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DERIVED RADIAL POSITION AND WIDTH SIGNALS FROM A TV BEAM VIEWER*

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Summary

We have, at the Zero Gradient Synchrotron (ZGS), a beam viewer which displays in near real time the brightness, width, and position of the beam. This consists basically of a calibrated phosphorescent screen which nondestructively collects ions generated by the circulating beam.[1] A closed circuit TV system transports the signal to the Main Control Room. Circuits were developed which derive analog voltages representative of the beam width and position from the synchronization and video signals. The brightness vs. horizontal position linearity was improved by vidicon model change and a simple shading circuit. A calibrator which simulates a beam was built into the system and is invaluable for initial setup and linearity tests.

Introduction

The beam viewer is invaluable for machine tuning and diagnosis because it provides a visual picture of the proton beam envelope. Numbered marks spaced 1 in apart provide calibration for the viewer. Figure 1 shows a typical beam photograph as seen by the viewer. An effort was begun to further improve the monitor by the extraction of electronic signals representative of width and position. Two design approaches which were tried are described.

Design Schemes

Since the horizontal drive pulses recur precisely in time, they were a logical reference with which to compare the beam signal. Figure 2 shows the video signal from a horizontal scan through the beam image. Now, the fundamental problem is how to extract beam data from the video signal.

The beam signal must first be amplified to a useful level. A first approach to converting the time related data into amplitude signals was to start two time-to-height converters, one at the front edge and one at the trailing edge of the beam pulse. The time-to-height converters were turned off by the horizontal drive pulse. An average of the two converter amplitudes was representative of position, and amplitude difference represented width. Some factors which can affect calibration are camera movement or change in focus, changes in gain of camera or monitor, and the ambient light level on the screen. Beam brightness will also have some effect, mainly on the width definition. Sophisticated thinking included a normalizing signal such as sampling of a known size bright spot each vertical scan. An analog multiplier corrected the system gain in response to the calibration signal. The complexity of the system grew rapidly since the calibration required additional time-to-height converters, gates, and sample-and-hold circuits. There was a maintenance problem since the calibration light was under vacuum. The automatic calibration scheme was soon abandoned in favor of an internal electronic calibrator.

Circuit Description

Amplifiers

Figure 3 shows a diagram of the circuit we are using. To assist in the description, a waveform and timing diagram is shown in Fig. 4. The high frequency amplifier amplifies that portion of the video signal above the threshold set by the bias control.

Shading

The baseline on which the beam signals ride is nonlinear, as can be seen in Fig. 2. In order to extract the beam signal uniformly by a circuit such as the voltage comparator, the baseline must be flat over the horizontal scan. Replacing the normally used 7735 vidicon with a model 8705 helped the linearity greatly.[2] A further improvement consists of a pulse, started by the horizontal drive and shaped in amplitude such that its addition to the video signal flattens the response.

Gating

The beam signal takes up only a small portion of a vertical scan. The vertical gate rejects signals that would give false beam information. The gate is set so that it opens only when the camera beam is sweeping the area which contains the proton beam image.

There are also bright areas along the edges of the picture which will cause false triggering. The horizontal gate rejects these signals.

Width Signal

The output of the voltage comparator is an amplitude limited pulse so that the beam width is directly proportional to the pulse width. All of the beam pulses that occur within the vertical gate time are integrated so that the output is representative of the average width of the beam image. The sample-and-hold circuit in front of the width output amplifier receives voltage each vertical scan at the time the vertical gate closes.

Position Signal

The leading edge of the pulse from the voltage comparator sets the flip-flop, and the flip-flop is reset by the horizontal drive pulse. Thus, the beam position relative to the edge of the viewer picture is proportional to the time the flip-flop is in the "set" mode. The dc offset circuit refers the zero position of the viewer to zero output voltage and also provides a dc

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average voltage that is proportional to the beam position from zero. The signal goes to an integrator so that the position signal is an average of position during the vertical gate on time. The output is a histogram whose amplitude is modified each vertical scan.

The position signal at the output amplifier is offset by one-half the amplitude of the width signal to relate position to beam center.

Calibrator

The electronic calibrator generates a simulated beam pulse which is fed simultaneously to the TV monitor and the signal processor. The signal appears as a bright vertical band whose position and width are adjustable. The actual electronics consist of two successive delays triggered by the horizontal drive. When the phosphorescent screen is illuminated just enough to make the calibration marks distinguishable, it is relatively easy to make an electronic vs. visual calibration. There is also an intensity control so that brightness effects can be evaluated.

Performance

The TV camera is set to view 15-in out of 28-in total radial aperture. Outputs are meaningless until the beam image is completely within the viewer aperture. In the ZGS, this occurs about 30 ms after beam is injected. With optimum intensity and adjustment, the resolution in both width and position is ±0.25 in.

The delay in response between circulating beam and output is determined mainly by the vidicon lag time which is 40 ms. The time resolution is also controlled by the vertical field time of 16.7 ms. This is because new data is received only after each vertical scan.

Conclusions

The system described provides reasonably accurate beam data without a new beam monitoring installation. The quantity and cost of the electronic hardware needed to do the job are small.

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2
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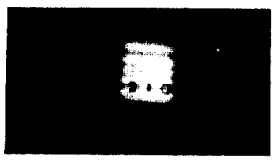


Fig. 1 Beam Viewer Photograph of Accelerated Beam. Numbers Identify 1-in Calibration Marks.

