TEMPERATURE STABILIZED LLRF CONTROL FOR THE NEW GENERATION OF LINEAR ACCELERATORS

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Abstract

The requirements on photon flux and bandwidth of LINAC based gamma sources are becoming more and more critical, demanding the use of more complex acceleration schemes (such as multi-bunch operation) and feedback strategies, as in ELI-NP gamma beam source under construction in Magurele by the European consortium Eurogammas. The paper will describe the ELI-NP requirements with respect to the LLRF system, how the Libera LLRF platform has been modified to fulfill them and the measured results. A new temperature stabilization scheme was designed in order to compensate long-term thermal drifts. New RF design concepts have been introduced to fulfill the requirements at C and S band within the same system. Furthermore, the development of a new signal processing approach, providing separated amplitude and phase control, together with the capability of generating arbitrary pulse shapes, increases LLRF flexibility and represents a key feature to compensate the beam loading contribution in multi-bunch regime.

ELI-NP RF system

Figure 1: ELI-NP building (Magurele).

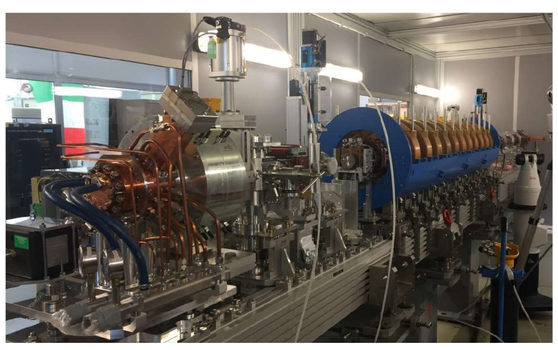

Figure 2: ELI-NP photoinjector.

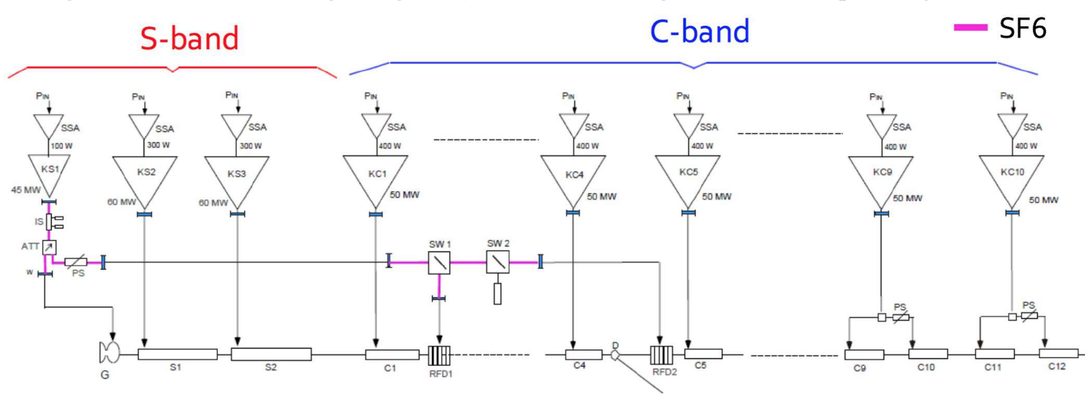

Figure 3: ELI-NP RF system block diagram.

Requirements	Values
RF frequencies:	• S-band: 2856 MHz • C-band: 5712 MHz
RF system topology:	• 1x NC SW S-band RF gun • 2x NC SW S-band deflecting cavities • 2x NC TW S-band structures • 12x NC TW C-band loaded structures
Beam structure and repetition rate:	32 bunches (16 ns spc.) 100 Hz
Additional requirements:	• Amplitude resolution 0.1% RMS • Phase jitter: < 10 fs RMS • Longterm stability 100 fs RMS (at 24 ± 2 °C) • Arbitrary pulse shape control

Figure 4: The Libera LLRF system, customized to meet the ELI-NP requirements, with a separate temperature stabilized RF front end unit.

RF front end unit design

To meet the long term stability requirements the Libera RF front end has been redesigned within a separate unit. All RF front end circuits are precisely temperature stabilized. The same design supports S and C band LLRF systems.

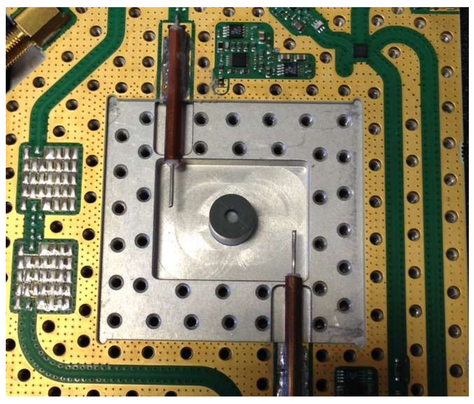

Figure 5: RF front end unit C band LO cavity filter implementation within the RF shield.

