Status of design and development of CEPC-DHCAL readout electronics

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Introduction

- The goal of this research is to provide a feasible readout scheme for CEPC DHCAl. As the active detector element of sampling calorimeter has finely segmented readout pads of $1 \times 1cm^2$, it's a real challenge to access huge mount data from calorimeter.
- In PFA-based calorimeters, simulation results suggest that for readout segments as small as $1cm^2$, simple hit counting is already a good energy measurement for hadrons, so called DHCAL. A more general calorimeter with multi-threshold readout (e.g. 3 thresholds) records more detailed hit information and has better energy for jet energy above 40GeV, a so-called Semi-Digital Hadron Calorimeter (SDHCAL)
- In out research, a double layer GEM using self-stretching technique has been used. It consists of 3mm drift gap, 1mm transfer gap and 1mm induction gap and the effective area is $30 \times 30cm^2$with the readout pads small as $1 \times 1cm^2$.
- The chip choosen to readout is a tri-threshold ASIC called MICROROC (MICRO-mesh gaseous structure Read-Out Chip)

MICROROC

MICROROC is a 64-channel Semi-Digital read-out chip.
Each channel of the MICROROC chip has:

- A very low noise fixed gain charge preamplifier, able to handle a dynamic range from 1 fC to 500fC
- Two different adjustable shaper. A high gain shaper for small signal and a low gain shaper for large signal
- Three comparators for tri-threshold read-out
- a random access memory used as a digital buffer

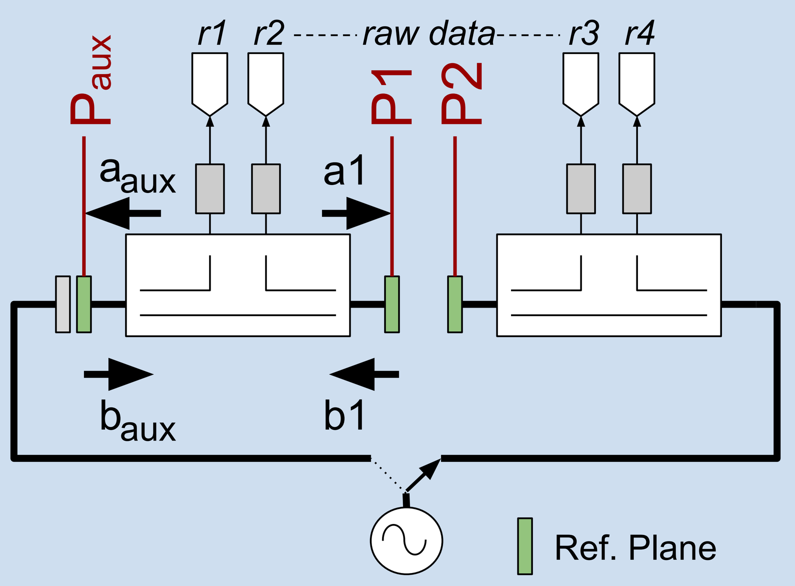
1. A relative VNA calibration creates an error-term matrix related to ports 1 and 2:

$$\begin{pmatrix} a_1 \\ b_1 \\ a_2 \\ b_2 \end{pmatrix} = K \begin{bmatrix} 1 & \beta_1 & 0 & 0 \\ \gamma_1 & \delta_1 & 0 & 0 \\ 0 & 0 & \alpha_2 & \beta_2 \\ 0 & 0 & \gamma_2 & \delta_2 \end{bmatrix} \cdot \begin{pmatrix} r_1 \\ r_2 \\ r_3 \\ r_4 \end{pmatrix}$$