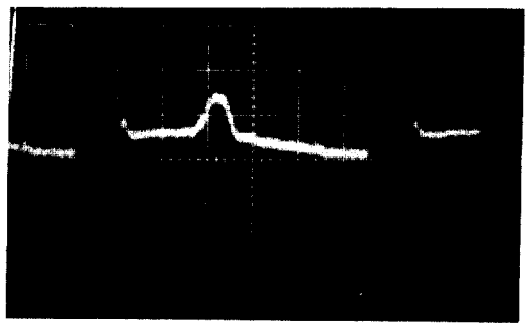


Fig. 2 Video Signal of One Horizontal Scan Showing Beam Pulse. Baseline Slope is Reduced by Adding a Shading Signal. Vertical = 50 mV/cm, Horizontal = 10 μs/cm.

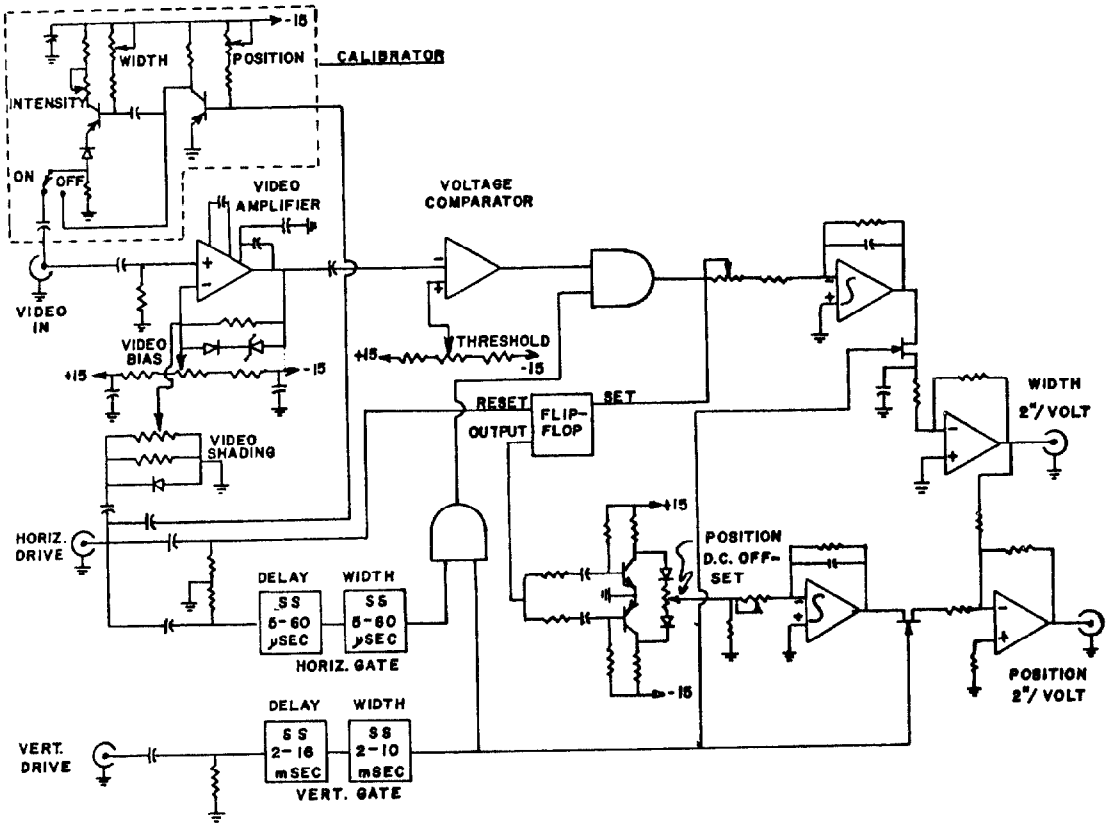


Fig. 3 Diagram of Unit for Generating Analog Width and Position Signals.

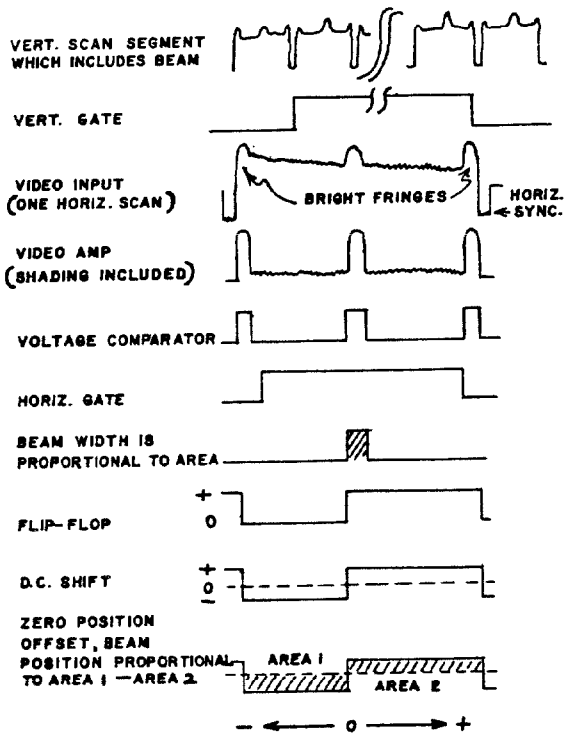


Fig. 4 Waveform and Timing Diagram.