Measurements of the Temporal and Spatial Phase Variations of a 33 GHz Pulsed Free Electron Laser Amplifier and Application to RF Acceleration

by

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Abstract

In this thesis we report the results of temporal and spatial measurements of phase of a pulsed free electron laser amplifier (FEL) operating in combined wiggler and axial guide magnetic fields. The 33 GHz FEL is driven by a mildly relativistic electron beam (750 kV, 90-300 A, 30 ns) and generates 61 MW of radiation with a high power magnetron as the input source. The phase is measured by an interferometric technique from which frequency shifting is determined. The results are simulated with a computer code.

Experimental studies on a CERN-CLIC 32.98 GHz 26-cell high gradient accelerating section (HGA) were carried out for input powers from 0.1 MW to 35 MW. The FEL served as the r.f. power source for the HGA. The maximum power in the transmitted pulse was measured to be 15 MW for an input pulse of 35 MW. The theoretically calculated shunt impedance of 116 \( M\Omega/m \) predicts a field gradient of 65 MeV/m inside the HGA. For power levels > 3 MW the pulse transmitted through the HGA was observed to be shorter than the input pulse and pulse shortening became more serious with increasing power input. At the highest power levels the output pulse length (about 5 nsec) was about one quarter of the input pulse length. Various tests suggest that these undesirable effects occur in the input coupler to the HGA. Light and X-ray production inside the HGA have been observed.

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