x2
L3 .A7 x2
L3 .A8 x2
rev.B x2
10 weeks
6 weeks
7 weeks
Shipping
US->CH->EU
Custom
Mechanical assembly
+ testing of the 1st unit

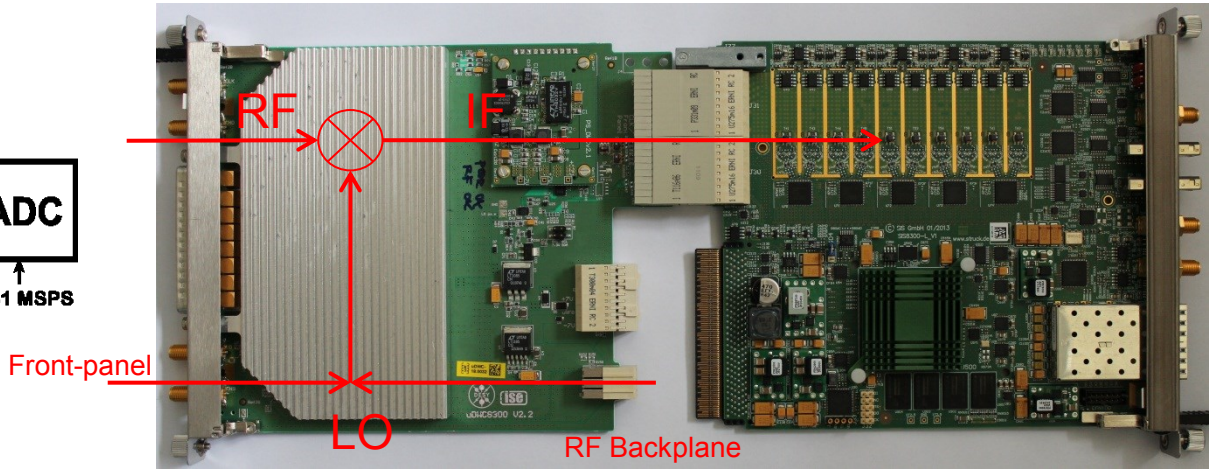
Back-up slides.

- No conference talks
- **Give status reports**
- **Only top level descriptions**
- Max. 1-2 slides with results of tests or operation
- **Show problems and open points**, without the technicality but the concepts and consequences
- **Steps and schedule toward mass production or finishing the project**
- **Test plans - show if they are ready, or must be prepared**
- **Availability of documentation, what is ready, what is missing!**
- **Estimated date of finishing the project**
- No long talks. (10-12 slides max)
- Leave time for discussion

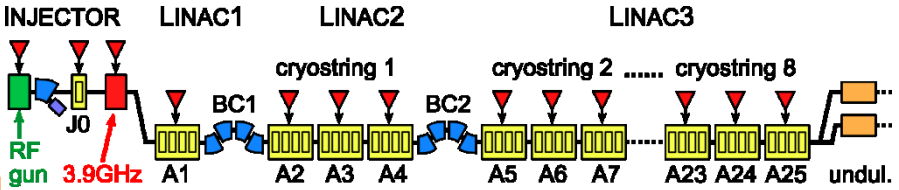
Motivation.

- The RF field detection scheme for the XFEL low-level RF system uses the down-conversion of 1.3 GHz pulsed RF. The frequency translation is performed through a mixer which mixes the **LO (1.354 GHz)** and the **RF (1.3 GHz)** down to **IF (54 MHz).**
- The IF (54 MHz) is sampled in a fast ADC with **Fs = 81.25 MHZ**.





- 25 RF stations
- 50 MTCA.4 Crates (master and slave)
- 9 LO and 9 CLK tap points per crate
- **450 LO tap-points and 450 CLK tap points**



Specifications for LO and CLK Signals.

- Specs for additive noise are derived from the noise contributions of other subsystems (RF front –end and ADC).

