The CEBAF Analog Monitoring System*

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Abstract

The purpose of the analog monitoring system (AMS) is to provide CEBAF operators the ability to monitor voltage signals from the RF control modules, beam loss monitors, and other dedicated systems from the accelerator service buildings with a 10 MHz (-1 dB), bandwidth. The signals are presented at the AMS receiving crate in the Machine Control Center (MCC). The system, when completed, will allow the operator to monitor any 4 signals from available channels in each location. At present these locations provide 800 signals in each of the linacs, 16 signals in each of the arcs, 120 signals in the injector, and 16 signals in the beam switchyard. This provides a total capacity of 1768 signals, with an upgrade ability of 3740 total signal capacity.

I. INTRODUCTION

The analog monitoring system is distributed in a zone architecture throughout the accelerator, (Figure 1), where a station zone is defined as the 8 RF control modules that control the field gradients in the cavities.

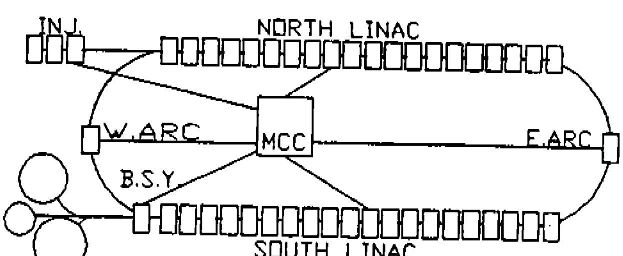

Figure 1. AMS Zone Locations

One AMS station will be located at each RF station. Each AMS's permanently connected inputs monitor the RF systems measured phase (PMES), phase vector modulator drive voltage (PASK), measured gradient (GMES), and gradient modulator drive voltage (GASK). In addition to the RF System inputs the AMS station has eight input channels to monitor the accelerators beam loss monitor signals (BLM) from 0 to 5 V, and to allow connection to any ± 10 V signal for observation. The AMS has the capability to expand and to monitor up to an additional 28 inputs, bringing the total capacity up to 68 input channels per crate. In the standard configuration, the AMS will provide the minimum requirement of 40 input channels (32 RF control module inputs, 8 BLM inputs), and eight output channels.

The system zones are divided into six groups: North linac, South Linac, East Arc, West Arc, Beam Switch Yard (BSY) and the Injector. The linac areas are sub-divided into two groups of 8 and 11 AMS stations. To link the accelerator to the MCC a specially configured AMS station called a concentrator crate is used. The concentrator crate links the analog signals from all of its assigned AMS standard crates and sends the selected output channel to the MCC through an analog fiber optic transmitter (Figure 2).

The concentrator crate also receives and transmits serial fiber optic control data to and from the MCC. The concentrator crate receives commands through the fiber optic serial link and distributes the control data through an RS-485 serial link to all of the connected AMS standard crates for channel selection commands.

The MCC concentrator receives 24 channels of analog data from the 6 system zones and routes them to 24 BNC type connectors on the monitoring panel located in the MCC. From the monitoring panel the operator can connect signals into a four channel oscilloscope for signal display or connect the signals into a four channel, 1 MHz data acquisition card.

II. SYSTEM DESCRIPTION

The analog monitoring system is composed of three main sub-systems. Together these sub-systems provide a means of selecting a desired input signal, routing the selected signal to the MCC, and conditioning the signal for observation in the MCC. These three sub-systems are:

A. AMS standard crate
B. AMS concentrator crate
C. MCC concentrator system

A. *AMS Standard Crate*

The AMS standard crate, Figure 3, performs two functions: it inputs selected analog signals from connected instrumentation and routes them to the concentrator, and allows subsequent AMS signals to pass through a daisy chain to the AMS concentrator crate. Equipment and instrumentation interface is accomplished by two types of analog signal modules. The input module (AMIC) is an eight channel signal input module that serves to input and condition the RF control module signals, and the variable gain module (AMVG) is a four channel signal input module that serves to input and condition BLM or other desired signals. In addition to a high input impedance the AMVG modules have user defined gains from unity to x 10. Each of the AMS standard crates is configured with four AMIC modules and two AMVG modules. Once a signal is selected for observation at the MCC the

