Elimination of Intensity Noise at SURF III

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Most applications of synchrotron radiation are not very sensitive to source intensity fluctuations. Fourier-transform spectroscopy, however, is very sensitive to intensity noise with frequencies of few Hz to several kHz. An infrared spectrometer installed at the Synchrotron Ultraviolet Radiation Facility (SURF II) in 1997 \cite{1} indicated that SURF II had a significant amount of intensity noise. Much of that noise has been attributed to bunch length relaxation oscillations (saw-tooth instability), which had been observed earlier \cite{2}. In addition, these oscillations were seen to be temporally correlated with coherently enhanced microwave emission \cite{3}. A firm connection between the two effects was proven shortly after their original discovery in an elaborate experiment employing several new diagnostics devices \cite{4}. Subsequent study uncovered a second source of intensity noise, namely the intentional excitation of the vertical betatron oscillation with a broadband noise source. (We drive this oscillation to increase the electron beam size and thereby stored-beam lifetime.) Both the saw-tooth oscillations and the vertical betatron oscillations can affect the beam size and thus cause intensity changes. The saw-tooth bunch length oscillations cause beam energy spread oscillations that cause variations in both the transverse beam size and the equilibrium orbit. Through several improvements of the radio-frequency system at SURF and an increase in the electron energy (more efficient damping) we can now tune the machine to suppress the saw-tooth instability. The excitation of the vertical betatron oscillation using the broadband noise source induces intensity noise, because of amplitude and phase variations at a given frequency, causing the vertical beam size to fluctuate. Replacing the broadband noise source with a narrowband frequency generator, which is tuned automatically with a feedback loop to keep the vertical beam size constant, solved the second problem. After eliminating these two contributions to the intensity noise, SURF is now providing synchrotron radiation with unprecedented stability.

References


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