Multi-channel non-intercepting phase probe for the University of Maryland cyclotron

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ABSTRACT

The University of Maryland Cyclotron will incorporate a non-intercepting phase probe using sampling techniques which will visually display the amplitude and phase of the beam pulse with respect to the rf voltage at 12 radii. There are no frequency-dependent or tuned circuits, and all controls are remote. Use of two additional identical probes, one of which samples the rf dee voltage, allows time calibration of the system.

An rf pick-up probe is used to trigger a series of high-speed monostable multivibrators which provide a phase position control and a linear phase sweep of the sampling pulse of up to 180°. These are followed by two more monos of fixed delay to provide a standard charge to a step recovery diode which produces the sampling pulse. The step recovery diode (HPA 0153) is mounted in the dee immediately below the 1¼ in × ¼ in pick-up plate which is located ¾ in below the median plane.

1. INTRODUCTION

A multi-channel non-intercepting phase probe can not only visually display the phase vs radius profile of the beam, but also indicate roughly the amplitude, width, and shape of the beam. Eventually, the displayed information could be used on line to a computer to directly control the trim-coil currents and to control other components necessary to stabilise the beam. Our basic system is a solid state modification of the one used at Karlsruhe,[1] with several other adaptations for the University of Maryland cyclotron.

2. GENERAL DESCRIPTION

2.1. *Summary of circuit operation*

The block diagram for the complete phase probe system is given in Fig. 1. Sampling techniques are used to convert the beam pulse into a 4 kHz signal.

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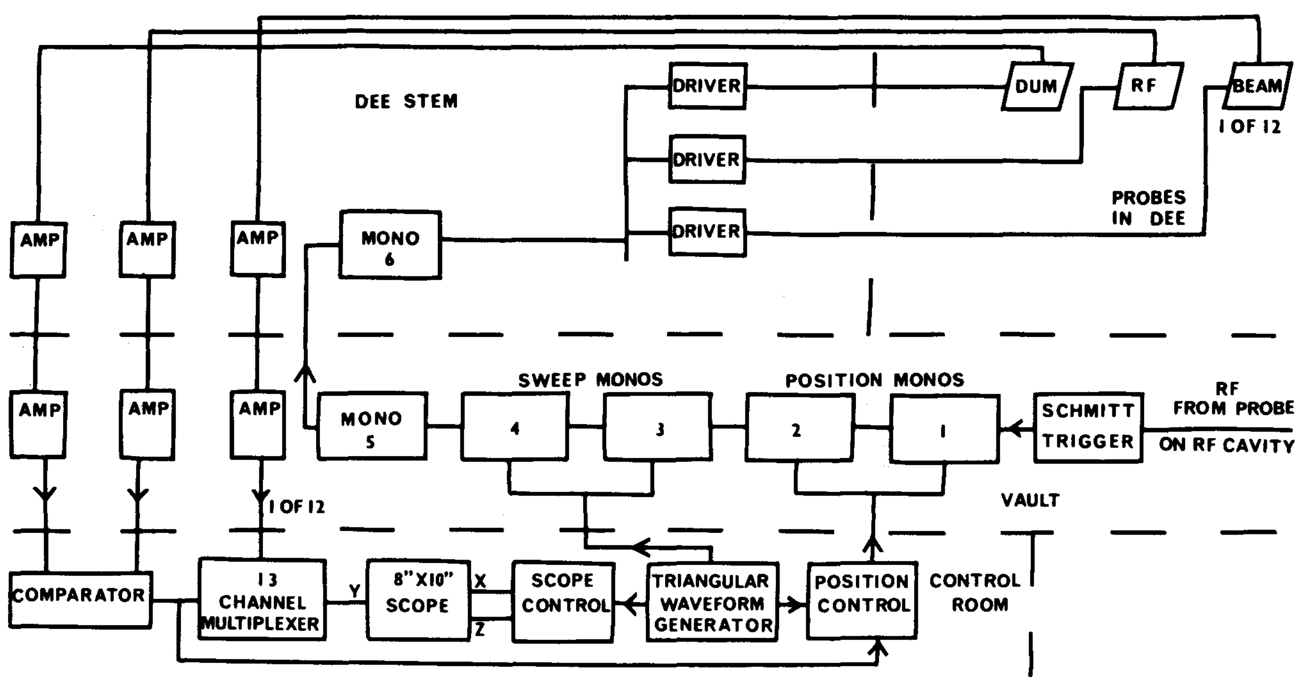