2 fs (1 mdeg at 1.3 GHz) [10 Hz - 10 MHz]

- Long term stability

0.2 ps_pp [forever – 10Hz]

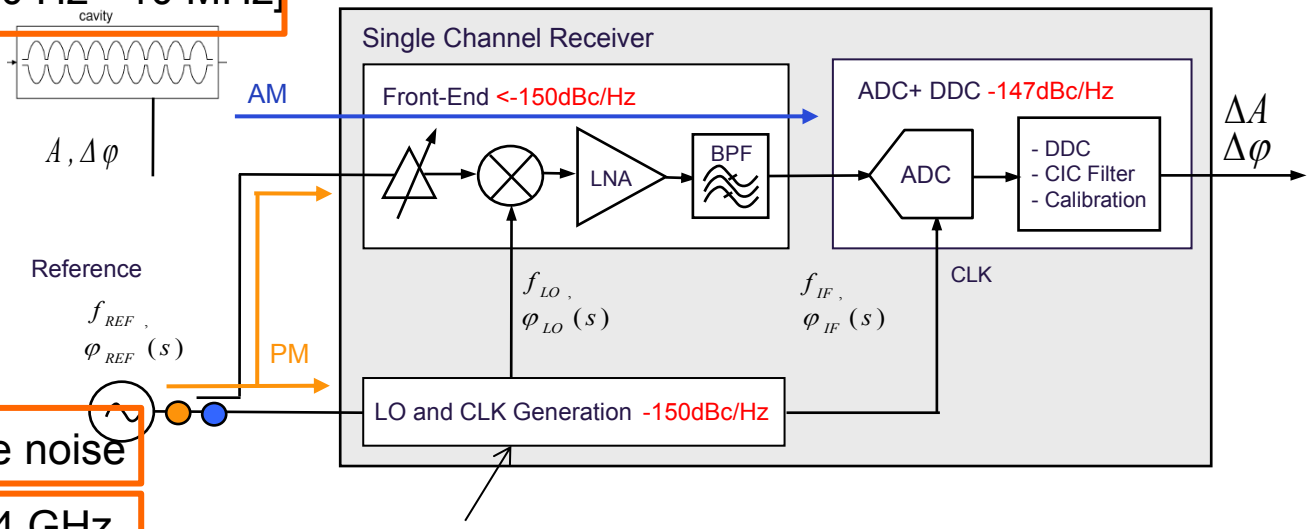
- Isolation on all ports

< -80 dBc

- CLK additive noise

< -160 dBc/Hz floor for white noise

- LO Output : 1 W at 1.354 GHz



-150dBc/Hz – 10log10(8) = -160dBc/Hz

Vector sum processing gain

Mixer: $\varphi_{IF}(s) = \varphi_{REF}(s) - \varphi_{LO}(s)$,

$f_{IF} = f_{REF} - f_{LO}$

LO: $\varphi_{LO}(s) = \left(\frac{f_{LO}}{f_{REF}}\right)\varphi_{REF}(s)$

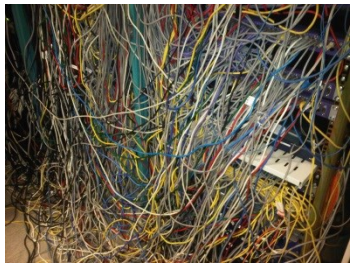
$$S_{\varphi,IF}(f) = S_{\varphi,REF}(f)\left(\frac{f_{IF}}{f_{REF}}\right)^2$$

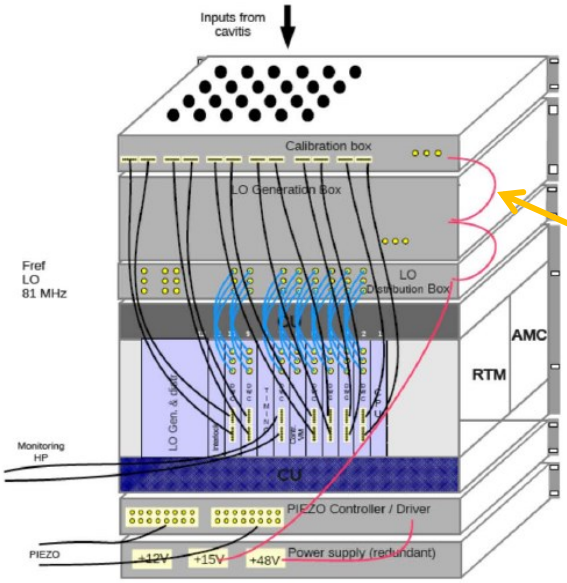
Cable vs. Backplane LO and CLK Distribution.

- Introduction of the new concept of integrating the LO and CLK distribution into the MTCA.4 crate.

  - External LO and CLK modules allow for better performance of the generated signals.
  - Better Temperature and humidity control of the distribution system (cables).

