FURTHER DEVELOPMENT OF INSTRUMENTATION FOR THE TEVATRON BEAM DUMP

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Summary

Circuitry has been developed for remote monitoring of the Tevatron beam dump instrumentation package. This package includes an x-y beam position detector, calorimeters, and temperature sensing devices. Details of the electronics design as well as expected response to beam-on conditions are presented.

Introduction

A beam dump designed to accept aborted protons from both the FNAL Main Ring and Tevatron has been installed external to the accelerator enclosure.[1] Incorporated into the dump's design was instrumentation appropriate for measuring the core temperature at the shower maxima, the temperature of the surrounding shield, the beam position as it enters the dump, and the long-term integrity of the core material.[2] Signals from the devices are carried distances of up to 7.5m by means of stainless steel-sheathed, MgO insulated cable into a connection box mounted on the Main Ring tunnel wall above the entrance point of the cables. This box serves as an interface between these cables and the more conventional multiple conductor cables which transport the signals to the electronics module at ground level.

Temperature Sensors

Seven platinum Resistance Temperature Detectors (RTD's) were installed and serve three purposes. Two measure the shower maxima temperatures, another monitors the temperature of the surrounding shielding. The remaining four are part of the calorimeters. A circuit was developed to measure the resistance of each RTD and produce a proportional voltage suitable for MADC input (-10.24 to +10.23V).

The electronics consists of a 5mA constant current source, powered by a precision voltage source for added stability, followed by a "level shifter" which amplifies the resultant voltage and allows for zeroing of the output. The zero point was arbitrarily chosen to be 200Ω.

The final design has proven to be linear over the expected RTD range of 100 to 300Ω. (Figure 1) Although it has not yet been possible to obtain aborted beam data, changes in the dump temperature consistent with the daily fluctuations of the core cooling water temperature have been obtained and recorded. The amplitudes of Figure 2 correspond to a ΔT of approximately 15°C.

Position Detector

An x-y beam position detector was installed 15cm upstream of the front face of the dump. In order to measure the charge deposited on each strip by the passing beam, an integrator was developed. In addition to measuring spill times as short as 500 ns, the circuit had to have a sufficiently large dynamic range to compensate for a 10^4 variance in beam intensity. An output suitable for use with an MADC was also necessary.

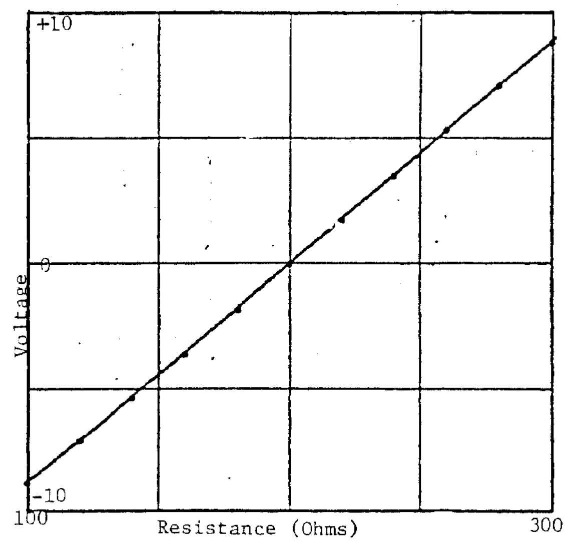

Figure 1-Response of RTD Circuit (Output Voltage vs. RTD Resistance)

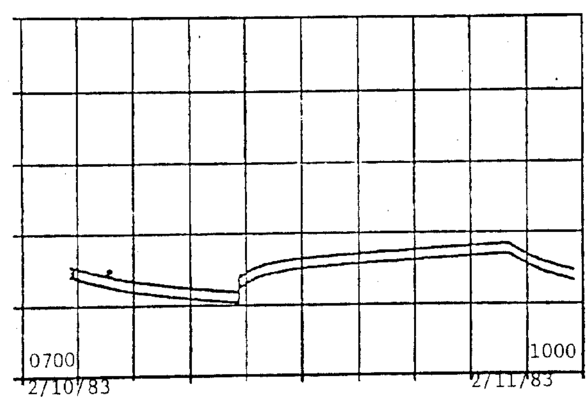

Figure 2-Change in Dump Temperature due to cooling water temperature changes.

The circuit ultimately chosen is a logarithmic amplifier used as a passive integrator. It was initially developed for the Tevatron Beam Loss Monitor system.[3] The amplifier's 5mV/μs rise time and 30 ms time constant are adequate for this application. In order to maintain a reasonable input voltage, the expected charge was calculated using the relation Q=INE where I = incident intensity (protons), e = electron charge, and N = electron production/incident proton. N is determined by the relation $N = \frac{dE}{dx} \Delta X \varepsilon$ where dE/dx = minimum rate of ionization energy loss Δx = path length = (Argon density)(plate separation), and ε = conversion efficiency. Using the highest and lowest expected intensities, a capacitor value was chosen which provides an input voltage range of 20mV to

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50V. The input is clamped to 15V, however, to prevent damage to the integrator components. Figure 3 shows the logarithmic relation between input and output voltage while Figure 4 notes the response of the integrator to a simulated 500 ns beam pulse.

