List of experiments to be carried out during hands-on training sessions during International Accelerator School – 2012

(1) Single cell RF cavity measurements using bead-pull setup

(2) Characterization of solid state RF amplifier and associated co-axial components

(3) Beam profile measurements using digital image processing techniques

Each experiment is of one hour duration and will be carried out at Raja Ramanna Centre for Advanced Technology, Indore, INDIA

Experiment-1

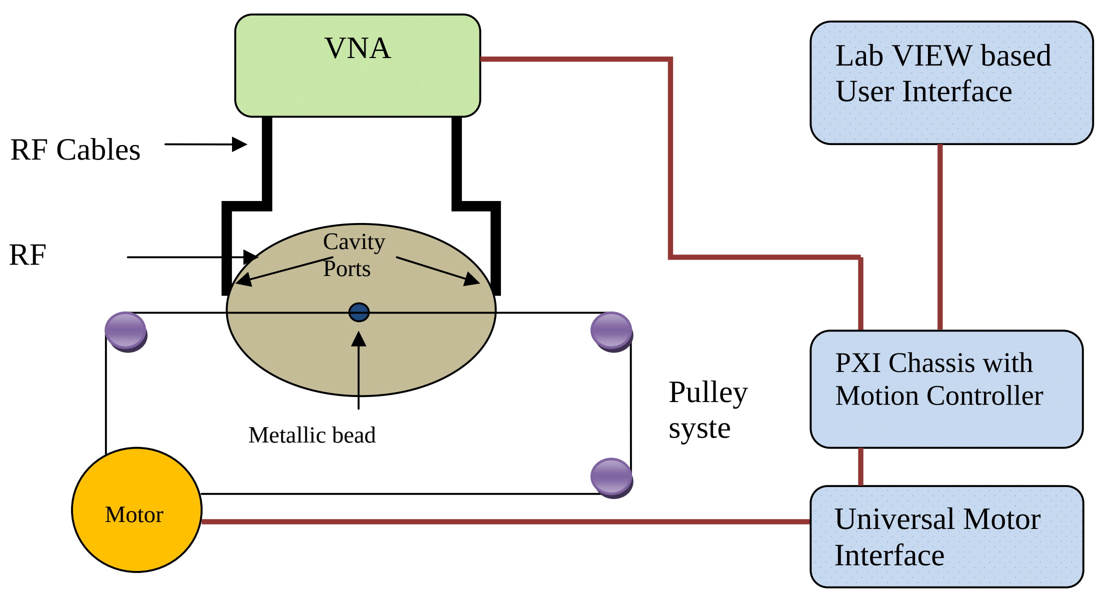
Objective of the experiment: To measure Quality factor (Q), R/Q and Shunt impedance of a single cell RF cavity using Bead-Pull setup.

Description of Experiment: Bead-Pull is a commonly used Radio Frequency (RF) field measurement technique, which plays important role in qualifying an RF cavity. It is based on the Slater Perturbation Theorem. According to Slater Perturbation theorem for spherical bead of radius ‘r’, ratio of change in frequency to unperturbed frequency of RF cavity is given by

$$\frac{\Delta f}{f_0} = -\frac{\pi r^3}{U}\left(\varepsilon_0 \frac{\varepsilon_r - 1}{\varepsilon_r + 2} E^2 + \mu_0 \frac{\mu_r - 1}{\mu_r + 2} H^2\right)$$

This ratio ($\Delta f / f_0$) can be determined using a Bead-Pull system which consists of a stepper motor (operated via universal motor interface UMI) and a pulley system which guide the motion of the bead through an RF cavity. A Vector Network Analyzer (R&S make ZVB8) is used to measure the resonance frequency (f_0), change in resonant frequency due to insertion of bead (Δf) and Quality Factor of the cavity (Q). A PXI interface is used to control the bead motion and acquire Network Analyzer data using LabVIEW. The software will then calculate the cavity parameters using value of Q and ($\Delta f / f_0$).