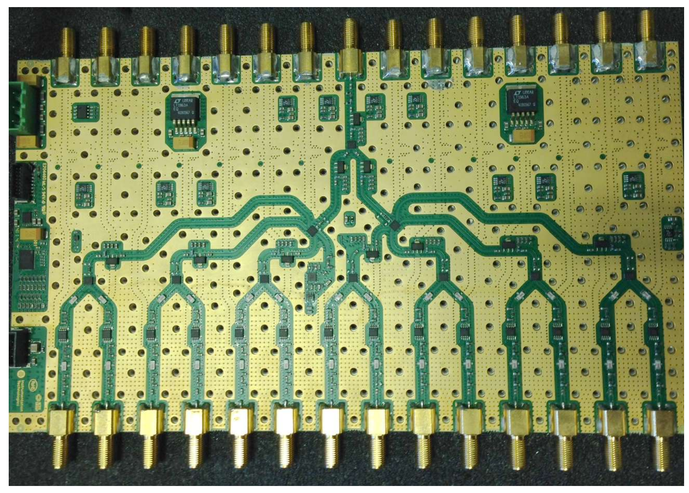

Figure 6: RF front end unit 14 channel down conversion

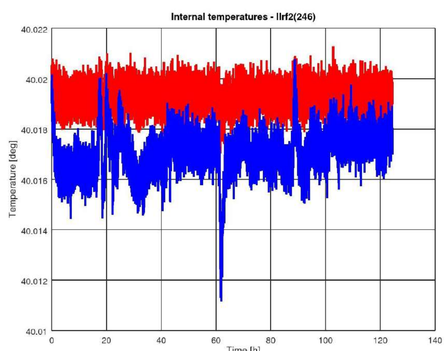

Figure 7: RF front end temperature stabilization down to thousands of a degree.

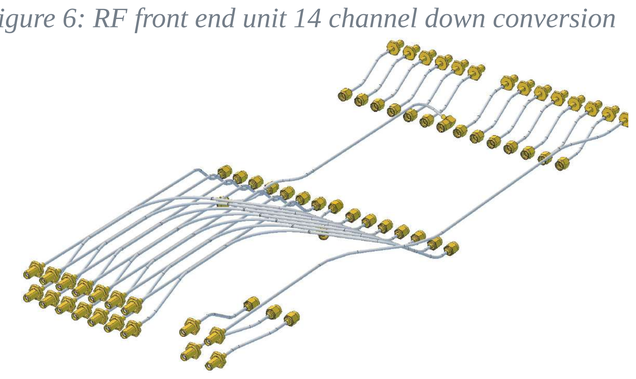

Figure 8: Cable layout 3D modeling within temperature stabilized RF front end.

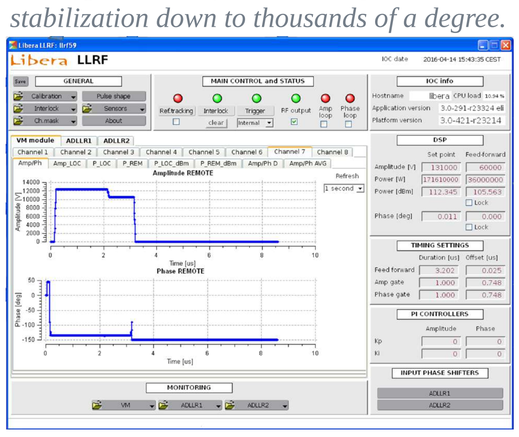

Figure 9:GUI supports arbitrary amplitude and phase pulse shape control. Separate baseband pulse by pulse amplitude and phase controllers simplify the operation of the system.

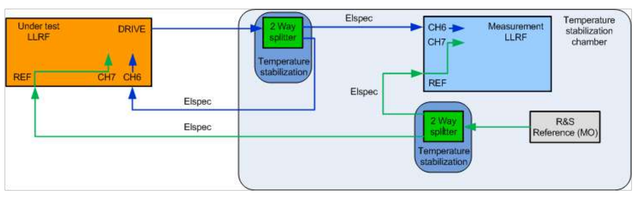

Figure 10: Longterm test setup based on two independent units: the LLRF unit under test is exposed to ambient environment and is applying feedback on the drive. The other LLRF unit is measuring the drift, while kept in temperature stable environment.

Results:		Values
Amplitude resolution	S band	0.005% RMS
Phase resolution	S band	0.003° RMS
Amplitude control	S band	0.014% RMS
Phase control	S band	0.008° RMS
Amplitude resolution	C band	0.005% RMS
Phase resolution	C band	0.007° RMS
Amplitude control	C band	0.010% RMS
Phase control	C band	0.009° RMS
Longterm drift	S band	92.7 fs RMS
Longterm drift	C band	77.68 fs RMS

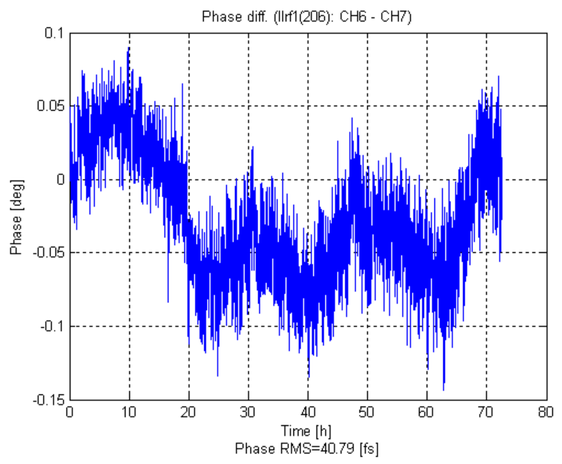

Figure 11: Measured phase drift over 72 h in the case of the S band LLRF system: 40.79 fs

Conclusions

A temperature stabilized LLRF system for the ELI-NP project has been developed within the Libera LLRF platform. The functionality has been extended in order to enable independent amplitude and phase pulse shaping. The measurement results are within the ELI-NP requirements for both C and S band systems. Three S band and 10 C band LLRF systems have been successfully tested and delivered for ELI-NP installation.

References

[1] L. Piersanti et al., “THE RF SYSTEM OF THE ELI-NP GAMMA BEAM SOURCE”, in Proc. IPAC’16 Busan, Korea, May 2016
[2] A. Giribono et al., "ELI-NP GBS STATUS", in Proc. IPAC2017, Copenhagen, Denmark

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