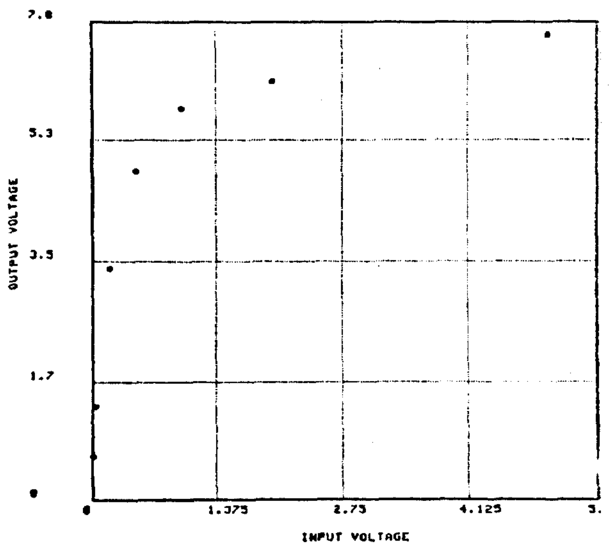

Figure 3 - Logarithmic Response of Position Detector Amplifier/Integrator

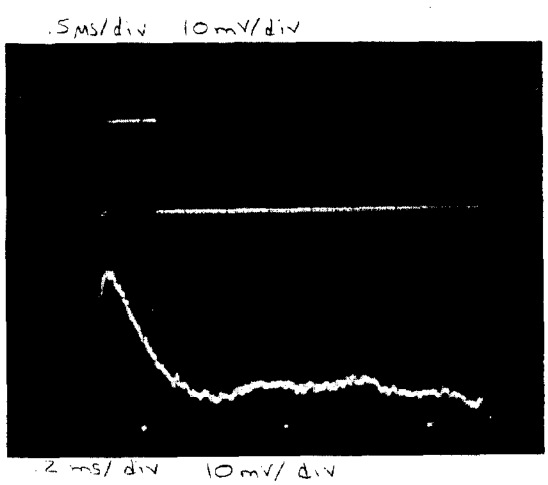

Figure 4 - Response of Integrator/Amplifier to a Simulated 500 ns Beam Pulse.

Argon Flooding System

Several aspects of the instrumentation package require the use of a flow of Argon gas. Firstly, an inert environment is desired inside the position detector to prevent recapture of freed electrons before reaching the signal plates. Secondly, the dump itself should be kept oxygen-free to prevent deterioration of the graphite core. Finally, due to the hygroscopic nature of the MgO insulated instrumentation cables, the tunnel connection box must be kept moisture free.

The system consists of two 330 SCF cylinders of Argon gas, a stainless steel manifold, and supply and return lines into the tunnel (Figure 5). In order to minimize development time and cost, one half of a Tevatron magnet relief (Kautzky) valve control manifold was employed.[4] A pressure gauge to monitor the high pressure portion of the system, a relief valve to protect the components on the manifold, a pressure switch, and a flow/pressure reducer are all mounted on the manifold. The pressure switch is the means by which the Control Room is alerted that the back up bottle has been put on line (the primary one is empty). This is made possible by maintaining the reserve bottle at a slightly lower operating pressure than the primary cylinder. The flow/pressure reducer allows the use of a reasonable manifold pressure (∿30 psi) while maintaining the very low pressure required by the instrumentation (∿2" H_2O). The reducer is comprised of a short length of 1/4" copper rod with a hole drilled through its major axis which was then crimped to obtain the desired flow rate.

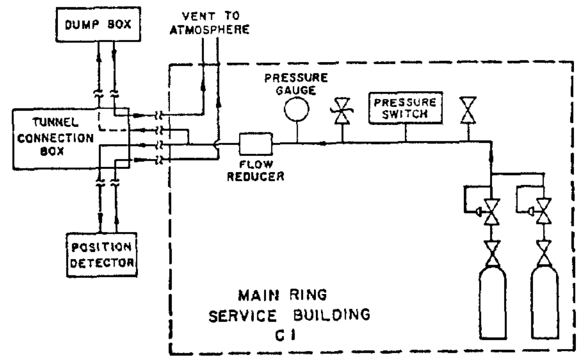

Figure 5 - Schematic of Argon Flooding System

Controls

The integrators, RTD boards, necessary power supplies and other auxiliary electronics are housed in one rack mounted chassis. Nineteen output channels are fed to the service building MADC, thence to the host computer. Software has been written which allows one to view all dump parameters from a single applications program. A plotting feature is included which will produce a histogram plot of the aborted beam position. Alarm capability can also be implemented if deemed necessary.

Acknowledgements

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3. J. Larson, private communication.
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