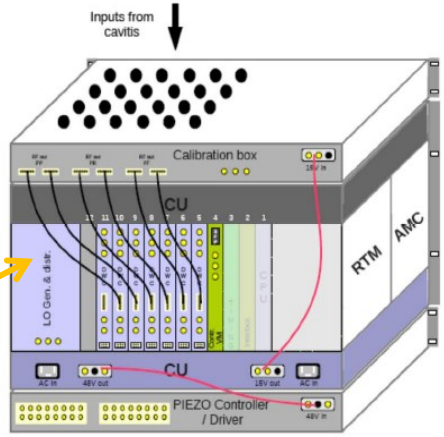
  - No external cables needed
  - Compact system





Ext. LO and CLK

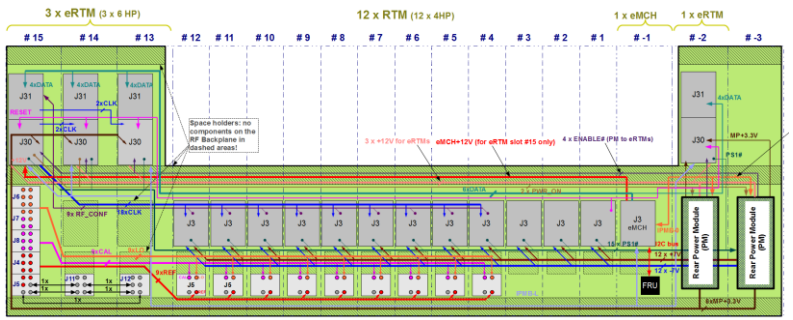
Integrated LO and CLK generation



uRF-Backplane.

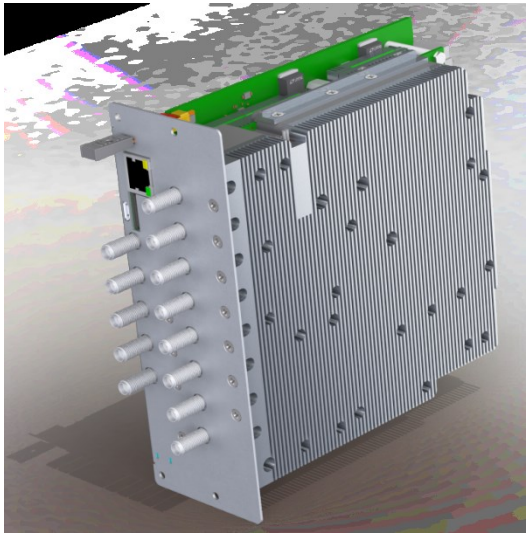
- The **uRF-backplane** is used for the distribution of the LO, CLK and calibration signals.

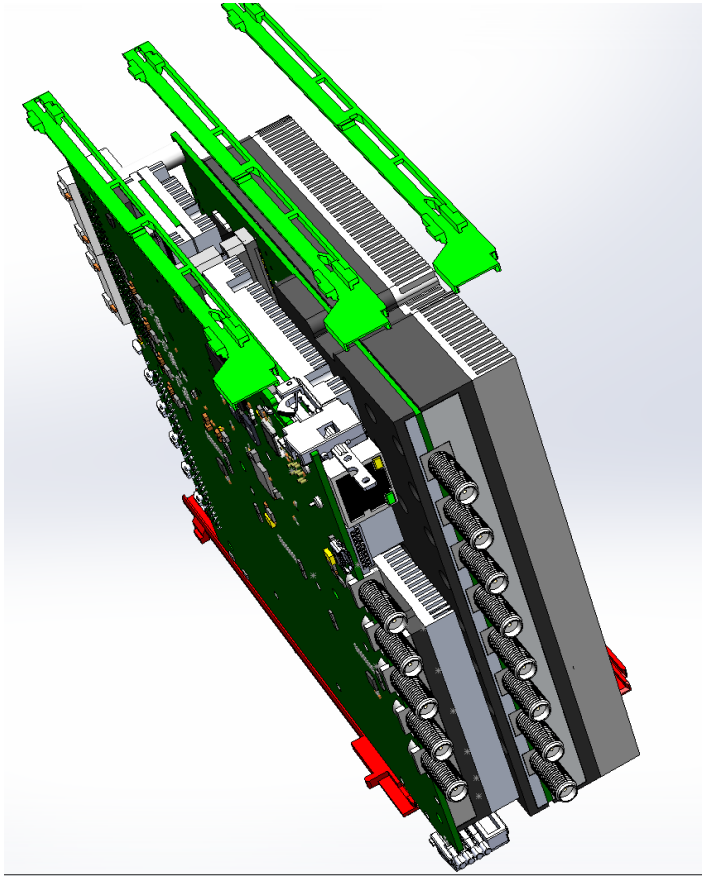
- The uRF-Backplane includes also other comm. signals such as I2C to modules, power lines, dedicated LVDS conn. etc.
- From the point of view of MTCA.4 management it can be treated as an extension of the front AMC backplane.
- It can accept 2 power modules that comply with MTCA.4 power specifications.
- It can accept 4 eRTM modules.
- DRTM-LOG1300 is an eRTM sitting in slot 15 in the rear.