Fig. 1. Block diagram of phase probe electronics, showing relation of components and their locations in cyclotron vault and control room

Most of the low-frequency circuitry, in which integrated circuits are extensively employed, is mounted in a Nim Bin in the control room. The rf circuitry is housed primarily in a Nim Bin in the cyclotron vault, with the exception of the components mounted in the probe head and the dee stem. Adjustable controls are located in the control room for ready access.

All circuits local to the cyclotron vault are composed of special radiation-resistant components.

Fourteen identical probes are used (Section 2.3); 12 probes will be placed to sample the beam. One of the remaining probes will be placed over a small hole in the dee to sample the rf, while the other 'dummy' probe will be shielded from all fields; the output of these two will be fed into a comparator. The resulting pulse occurs at 0° rf, and will be displayed with the 12 beam signals.

The expected signal at the probe is over 1 mV/μA beam current.

2.2. *Rf circuitry*

The first problem arising is the sweeping of the sampling pulse through a portion of the rf cycle and the positioning of this portion to 'see' the beam. This problem is solved by the use of monostable multi-vibrators[2] whose length of time in the unstable state depends upon an applied voltage. The applied voltage changes the charging rate of the timing capacitor and, therefore, the length of time in the unstable state.

Rf from a probe mounted on one rf cavity feeds a Schmidt trigger and differentiator, resulting in one pulse per cycle. This pulse (see Fig. 1) triggers the first of two position monos. By differentiating the trailing edge, each of these two monos can be made to delay the pulse by a variable length, which depends on a d.c. voltage from the control room. Since each mono can vary the length over at least a quarter (but not up to half) of an rf cycle, the two in series can vary the pulse by half an rf cycle. Insertion of an inverting transformer before the Schmidt trigger allows timing of the pulse from the second mono at any position in the rf cycle.

The resulting pulse from the second position mono triggers two more cascaded monos, the length of each of which is dependent on the low frequency triangular wave. The pulse generated by the trailing edge of the second 'sweep mono' will then sweep through a portion of the rf cycle as the amplitude of the triangular wave increases.

The 'sweep' monos are followed by two fixed length monos used to provide a fixed charge to the step recovery diode used to generate the sampling pulse. Between the final mono and each probe is a driving circuit consisting of a pair of emitter followers. Thus, the sampling pulse can be moved through a portion of the rf cycle determined by the sweep monos where that portion of the sweep is determined by the position monos.

2.3. *Probe assembly*

The probe assembly is shown in Fig. 2. The voltage coming from the driver circuits switches from +0·7 to −3·5 in 5 ns; the resulting sampling pulse is 2 V high and the half width is 400 ps.[3]

The pulse samples the beam and the resulting low-frequency pulses are integrated by the 2K resistor and output cable capacitance of 250 pf. This low

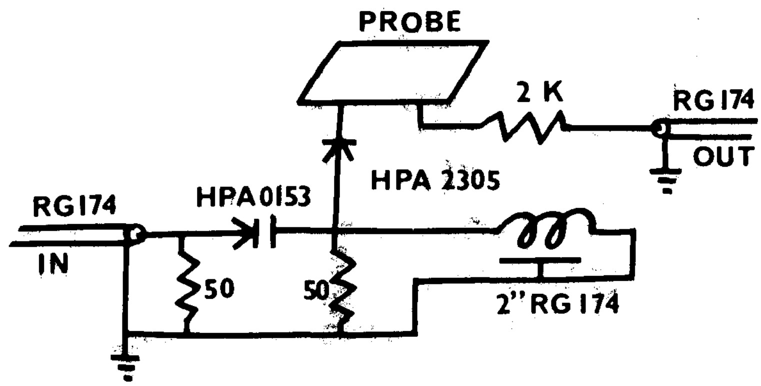

Fig. 2. Circuit diagram of a probe head

frequency is then amplified by 30 by a two-transistor amplifier in the dee stem and again by about 10 in the vault before being sent to the control room for display.

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