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COMPUTER-AUTOMATED LINAC DIAGNOSTICS AND DATA ACQUISITION

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Abstract

7

Computer interactive diagnostics have been developed and tested for measuring RF Linac electron beam position and emittance. Electron beam position is measured with ferrite-loaded stripline monitors. The measured signals are processed by an APPLE-II computer, displayed and updated (at the Linac repetition rate) on a monitor. Data to determine emittance is collected by measuring electron beam spot size (using the wire scanner technique) as the focal strength of a quadrupole triplet is adjusted around the focus at the scanner. The emittance is calculated by the APPLE-II making a hyperbolic curve fit to these data.

Introduction

The computer interactive instrumentation systems consists of an APPLE-II-plus host computer which communicates with the data acquisition modules contained in a CAMAC crate via a compatible controller. The processed data is displayed on a color monitor. Hard copies are provided by a dot matrix printer with graphics. To date the interactive instrumentation system has been used to display electron beam position and calculate electron beam emittance.

Electron Beam Position

The electron beam position is monitored using a ferriteloaded stripline¹ (Figure 1). The ferrite increases the stripline signal response by a factor of two. The stripline output is a differential signal proportional to the beam current, and inversely proportional to the separation distance from the beam. Calibration data were obtained for each stripline by bench testing with a pulsed wire.

Each monitor is made up of four striplines, two each along the horizontal and vertical axis of the plane perpendicular to the beam centerline. These striplines straddle the beam along each axis and are located equidistant from the drift centerline. The beam position can be measured to about 0.5 mm using these striplines.

The signal from each stripline is integrated by a 12channel CAMAC compatible integrator and is processed by the APPLE-II. The beam position is determined by the APPLE using the expression

$$P = K \frac{S_1 - S_2}{S_1 + S_2}$$

- P = electron beam position
- S₁ = integrated signal of stripline 1
- S₂ = integrated signal of stripline 2 K = Proportionality constant de
 - Proportionality constant dependent on the configuration of the striplines in the beam pipe.

The output beam position data can be displayed on a NEC color monitor in one of two formats selected by the experimenter. The monitor first displays the beam position at a selected location. The graphic display includes a dot to represent the beam position and a set of cartesian coordinates to reference the beam pipe centerline. The second format displays the beam position at a number of diagnostic stations simultaneously in both the horizontal and vertical axes.

Emittance Measurement

The technique used for measuring beam emittance is based on the assumption that the phase space distribution is elliptical. Consequently, the radius of the beam will vary hyperbolically with the strength of an upstream lens. The beam emittance can be evaluated from the minimum and the asymptote of the hyperbola.²

A schematic of the experimental arrangement is illustrated in Figure 2. A wire scanner in conjunction with a turnout magnet and a Faraday cup are used to measure the beam radius. A quadrople triplet, located 2.5m upstream of the wire scanner, has its focal strength adjusted around focus at the scanner.

The scanner contains a 0.5 mm tungsten wire bent into a section of a 45° helix. As the wire rotates in the beam pipe it cuts orthogonal axes each 180°. The scan monitor is rotated 45° to the pipe for vertical and horizontal scanning.

Beam profiles are generated by observing the amplitude of the remaining (unscattered) beam at a downstream Faraday cup. (The technique requires an analysis magnet between the scanner and cup to ensure rejection of small angle scattered electrons.)

Oscilloscope display of Farady cup current is gated to allow profiling of the beamshape in a specific time window. An oscilloscope photograph of a characteristic beam profile is shown in Figure 3.

At each setting of quadrupole strength a beam profile is taken. The beam radius is measured from the scan photograph and entered into the APPLE-II with the corresponding quadrupole currents.

The computer calculates the focal strength of the triplet using quad matrices. The triplet calibrations needed for the calculation already reside in the software.

The APPLE plots the beam radius at the scanner versus the focal strength of the quad and displays the points on the monitor. It then fits a hyperbola to the points and calculates the emittance. The hyperbolic fit and the emittance are also displayed on the monitor. The screen output is shown in Figure 4.

Summary

The computer-automated acquisition system has been useful in displaying the electron beam position and calculating the electron beam emittance for the RF linac experiments at Boeing.

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- G. Mavrogenes, M. B. James, R. F. Koontz and R. H. Miller, "Beam Measurements on Argonne Linac for Collider Injector Design," Proc. of 11th International Conf. on High-Energy Accelerators, CERN, Geneva, Switzerland, July 7-11, 1980, pp. 481-485.

Illustrations



Figure 1. Beam Position Monitors.



Figure 2. Experimental Arrangement for Emittance Measurement.

VERTICAL PLANE, FULL WIDTH, 0.16A PK



HYPERBOLIC FIT YIELDS r_{min} = 0.03 α = 1.6 mr

 ε = $\pi r \alpha$ = 1.3 π mm-mr

Figure 4. Computer Display of Emittance Measurement.



2.9 mm/div.

Figure 3. Characteristic Beam Profile.