DeRTM-LOG1300.

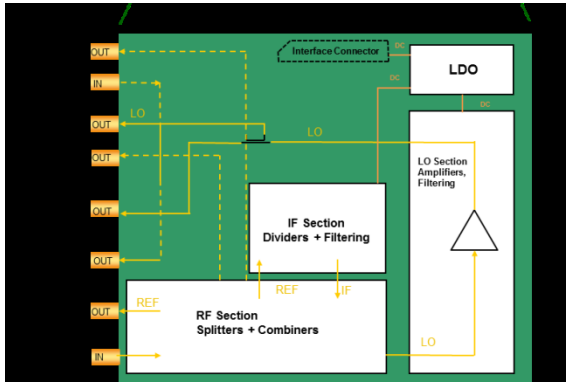
- Double-width, double full-size (12HP) module
- Composed of several sub-modules
  - RF daughter card
  - Carrier mezz. + RF distribution mezz.
  - DC/DC mezz.
  - TEC mezz.

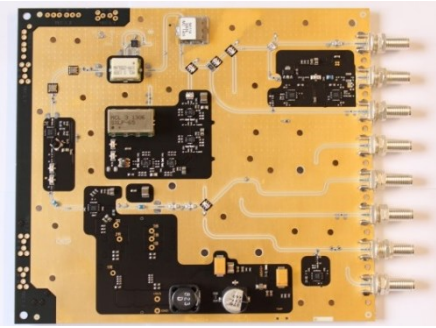


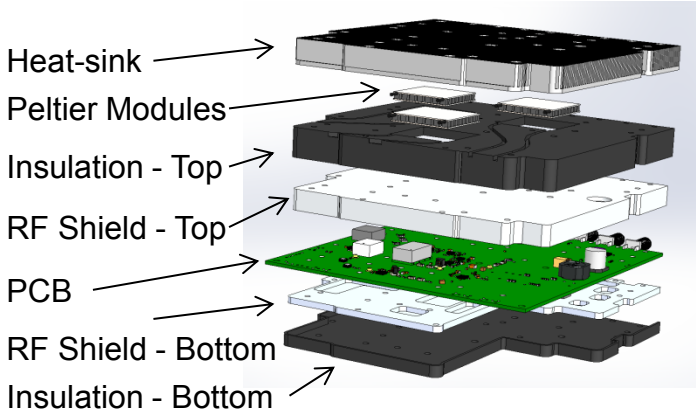


DeRTM-LOG1300 - RF.

- Need to use small surface mount components because of compactness -> performance is deteriorated.
- LO generated from REF via dividers
- Features:
  - Variable LO output power by -3dB
  - High resolution temperature sensor (24 bit ADC with NTC Thermistor)
  - Dividers in the range from 1 to 64
  - 2 variants (IF=54 MHz, IF=36 MHz) – assembly defined
  - Can cover RF/LO frequency range from 720 MHz To 3 GHz – assembly variant
  - 3 Peltier modules for temperature regulation
  - All voltages on all chips are monitored