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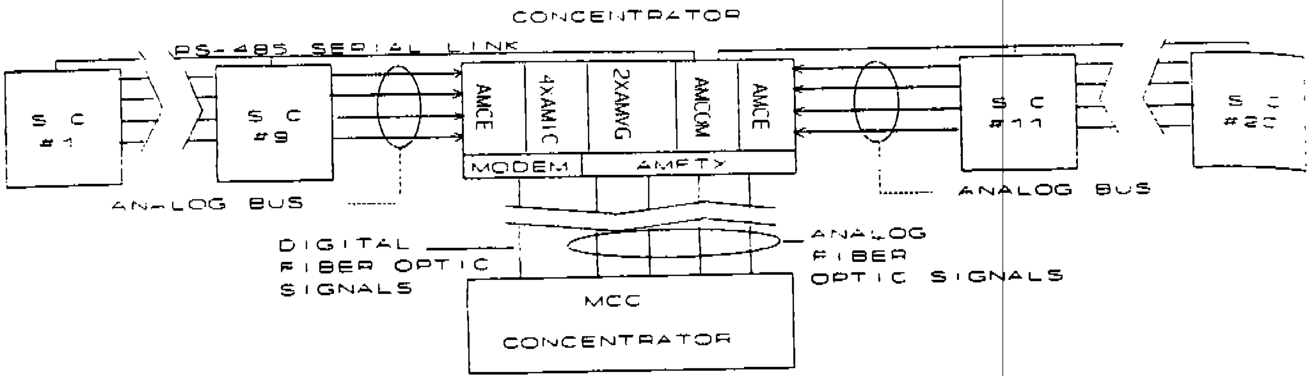

Figure 2. AMS Zone Architecture

appropriate module is programmed to place the connected signal on the "analog bus".

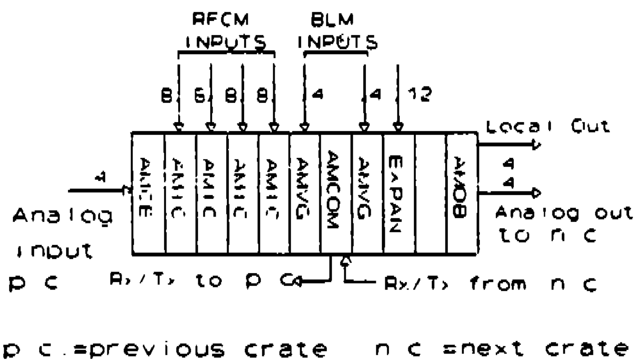

Figure 3. AMS Standard Crate

This bus is made up of four dedicated wires with multiple switches that span 1/2 the length of a system zone terminating into a concentrator crate. The switching action is accomplished through 64 T matrix type video crosspoints. Once a signal is selected the AMS closes the appropriate semiconductor switches to complete an electrical path from the desired input signal to the analog bus, through intermediate AMS standard crates (effectively bypassing these crates) to the appropriate channel of the AMS Concentrator Crate. The signal is then sent via an analog fiber optic transmitter to the MCC for conditioning and observation. The interconnection of the selected signals through a daisy chain architecture is achieved through the cable equalizer module (AMCE). This module accepts four differentially driven inputs from a previous AMS standard crate and restores any frequency dependent losses that have occurred in the RG-58 connection cable by a passive cable equalizer network at the input of the AMCE module. In the event an AMS standard crate is being bypassed the AMCE will place its output on the analog bus, effectively connecting the crate input to the crate output. This mode, bypass mode, allows a signal originating from the end of the linac to pass through the daisy chain architecture with good signal isolation from crates in the serial path to the termination point, the concentrator crate.