2. The power calibration gives $|K|$
3. The phase calibration yields $\arg\{K\}$

Power and phase calibration are performed at an auxiliary reference plane (P_{aux}) after its own 1-port SOL coaxial calibration:

$$\begin{pmatrix} a_{aux} \\ b_{aux} \end{pmatrix} = K_{aux} \begin{bmatrix} 1 & \beta_{aux} \\ \gamma_{aux} & \delta_{aux} \end{bmatrix} \cdot \begin{pmatrix} r_1 \\ r_2 \end{pmatrix}$$



⇒ **Power** calibration at P_{aux} reference plane requires the connection of a power sensor. According to the measured value, in dBm, we can calculate $|K_{aux}|$ such as:

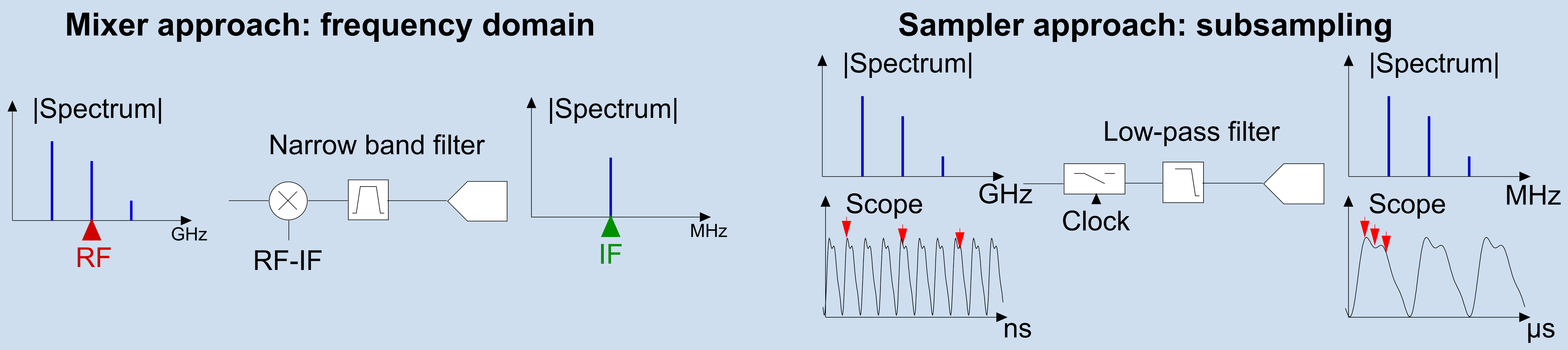
$$|K_{aux}| = \left| \frac{10^{(Power-10)/20}}{r_1 + \beta_{aux}.r_2} \right|$$

⇒ **Phase** calibration at P_{aux} is performed by connecting a direct receiver (e.g. r_3) at P_{aux}:

Time-domain instrumentation for non-linear devices

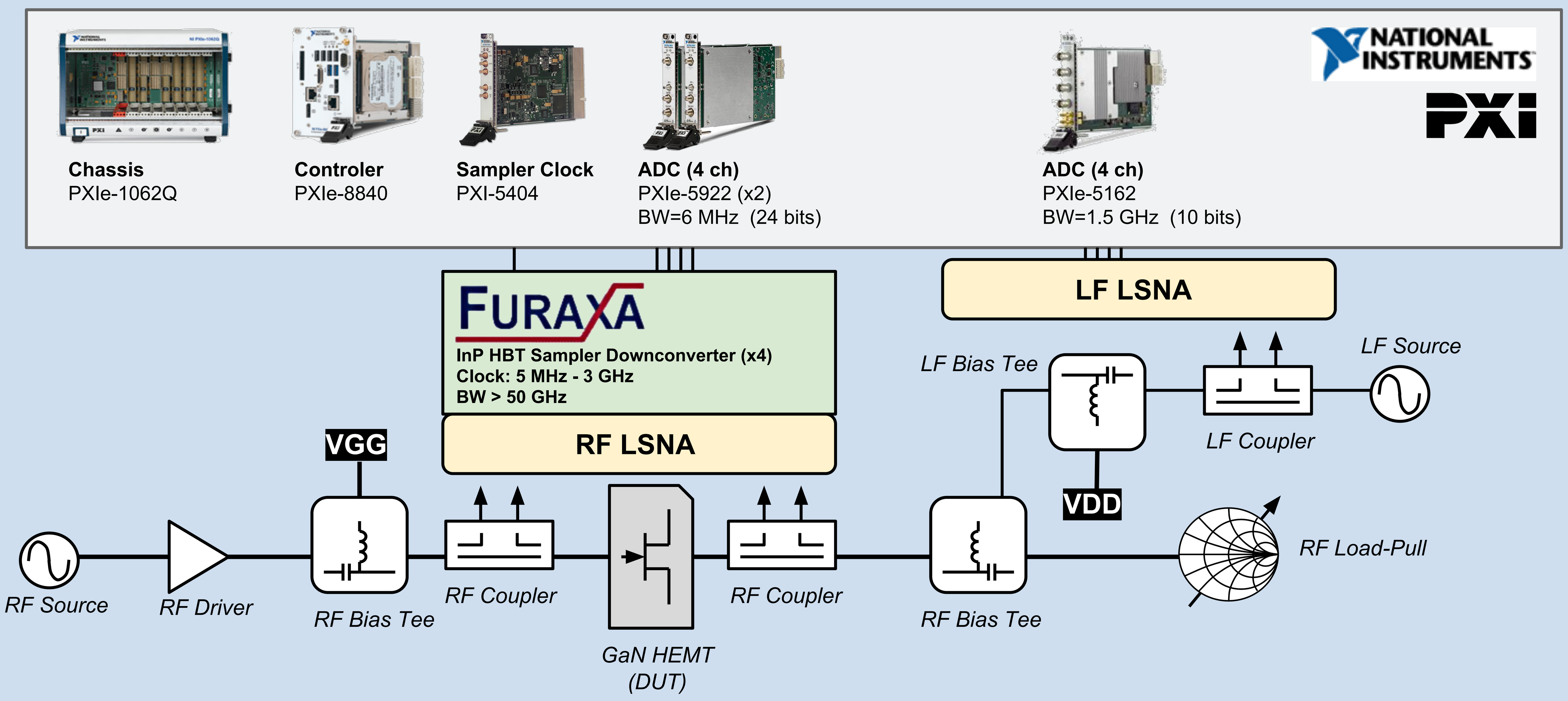
Name	Manufacturer	Receivers	Availability
MTA (requires two synchronized)	HP	Sampler	Discontinued
LSNA	Agilent	Sampler	Discontinued
PNA-X + Nonlinear option	Agilent	Mixer	$$
ZVA + Nonlinear option	Rohde and Schwarz	Mixer	$$
SWAP X-402	VTD	Sampler	Discontinued

Receiver: Mixer vs. Sampler



Measurement Setup for Envelope Tracking Application

The setup includes **two LSNAs simultaneously**. One is dedicated to RF (sampler based down-conversion), the other one samples directly the LF stimulus. The purpose is to investigate **low-frequencies** S_{22} of the DUT under RF large signal conditions.



Low-frequency measurement of drain supply envelope-bandwidth impedance for supply-modulated PAs

Conclusion

This new project will enable a new RF measurement capability by enabling an instrument that currently does not exist on the market. Some additional benefits include:

- frequency range extension of NI RF instrument products currently available;
- sampler architecture offers a unique multi-scale time analysis possibility (e.g. signal and carrier domains);
- can be implemented with various ADCs and downconverters (e.g. THAs);
- 100% LabVIEW environment;
- goal is to offer open-source LabVIEW software for user measurement flexibility.

Acknowledgements

This work is funded by National Instruments (Dr. Truchard) through a charitable donation. We would like to acknowledge DARPA (Dr. Greene) and ONR (Dr. Maki) for funding the initial part of this work under grant N00014-11-1-0931.