Rear-Transition-Module for Higher-Order Modes Diagnostics.

Szymon Jabłoński, Uroš Mavrič (presenter), Nicoleta-Ionela Baboi, Frank Ludwig, Holger Schlarb

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HOMs “Primer”

- HOMs carry information about the beam properties.
  - The amplitude of the excited dipole mode depends linearly on the beam **charge** and **transverse position**.
  - The timing of the excited modes depends on the **beam arrival time**.

- Therefore, HOMs can provide information about:
  - Beam position
  - Cavity alignment
  - Beam phase in respect to the RF phase

Courtesy of Nicoleta-Ionela Baboi
Instrument Architecture

> Signals we have to detect:

- Qext from $1\times 10^4$ up to $1\times 10^5$ ($\rightarrow \tau \sim 1-10\mu s$), superposition of various exponentially decaying signals
- High dynamic range of modes (fundamental $\sim 80 \text{ dB}$, dipole $\sim 20 \text{ dB}$, monopole $\sim 10 \text{ dB}$)
- Measure phase between the fundamental and the monopole
- Detect amplitude of the dipole

> Down-conversion is problematic because:

- 3 different LOs need to be generated $\rightarrow$ additional HW needed
- Different frequencies that need to be detected $\rightarrow$ problems with LO drifts

> Direct RF sampling:

- We need a high analog bandwidth ADC ($> 2.4 \text{ GHz}$)
- We need a high sampling rate due to the short measurement time window (We hope to gain SNR by assuming noise between samples in one RF pulse is uncorrelated).
System Block Diagram

- One RTM can process HOMs from 8 cavity couplers

- System drifts are minimized:
  - All signals travel on the same RF cable
  - The filter structure is temperature (actively) and humidity (passively) stabilized.

- Digital control (disturbances) minimized
Expected Performance – rough estimation

Noise amplification by the FE

ADC noise limit

Transform SNR into phase noise (assumed uncorrelated noise)

Phase accuracy of $0.02\ \text{degree}$ and amplitude accuracy of $0.03\%$ over the whole dynamic range of the 2.4 GHz monopole
DRTM-HOM1300 Carrier

- 8 input channels for HOM diagnostics
- 1.3 GHz reference input
- CLK output on the front panel
- MicroRFBackplane support
- High frequency zone3 connector
  - Better matching
  - Better channel-to-channel isolation
- On-board temperature regulation possible

Filter Mezz.
CLK Mezz.
DC/DC, RTM Management
DRTM-HOM1300 Clock Mezzanine

- Compact
- Locked to the 1.3 GHz reference input
- Based on the 500 MHz VCSO (other frequencies possible, e.g. 450 MHz, 800 MHz, 1 GHz)
- Timing jitter of 48 fs (10 Hz – 10 MHz) -> can be further improved

![Diagram of the DRTM-HOM1300 Clock Mezzanine](image)

**Courtesy of Szymon Jabłoński**
DRTM-HOM1300 Filter Mezzanine

> Will work as a selective structure for 3 different frequencies
  - Amplitudes of the measured modes must be individually adjusted

> Proposed design (tunable interdigital filter)
  - Satisfying RH and Temp. dependence
  - Low cost
  - The transfer function can be manually tuned with lumped comp. (Cs)
  - Simulations show that we meet the specs
  - 6 filters per mezzanine will fit

> Large dynamic range requires variable attenuators included in the structure on individual legs

> 6 filters (2 x 3) fit on 5.5 cm x 6.5 cm PCB

Composite Structure S21

Individual Filters S21
Mechanics

- Provides RF Shielding
- Provides heat-sink for the active temperature control
- Larger thermal mass smooths faster temp. variations
- Will be used as part of the humidity encapsulation
- Shield will be composed of 2 pcs.
500/800 MS/s Digitizer

> The RTM is designed to operate with the DAMC-DS500/800
  - Based on the TI ADC12D500/800RF ADCs
> Evaluation of the RTM will be done with DFMC-DS500/800
  - The same front-end as the DAMC-DS500/800

Courtesy of Johannes Zink (Presented in the previous talk)
Thank you for your attention