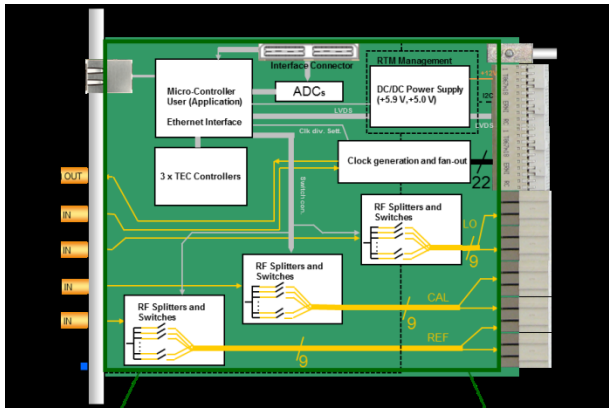


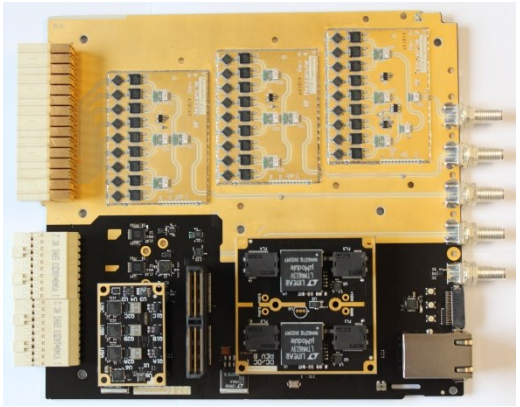


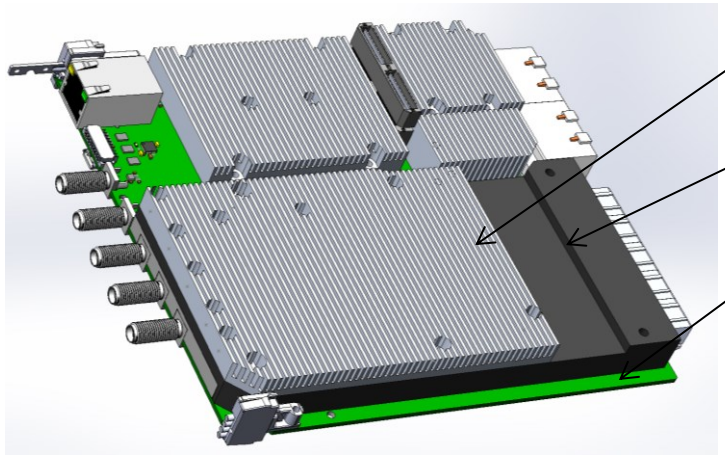


DeRTM-LOG1300 - Carrier.

- Module that splits the RF, CLK signals and interconnects to the uRF-backplane.
- Features:
  - 9 x LO/REF/Pilot outputs on Radiall connectors
  - 22 Diff. LVPECL CLK outputs on ERNI connectors
  - Switching OFF/ON each individual CLK, LO, REF and Pilot Output
  - Monitoring of the main voltages and currents
  - Temperature and humidity measurements
  - MMC 1.0 compliant
  - Application microcontroller
  - Connectivity to the ext. world

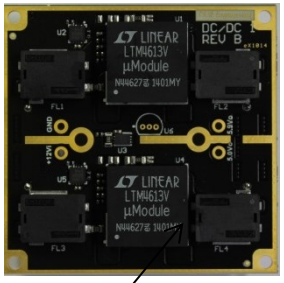




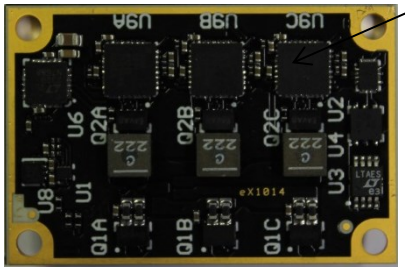


Other Mezzanine Modules.

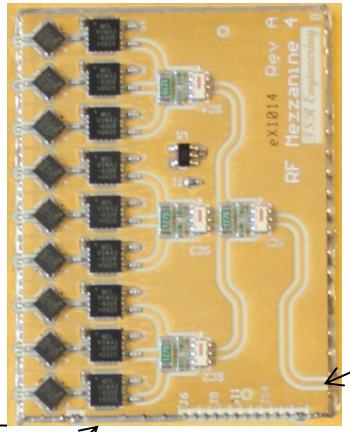
- DC/DC power converter mezzanine
  - +12V into +5.9V and +5.4 V
- RF splitting mezzanines
  - For splitting the REF, LO and calibration signal
- Temperature controller mezzanine
  - Integrated 3 temperature controllers



