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Jitter study on the phase control approach of the high power RF supply in EuPRAXIA

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This work presents a jitter study of the fast intra-pulse feedback loop for klystron-driven RF power stations in SPARC_LAB. To meet the rigorous RF stability demands of next-generation accelerators, such as the EuPRAXIA facility, the LLRF system in SPARC_LAB has undergone a comprehensive upgrade. The requirement for phase jitter in plasma wakefield acceleration and seeded free-electron laser (FEL) experiments is sub-10 fs timing precision. A feedback loop is implemented to control this, and the original loop—operational since 2008—achieved a reduction in phase jitter from hundreds of femtoseconds to tens of femtoseconds for S-band klystrons. As part of this upgrade, the S-band system was further enhanced through several modifications, including the replacement of the fast phase shifter, an upgrade of the error amplifier, and the introduction of a slow feedback loop. Recent results on the S-band system show that the jitter can be reduced to less than 20 fs. Long-term measurements have been performed to further investigate the factors that impact loop performance. These measurements represent a significant step toward achieving sub-femtosecond RF stability, which is crucial for novel plasma accelerator facilities.

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