The output section of the standard crate is comprised of an output buffer module (AMOB). This module is a four channel differential output driver capable of driving 100 mA with a small signal bandwidth > 15 MHz. Each of the AMOB modules in an AMS standard crate differentially drives eight RG-58 cables approximately 60 feet to the upstream AMS standard crate's AMCE module. This architecture repeats itself until the signal path terminates into an AMS concentrator crate.

System communication is accomplished through an RS-485 serial link connected to all of the standard crates. This link provides bi-directional communication to/from the concentrator. This serial link programs the standard crate to place the selected analog signal on the analog bus defined by the program code that contains the card address (similar to the CAMAC card addressing scheme), input channel, and output channel information. In addition to the serial link for remote control of the standard crate, the system offers local control through an RS-232 port on the communication and control module (AMCOM) to observe selected signals locally as accessed through the front panel of the AMOB module. The AMCOM module is based around a MC68701 microcontroller. This controller has 4K PROM on chip for the system program that controls RS-485 communication, card addressing, input/output selection, start-up routines, and confirmation echoing.

B. *AMS Concentrator Crate*

The concentrator crate is a specially configured standard crate that has three basic functions: input analog signal data, to convert and transmit analog fiber to optic data to the MCC, and to act as a node controller for all of the connected AMS standard crates. The substitution of a fiber optic transmitter (AMFTX) in place of an AMOB module (Figure 2) allows the concentrator crate to output optical signals instead of an analog signal. The concentrator crate is made from a standard crate by the addition of this module, an additional AMCE module to terminate two linac sections, and a fiber optic data modem. This modem receives commands from the MCC and presents the data to the communication module (AMCOM). This module acts as the crate controller by interpreting commands, echoing the program code for signal selection through the RS-485 serial link, and transmitting confirmation codes back to the MCC Concentrator.

C. MCC Concentrator System

The Machine Control Center is the central node from which the user can select any one of 1768 connected signals from anywhere around the accelerator. The controller for this system utilizes a 486DX, 33 MHz PC based computer equipped with an EISA bus supporting both a GPIB interface and a four-channel, 1 MHz data acquisition board. The MCC concentrator system is composed of three major components. These are:

1. 486DX PC
2. Fiber optic receiver
3. AMS buffer crate

1. 486DX PC

The rack-mounted PC is equipped with Labview software configured as graphical interface for input channel selection from all of the six system zones. In addition to AMS system control the computer functions as both a GPIB controller for a rack-mounted digital storage scope located at the AMS operators panel, and a data acquisition system capable of single channel operation at 1 MHz or four channel operation at 250 kHz.

2. Fiber Optic Receiver

The analog fiber optic receiver is a 24-input rack-mounted receiver with power supply manufactured to a 3U eurocrate specification by Meret Optical, Inc. The system is designed as a modular receiver with plug-in type four-channel optical receiver cards. The transmitter/receiver system from Meret provides 20 MHz, -3 dB bandwidth, with 2% signal linearity and a -8 dB optical loss budget. The electrical output of the receiver module is presented to the AMS buffer module for final signal conditioning before being presented to the user panel.

3. AMS Buffer Module

The buffer module provides the necessary gain and rolloff to restore the analog signal to the unity gain level and to reduce broadband noise figures above 10 MHz from excessively degrading signal fidelity. The output of the buffer module is presented to an oscilloscope for signal observation, or presented to the input of the data acquisition board mounted in the PC.

III. SPECIFICATIONS

System Specifications:

Required System Performance at MCC	
Input range	+/-10 V
Output range	+/-10 V
Noise level	<35 mV rms
-1dB bandwidth	10 MHz
THD	<0.6%
Crosstalk	>60 dB
Gain accuracy	<5%

Fiber Optic System Performance	
Link noise	3 mV
Link linearity	2%
Input/output impedance	50 Ω
Pulse response time	20 nsec
SNR (peak signal to rms noise)	48 dB
Maximum overshoot	10%
Operating wavelength	820 nm
Loss budget	-8 dB (50 um fiber)

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