DC/DC Converters



Temperature Controllers



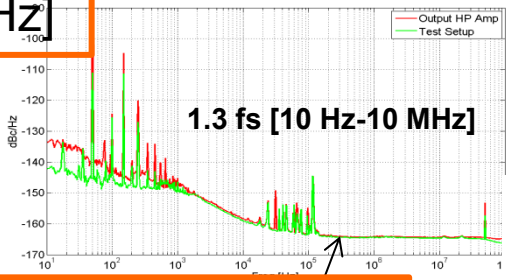
9 x RF Outputs

RF Input

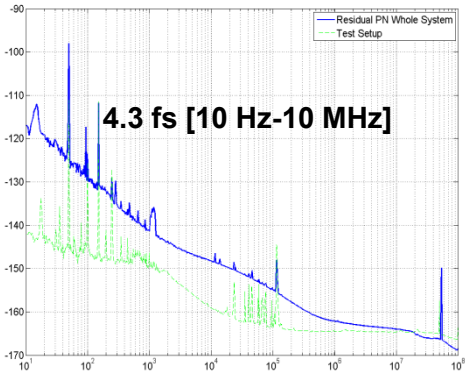
RF switches

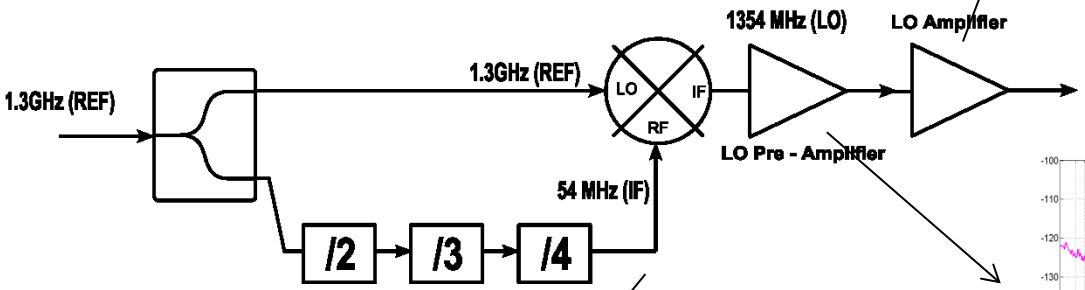
Res. Phase Noise Analysis.

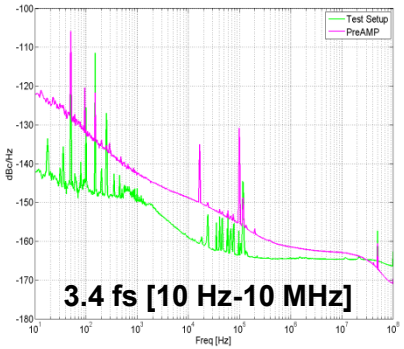
- 2 DUT measurements of residual phase noise of individual subsystems.
- Test setup **1.3 fs** [10 Hz – 10 MHz]
- Main limitations:
  - Dividers – 3.2 fs
  - Pre-amp – 3.4 fs
- Overall system res. jitter = 4.3 fs (2.7 fs with de-embedded setup) [10 Hz – 10 MHz]

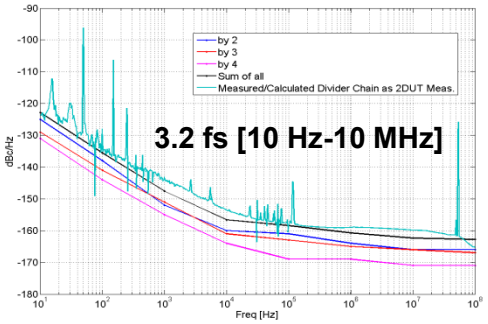


Overall Res. Phase Noise









Other spurs:

- 54 MHz - unshielded setup
- 1 kHz - unknown
- Other spurs come from the test setup

Measurements I.

- RF daughter board:
  - Isolation between channels
  - Return loss at connector
  - Harmonic content in output signals
  - Output power
- The RF daughter card consumes 11 W

Return Loss

Reflection at [GHz]:	S11 [dB] – Measured-Shield
Ref In (1.3)	-24
Ref Aux Out (1.3)	-27
Ref Out (1.3)	-26
Cal Out (1.3)	-29
LO Out (1.354)	-26
CLK Out (1.3)	-23
LO Mon Out (1.354)	-32
CAL In (1.3)	-29

Output Power

Power out	Power [dBm] - Expected	Power [dBm] - Measured
Ref Aux Out (1.3)	26.2	25.8
Ref Out (1.3)	13	14.7
LO Out (1.354)	31.0	30.2
CLK Out (1.3)	9.2	10.0
LO Mon Out (1.354)	14	16.5

Isolation between Ch.

Power out	Shielded [dBc]
Ref Aux Out (1.3)	< -80
Ref Out (1.3)	< -80
LO Out (1.354)	< -80
CLK Out (1.3)	< -80
LO Mon Out (1.354)	< -80
Pilot	< -80

Harmonic Content

Power out	2nd [dBc]	3rd [dBc]
Ref Aux Out (1.3)	<-80	<-80
LO Out (1.354)	<-80	<-80
CLK Out (1.3)	<-80	<-80
REF (1.3)	<-80	<-80

Measurements II.

