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Reliable, Optically Augmented RF Reference Distribution with Femtosecond Stability

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State of the art Free Electron Lasers have rigorous electron beam stability requirements. To fulfill these requirements the low-level RF systems rely on a phase stable RF reference. Classical coaxial RF distribution systems have low complexity and thus offer excellent reliability and also a good short-term performance. However, their long-term stability does not meet today's requirements of large-scale FELs. Optical reference distribution methods offer significantly superior long-term stability but are also more expensive and complex to implement and maintain. Our optically augmented RF distribution system features drift compensation of the RF signal at the client with respect to a drift-free optical reference signal. The key component of the RF re-synchronization module is an opto-electrical phase detector based on a commercial Mach-Zehnder based amplitude modulator - for which we show few femtosecond long-term stability. Our augmented system offers the advantages of a coaxial RF distribution system while providing the femtosecond stability of a pulsed optical synchronization system to those clients with a high stability requirement. We present the topological advantages of an augmented RF distribution in terms of reliability, scalability, costs, and performance.

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