DO ENGINEERING NOTE 45

Capacitance Flatness Gauge Prototype

A. Pitas, R. Angstadt

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I. Introduction

The DO calorimeter has within it thousands of large plates. Our ability to construct the detector depends on the flatness of these plates. The performance of the detector depends on the flatness of the plates after they are assembled into a module. It has been proposed that the flatness of the plates before and after assembly could be determined by measuring capacitance. This device demonstrates the viability of using capacitance to measure the flatness of individual plates. No attempt has been made to extrapolate the results to measuring the flatness of the plates once they are in a module.

II. The Device

The prototype is intended to measure the flatness of a single plate. The device consists of two parts: the electronics and the readout board. The electronics (Figure 1) consists of an LCR meter, Hewlett-Packard model 4262A, a multiplexer, Racal-Dana 1200 series Universal Switch Controller with 1213 Low Thermal Noise Relays, and an IBM-PC XT with an IEEE-488 Interface Bus. The IBM controls and receives data from both the LCR meter and the multiplexer.

The readout board measures 25"x25"x1 1/16" (Figure 2). It consists of three G-10 boards glued together. The top board is 1/32" thick with 1 oz. copper on one side. The copper has been routed away to form a 6x6 array of 4"x4" pads. The middle sheet is 1" thick with both sides bare. The third sheet is 1/32" thick with 1 oz. copper on one side. The copper has been etched to leave lead lines running from under each pad to the edge of the board. Each lead is connected to a pad by a soldered wire that runs through the boards.

The readout board is connected to the multiplexer by coaxial cable. A separate cable is run from each board lead to a channel of the multiplexer. The cable sheaths are

connected to the guard on the LCR meter and to a copper guard plane under the readout board. The return for the LCR meter is connected by coaxial cable to the plate whose flatness will be measured.

III. Procedure

There are two measurements that determine whether a device of this type will provide useful information. The first is the repeatability of the stray capacitance. Before a plate is put on the readout the stray capacitance of each pad in the system is measured. This data is read into a zero table. The zero table is subtracted from the plate readings to yield the actual capacitance measurement. If the stray capacitance varied by more than 5 pF the gauge would not have the necessary precision. The stray capacitance has been reduced to .04 pF. The maximum variation in stray capacitance is .02 pF. Stray Capacitance should not be a problem.

The second measurement was the actual precision of the gauge. An aluminium plate was placed over 12 of the pads. It was placed on .127" long G-10 standoffs. One stand off was positioned in the center of each pad. The capacitance of each gap was recorded. Then a .003" shim was placed under each stand off. The calculated change in capacitance was .8 pF. The measured change in capacitance was .6 to .8 pF. The device has much better precision than is needed.

IV. Problems

In addition to measuring flatness, concern has been expressed that this device be used to measure surface quality. The proposed method is to put high voltage on the plate and look at both the total leakage current and the leakage current to each pad. The device as configured could be used to measure the total leakage current. This would be done by closing all of the relays before high voltage is applied to the plate. However, it is deemed inadvisable to try to close or open individual relays while the plate is at high voltage. Sparking between contacts could radically alter the capacitance of individual relays in an unpredictable way. The determination of the exact location of surface defects in unacceptable plates should be made with a separate device.

The calibration of the device has not been done. There is approximately 13 pF cross talk capacitance between pads. This results in measurements of which are 10 to 15 pF too high for the plate to readout board gap. This problem can be overcome by leaving a thin guard line between each pad or

by creating a calibration curve for each pad. The former solution seems the more advisable.

Finally, the readout board is not as flat as it should be. The top surface varies by .012" from flat. A readout board with a maximum tolerance of .002" should be easily produced if more care is taken in the laminating process.

Figure 1

Read-out Board

Figure 2