> S parameters of the splitting section:

- S21 = LO -16 dB (spread = 0.4 dB), CAL -16 dB (spread = 0.5 dB)
- S11 = < -22 dB
- Isolation = mostly < -80 dB, some specific channels -65 dB

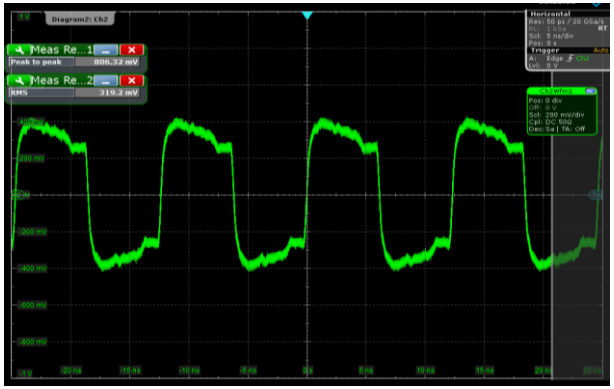
	REF 1.3 GHz				Isolation		
	S11	S21	S12	S22	Clk→REF	CAL→REF	LO→REF
Channel	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)
1	-32.6	-14.0	-14.0	-23.0	-95	-73	-91
2	-32.6	-14.0	-14.1	-22.6	-100	-75	-95
3	-32.3	-14.2	-14.3	-24.9	-97	-76	-95
4	-32.4	-14.7	-14.7	-24.1	-97	-79	-94
5	-32.3	-14.6	-14.6	-21.5	-97	-82	-97
6	-30.2	-14.9	-14.9	-25.4	-97	-84	-99
7	-30.0	-10.4	-10.5	-29.2	-93	-87	-97
8	-32.3	-10.8	-10.8	-23.8	-98	-95	-100
9	-30.3	-10.6	-10.6	-25.7	-91	-90	-97

WITH RF SHIELD							
	CAL 1.3 GHz				Isolation		
S11	S21	S12	S22	Clk→CAL	REF→CAL	LO→CAL	
(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	
-21.7	-8.6	-8.7	-17.9	-95	-83	-72	
-21.7	-16.2	-16.2	-23.7	-97	-92	-75	
-21.7	-16.2	-16.2	-26.0	-96	-89	-77	
-23.7	-16.4	-16.4	-30.9	-100	-81	-78	
-23.6	-16.7	-16.7	-26.0	-97	-80	-81	
-23.6	-16.5	-16.4	-26.7	-98	-81	-83	
-23.5	-16.3	-16.3	-24.2	-98	-82	-85	
-23.6	-16.4	-16.4	-23.1	-99	-81	-90	
-23.6	-16.4	-16.4	-22.3	-97	-84	-94	

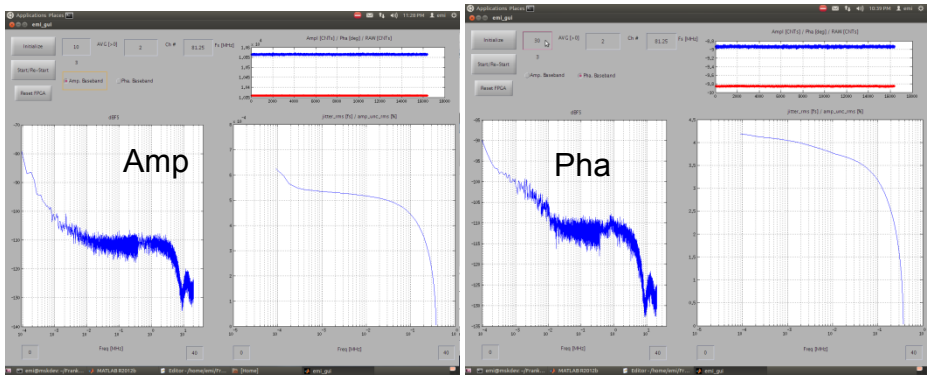
	LO 1.354 GHz				Isolation		
S11	S21	S12	S22	Clk→LO	REF→LO	CAL→LO	
(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	
-22.5	-8.7	-8.7	-20.6	-97	-96	-75	
-22.5	-16.2	-16.2	-16.6	-98	-92	-80	
-22.5	-16.2	-16.2	-17.8	-97	-90	-81	
-22.8	-16.2	-16.2	-16.5	-98	-93	-81	
-22.4	-16.2	-16.2	-20.1	-97	-91	-79	
-22.3	-16.3	-16.3	-19.9	-97	-92	-79	
-22.3	-16.0	-16.0	-20.0	-90	-94	-75	
-22.4	-15.9	-15.9	-19.5	-88	-94	-77	
-22.3	-16.0	-16.0	-17.2	-89	-95	-64	