Block diagram of the system



Experiment-2

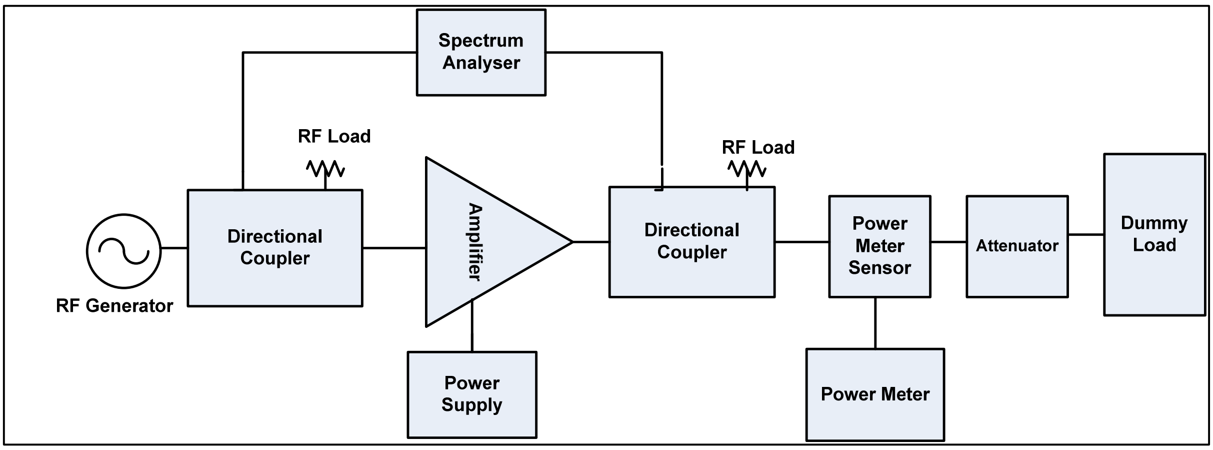
Objective of the experiment: Characterization of Solid State RF Power Amplifier and Directional Coupler using Vector Network Analyzer (VNA), Spectrum Analyzer, Signal Generator, Power Meter, Coaxial lines and Matched Terminations.

Description of the Experiment: In this experiment RF characterization of solid state RF amplifier and directional coupler will be carried out with the help of vector network analyzer, spectrum analyzer and power meter. Characterization of solid state RF amplifier includes measurement of gain, output power and efficiency.

Directional coupler is a 4 port device and is used to measure output power of high power amplifiers by extracting a sample of forward power and reflected power from termination. For direction coupler key parameters like directivity, return loss, insertion loss and coupling will be determined with swept frequency measurement. Effect on directivity as a function of mismatch at coupled ports will be highlighted.

Block diagram for the solid state amplifier experiment is shown below. Different parameters will be measured using RF instruments as shown in this diagram.

Block Diagram of the experiment



To characterize directional coupler, first calibration of VNA will be performed with electronic calibration kit and directional coupler will be connected between VNA ports using suitable RF cables. Coupler parameters like power coupling, directivity, isolation and return loss will be measured using VNA.

Experiment-3

Objective of the experiment: Beam profile measurements using digital image processing techniques.

Description of Experiment: In particle accelerators, the density distribution of particles over the two coordinates- x (horizontal) and y (vertical) in the transverse plane is termed as beam profile. Beam profile measurement is important for routine machine operation and is also useful in optimizing various machine parameters. Scintillating screens, sometimes also called fluorescent screens, are widely used to measure transverse profiles of particle beams in particle accelerators due to their simplicity and ease of operation. A typical material widely used in accelerators is aluminium oxide, also known as *alumina*, doped with chromium (*Chromox* Al_2O_3 : Cr). This material is particularly robust and is well suited for the fabrication of beam observation screens. The other reason for using this material is that the emission of light matches to the sensitivity of solid state image sensors (CCD).

In this experiment, a laboratory setup will be used to demonstrate the principle of beam profile measurement using scintillating screens. A diode laser will be used to simulate the particle beam. The images will be monitored by a charge coupled device (CCD) camera and digitized image data will be acquired by a computer. As digital images in accelerator environment are normally corrupted by various types of noises, the methods of image de-noising with various digital filters will be discussed. Basic methods of digital image processing for image enhancement, edge detection, image thresholding and image segmentation will be explored. Methods of beam size and beam centroid measurement using Gaussian fitting on line profile data will be demonstrated. Block diagram of the experiment setup is shown below.

Block diagram of setup