SINGLE PASS COLLIDER MEMO

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DATE: 9/23/83

REPLACES CN#

TITLE: Optimum Operating Temperature for Accelerator Diskloaded Waveguide -
Test Results from Sector 2

INTRODUCTION

By comparing the phase of a beam-induced RF wave in an accelerating structure with a reference RF signal locked to the SLAC master oscillator, the tuning status of the accelerator structure may be determined. The proper tune is achieved when the phase of the beam-induced RF is constant over the length of the induced pulse.

Using this criterion, measurements were made in Sector 2 to determine the proper accelerator structure operating temperature for different applied RF power levels. The average power was varied by changing the repetition rate of the klystrons. The tuning status of each of the eight stations of Sector 2 under constant operating conditions was also measured.

CONDITIONS

The sector was operating unslidded with 2.3μsec pulse length and nominal 60Hz repetition rate in a standby mode (RF pulse delayed 34μsec from beam pulse). The beam-induced signal was obtained from a 300μA beam derived from the PEP gun as it drifted through Sector 2.

TEST SETUP

The phase was measured with a mixer as a phase detector. A limiter was used to reduce the power level into the mixer during the RF pulse. This increases the sensitivity of the phase detector during the beam-induced pulse.

Water and accelerating structure temperatures were measured with the temperature readout system on the SLC computer.

RESULTS

Fig. 1 shows the phase of the beam-induced signal of station 2-5 when the klystron repetition rate is varied from 120Hz to 60Hz to 0Hz (RF power off) with the input water temperature kept constant. The phaseshift across the ten-foot structure changes 7.4 degrees for each 60Hz step. Changing the klystron repetition rate by 60Hz is equivalent to a 4.6kW step in applied average RF power.

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Fig. 2 shows the same phase pictures with constant Cu-temperature as measured on a thermocouple imbedded in the accelerator structure. The constant temperature is maintained by changing the input water temperature to compensate for changes in applied average RF power. The phaseshift is considerably reduced.

Some calibration data derived from these measurements:

$\Delta\theta/\Delta T = 8.9$ degrees/ $^{\circ}\text{F}$ for a ten-foot accelerator structure, which agrees fairly well with an old number of 7.9 degrees/ $^{\circ}\text{F}$ from Ref. 1.

Taking the latter more accurate calibration, we can derive a temperature change of the accelerator structure with applied average RF power of $0.9^{\circ}\text{F}/4.6\text{kW}$. This agrees quite well with the measured temperature variation in Fig. 1.

To see how well different structures are tuned, phase measurements were made on all eight stations of Sector 2 under constant repetition rate and input water temperature. The phase plots for eight stations in Fig. 3 show very little slope for all but station 2-8. Since station 2-8 is running at the very low power of 13MW peak, a negative phase slope is expected. Stations 2-1 through 2-7 are operating at the correct temperature for their respective power levels at 60Hz repetition rate.

CONCLUSION

To keep the accelerator structures in proper tuned condition with variable applied RF power, the Cu-temperature of the structures should be kept constant. From the specifications in CN 102 by R. Stiening, we derive that a $\Delta\theta = \pm 10^{\circ}$ per ten-foot structure would be permissible to stay within a $\frac{\Delta E}{E}$ of 0.5%. Further measurements should be performed to prove that all structures stay within this limit under the SLC operating conditions where the average RF power level will be in the order of ten times the average power used for the present test.

¹J. Weaver, "Microwave Phase Dependence of the Accelerator Sections and the Waveguide Network", SLAC-TN-66-6, May 1966.

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Fig. 1 Constant input water temp. of 111.1°F (7°div. , 200nsec/div.).

120 Hz

Cat Temp. 112.9°F

60 Hz

Cat Temp. 111.1°F

0 Hz

Cat Temp. 111.2°F

Fig. 2 Constant Cu-Temp.
($7^\circ/\text{div.}$, 200nsec/div).

120 Hz
Cu Temp. 111.8°F
 H_2O Temp. 109.9°F

60 Hz
Cu Temp. 112.1°F
 H_2O Temp. 111.0°F

0 Hz
Cu Temp. 112.2°F
 H_2O Temp. 112.0°F

Fig. 3 Phase flatness of beam induced signal in 8 stations of Sector 2
(7°/div., 200nsec/div., H₂O temp. 111.0°F, 60Hz)

STA 2-1
25.1 MW
Cu-temp
111.9°F

STA 2-5
30.9 MW
Cu-temp.
112.1°F

STA 2-2
17 MW
Cu-temp.
111.9°F

STA 2-6
35 MW
Cu-temp.
112.3°F

STA 2-3
22.8 MW
Cu-temp.
111.8°F

STA 2-7
29.5 MW
Cu-temp.
112.0°F

STA 2-4
26.1 MW
Cu-temp.
111.9°F

STA 2-8
13.1 MW
Cu-temp.
111.7°F

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