C Beam Shut-off Ion Chamber System

Introduction

Beam Shut-off Ion Chambers (BSOICs) are radiation detectors that have been installed in a number of locations around the SLAC site. Their function is to measure beam-related radiation outside the shielded areas and to turn off the accelerator beams if radiation levels exceed design limits. Typically, the limits are set to either 10 millirem/hr or 100 millirem/hr, depending on the location of the BSOIC.

BSOIC Description

C.2.1 Ionization Chamber

The ionization chamber and associated electronics are housed in a watertight cylindrical can, 10 inches in diameter by 28 inches high. The ionization detector is a 10-liter aluminum chamber filled with ethane at one atmosphere. Aluminum and ethane are approximately tissue-equivalent for photons in the energy range from 200 KeV to 10 MeV. Ethane was selected to enhance the response to fast neutrons. The chamber response to neutrons is about 20% less than its response to the same dose of photons. Since warning and trip levels are adjustable, this under-response can be calibrated out.

The chamber is designed to produce one pA/mrad/hr at 10-liter-atm with a collecting potential of 500 V. It has been checked for saturation in fields up to 100 rads/hr. The nominal operating range is from one to 1000 mrad/hr.

C.2.2 Electronics

The entire unit is AC-powered and the electronic processing is all solid-state. The collecting potential is provided by a 500 V internal power supply. The log converter consists of two base-to-emitter junctions in series as the major part of a feedback network in an operational amplifier. This amplifier has a dual MOS-FET input and has an open loop gain of the order of 10,000. Primarily because of the temperature dependence of the log converter, the entire circuit is enclosed in an oven operating at approximately 50°C. The proportional controller for the oven uses a thermistor for temperature sensing. Within 1/2 hour from a cold start, the oven stabilizes to within ±0.1°C. The entire oven temperature control circuit is also located within the oven housing. The oven housing measures approximately 3 1/4 × 3 1/4 × 2 1/4 inches. The log converter uses two 2N2913 transistors. These exhibit an almost ideal logarithmic characteristic (i.e., base-to-emitter voltage versus base-to-emitter current) over the range of 10^{-5} to 10^{-12}.

Figure 1 is a block diagram of the internal BSOIC circuit. It also shows typical external connections to beam shut-off and monitoring devices. The complete electronic diagram including oven control, is shown on drawing SD-123-823-00, available from SLAC Document Control.

C.2.3 Fail-safe Design

C.2.3.1 Self-Test

To provide fail-safe operation, a 0.4 -μCi90 Sr. source is incorporated within the chamber. The source produces a current corresponding to about 2 mrads/hr. This "housekeeping" current generates a continuous analog voltage at the output of the integrator. When the output signal drops below a preset level, indicating either a deterioration of the source, a fault in the electronics, or an open circuit or short circuit on the wire pair to MCC, an alarm is generated and the BSOIC is replaced or repaired.

C.2.4 Power Disconnection

In addition to the fail-safe operation provided by the internal source, the BSOIC is fail-safe when AC power is disconnected. To prevent inadvertent disconnection, and thus the shutting down of the accelerator, the AC plugs are protected by locking collars.

C.2.5 Cable or Connector Disconnection

When the signal cable that connects the BSOIC to the external safety devices (stoppers) is disconnected or short circuited, the accelerator is immediately shut down.

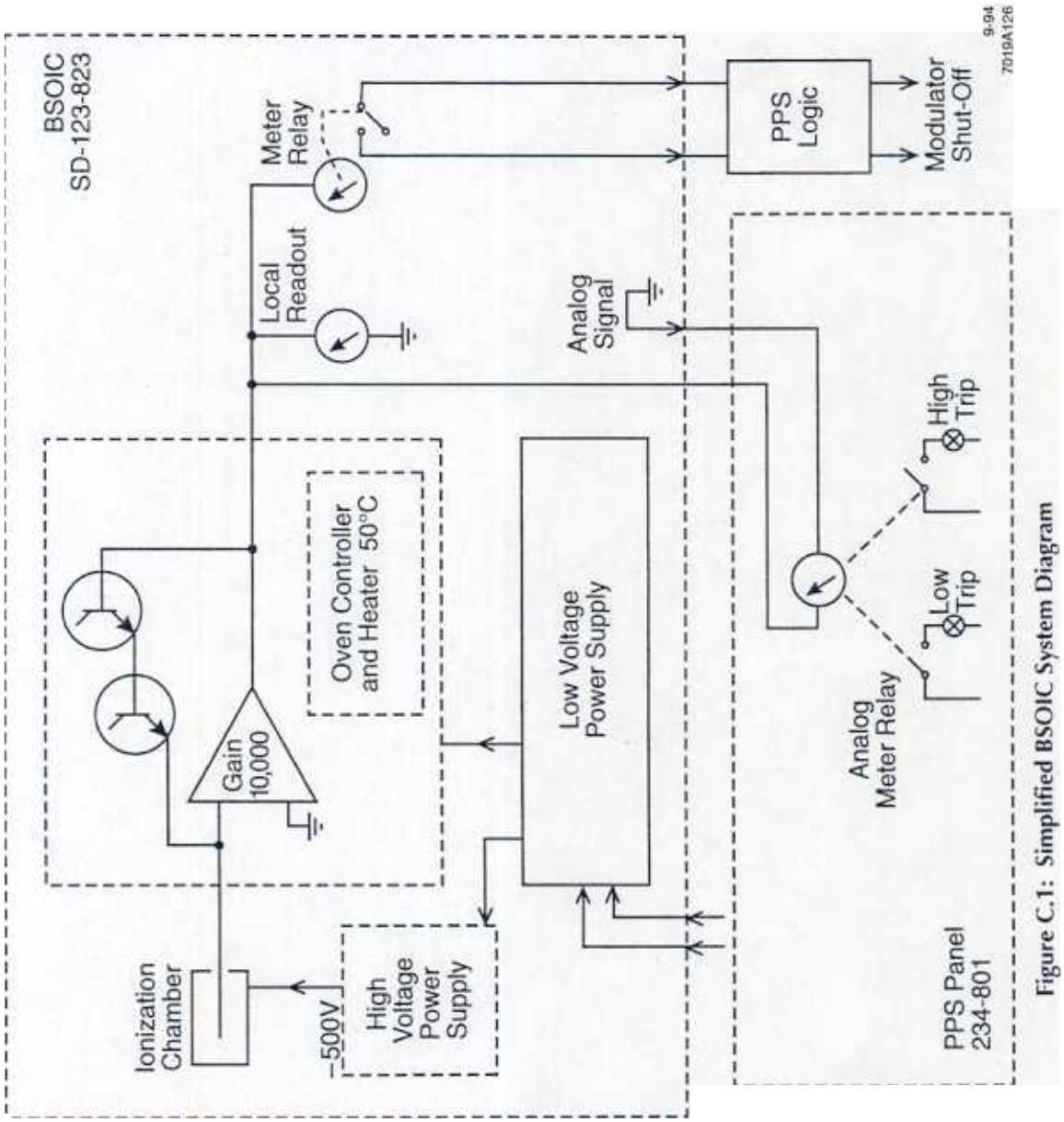

Figure C.1: Simplified BSOIC System Diagram