> LO and CLK Distribution over the uRF-Backplane:

CLK distributed over the RF backplane to slot 4 (long. distance).

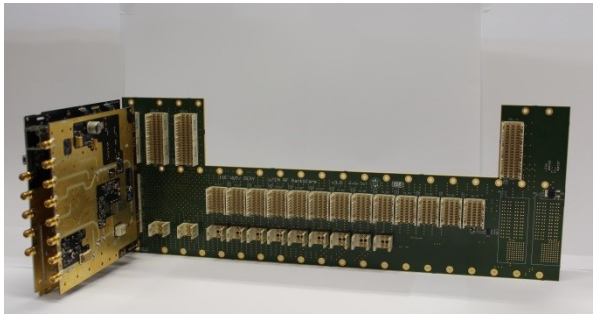


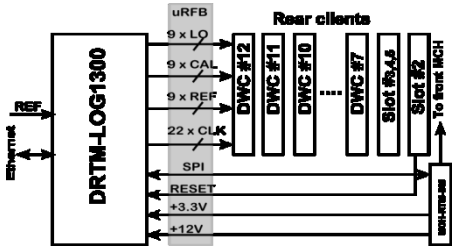
Sampling of signals with CLKs that were distributed over the uRF-backplane. No additional spurs were visible.

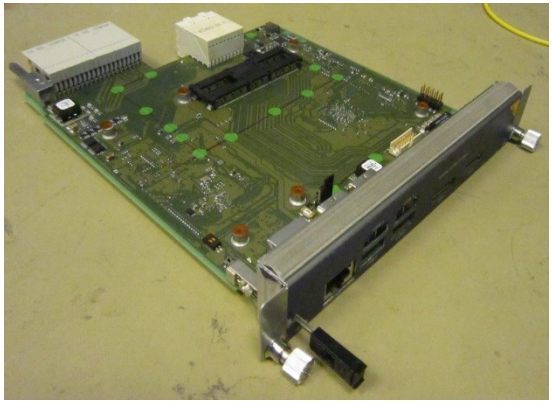


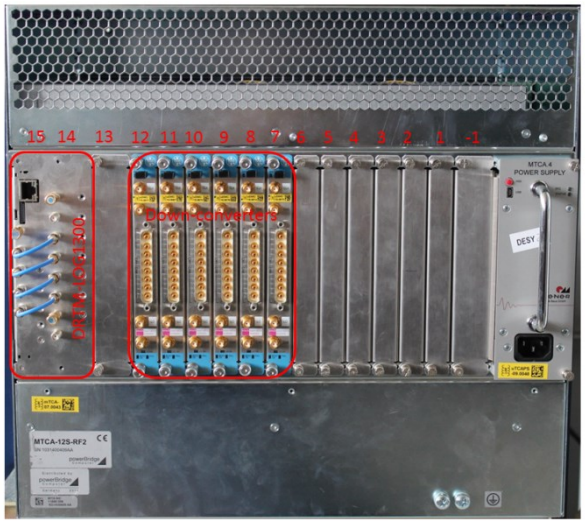
System Integration.

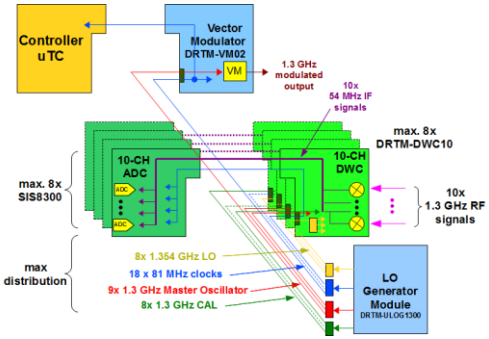
- Subsystems Involved:
  - DRTM-LOG1300
  - uRF-Backplane
  - 9U Chassis
  - NAT-MCH-BM or Rear Power module
  - End-Users (RTMs)











Thank you for your attention!