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Phase Noise Cancellation Impact on IQ Measurement Accuracy in LLRF Systems with Frequency Downconversion

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High performance synchrotron light sources like Soleil2 or Lunex5 require LLRF systems with high IQ accuracy: typically 0.01° RMS in phase and 1e-4 relative error in amplitude. This accuracy may be ultimately limited by the phase noise of the reference signal. In most LLRF systems, frequency downconversion to an IF signal of10 MHz is used before the digital IQ-demodulation. It can be shown experimentally or based on numerical simulation that the phase noise information is largely lost when the local signal is produced by mixing the reference RF signal with a spectrally ultrapure 10 MHz-signal. In that usual case, the RF and local signals have almost the same phase noise, which will cancel out in the downconversion process. Phase noise measurements for frequency offsets from carrier in the range of 3 Hz to 1 MHz, with a signal analyzer showed up to a factor 4 of reduction in the phase jitter for the IF signal as compared to the RF signal. Meanwhile, the IQ-demodulation followed by phase rotations is subjected to other noise or error sources, which lead to an overestimation of the phase error. The impact of those uncertainties on the operation of an accelerator will be discussed.

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