Microwave Measurement and Beam Instrumentation Lab

Purpose and Audience
Modern accelerators rely on beam manipulation using electromagnetic fields at RF and microwave frequencies. This laboratory course introduces the student to some of the RF and microwave technology and laboratory methods for its characterization. The course consists of short lectures introducing the topics covered in the laboratory exercises. Students will spend most of their time on actual measurements. Successful completion of this course carries 3 semester hours of graduate XXX credit. Prerequisites: Undergraduate Electromagnetism and Accelerator Fundamentals. Due to the limited availability of equipment, this course is limited to 20 students.

Objectives
Provide the student with experience in measurements of RF and microwave accelerator hardware and signals using modern equipment.

Instructional Method
This course includes a series of short lectures introducing the lab topics during morning sessions, and extensive lab sessions to demonstrate theoretical concepts. These hand-on labs include:

(1) Spectrum Analyzer: for measurement of simple signals on a spectrum analyzer to understand resolution bandwidth, video bandwidth, dynamic range, noise, etc;

(2) Time Domain Reflectometry (TDR): measure characteristics of various connector families, transmission lines, complex loads;

(3) Beam Impedance: use the wire method to measure the beam impedance of an accelerator component;

(4) Beam Signals: utilize an arbitrary function generator to simulate beam signals from the accelerator, AM for betatron signals, FM for synchrotron signals;

(5) Pickups and kickers: measure and understand to performance of a stripline used as either a pickup or kicker;

(6) Matching: design and build a simple single stub transmission line matching circuit; and

(7) RF Cavities: measure mode spectrums of a cavity, the cavity coupling, loaded and unloaded Q, the electric field profile and R/Q of a cavity by the bead pull method.

(8) Use of a vector signal analyzer for measuring beam signals.

Course Content
(1) Microwave Measurements in the time and frequency domains, basics of spectrum analyzers, vector signal analyzers, and time domain reflectometers;

(2) Transmission lines, complex impedance, reflection coefficients;

(3) Microwave measurements with a Vector Network Analyzer, basics of vector network analyzers;

(4) Stripline pickups and kickers;

(5) Beam signals for Circular Accelerators, beam spectrums, power spectral density, betatron and synchrotron signals;

(6) Beam impedance and methods for measuring it.

(7) Impedance matching, basic of matching devices; and

(8) RF cavity measurements, cavity basics, bead pull, coupling, cavity bandwidth.

Reading Requirements
“Microwave Engineering” by David Pozar will be available as reference material. The course will follow our notes which will be available on-line.

Credit Requirements
Students will be evaluated based on performance in the laboratory. Both instructors will be actively involved with each of the students during the course of each day and each experiment. The students will be evaluated by one on one discussions about the experiments.
Students are expected to submit written lab reports and solutions to the homework assignments.