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Control, Timing, and Data Acquisition for the Argonne Wakefield Accelerator (AWA)

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Abstract

The AWA [1] is a new facility primarily designed for wakefield acceleration experiments at the 100 MV/m scale, which incorporates a high current linac and rf photocathode electron source, a low emittance rf electron gun for witness beam generation, and associated beamlines and diagnostics. The control system is based on VME and CAMAC electronics interfaced to a high performance workstation and provides some distributed processing capability. In addition to the control of linac rf, laser optics, and beamlines, the system is also used for aquisition of video data both from luminescent beam position monitors and from streak camera pulse length diagnostics. Online image feature extraction will permit wakefields to be computed during the course of data taking. The linac timing electronics and its interface to the control system is described.

Introduction

The design of the AWA control system is based in part on experience gained at the Advanced Accelerator Test Facility (AATF), and also on more extensive data acquisition systems used for high energy physics experiments. The goal of the AWA system is to provide easy selection and adjustment of accelerator and beamline parameters, as well as the online analysis of diagnostic and physics data. Other necessary functions are the storage and recall of working parameter sets and the automatic monitoring of component performance (and flagging of deviations from preselected tolerances). The control system must also be sufficiently flexible to permit expansion for subsequent phases of the AWA project.

At the core of the system is an HP-750 RISC workstation using the UNIX operating system. The workstation is interfaced to VMEbus via a high speed bus adaptor with dual port RAM. A 68030 CPU board on the VMEbus handles command requests from the workstation and provides auxiliary processing capabilities.

Most of the control and monitoring functions are handled through a VME-CAMAC parallel bus interface. Video signals from beam position monitors and from the streak camera, comprising the actual physics data from the experiment, are acquired using a high resolution VME-based frame grabber. A block diagram of the AWA control system is shown in figure 1.

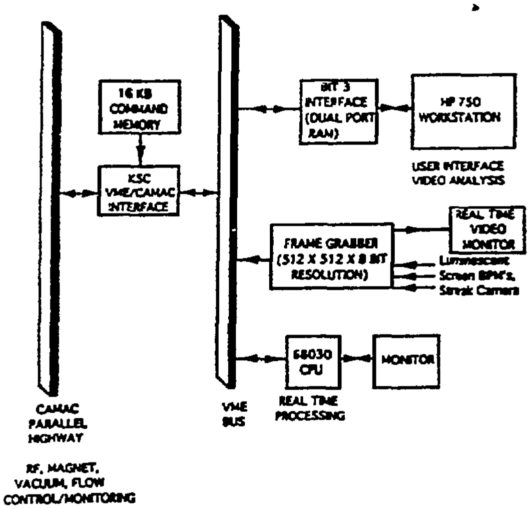

Figure 1: Block diagram of the AWA control and data acquisition system.

HP Workstation

The HP-750 workstation provides the user interface to the AWA control system, data analysis and display, and data storage. User input to the control software can be made using either a mouse, keyboard, or knob panel. The AWA control software is being developed in-house and is based upon the Motif graphical user interface. The various codes comprising the system are written in C and FORTRAN77.

Experience with the AATF control system [2] demonstrated the importance of rapid online image data analysis for wakefield measurements. This procedure (for each frame in a delay scan) consists of fitting edge data to a model of the background, performing a background subtraction, and extracting moments of the resulting 2D beam intensity distribution. The high floating point performance of the HP-750 will enable this analysis to be accomplished in real time.

VMEbus and CAMAC Systems

The interface between the HP workstation and the VMEbus is provided by a Bit3 Model 487 bus adaptor. Communications are handled primarily via the adaptor's 1 MB dual port RAM, which appears transparently as a shared memory space accessible from both the workstation and the VMEbus. Memory access conflicts are arbitrated by the adaptor itself.

In general the workstation does not directly control devices on the VMEbus. Rather, the control processes on the

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HP write commands to a queue in dual port RAM. The queue is then serviced by the Heurikon V3D 68030 CPU board, which issues the command to the approprate VME device. Another section of dual port RAM is used to store data read back from VME devices for use by monitoring and display processes on the workstation.

The bus adaptor also provides the option of bypassing the dual port RAM and addressing the VMEbus directly from the HP workstation. This is desirable for large data transfers like video images, since the V3D does not support block transfer modes.

The V3D board uses the OS9 operating system. Software is written in C and 68030 assembly language. The V3D board can act autonomously to control the system for hardware testing and diagnostics, and will be used if required to service interrupts generated from the VMEbus.

The interface to CAMAC from the VMEbus is provided by a Kinetic Systems Model 2917 interface card. The interface incorporates an 8k Word command memory, and can autonomously execute a programmed command list without processor intervention. All control and monitor functions with the exception of image acquisition are currently performed in CAMAC.

Accelerator Controls

In order to minimize the problem of rf noise pickup, all rf system control and monitoring signals are carried by fiber optic cables. Analog signals are encoded by the repetition rate of an optical pulse train, using voltage to frequency (V/F) converters. Digital signals (such as fault and status indicators) are encoded simply as the presence or absence of light (DFO).

The cards provided by the rf system vendor to perform these functions were designed to be compatible with signals provided by standard CAMAC modules. DFO out cards are controlled by contact closures provided by a CAMAC output register, while DFO in cards are read by an input gate module. Analog levels are provided to the V/F cards by CAMAC DAC's, and readout of the F/V cards by ADC's. A 12 bit resolution is adequate for both DAC's and ADC's.

Other functions handled by the CAMAC system include stepping motor controls for phase shifters and wavefront shaper [3], and beamline magnet power supply control and readback. Adjustment of linac cooling water temperatures and cavity temperature monitoring will also be implemented.

Master Trigger/Timing Module

The master trigger is a custom designed CAMAC card which provides the signal that triggers the laser and rf systems to begin their firing sequences, allowing the repetition rate and delay of the trigger pulse to be programmed. A zero crossing detector is used to synchronize the trigger to the 60 Hz line signal to provide shot-to-shot stability of experimental apparatus. The triggering phase with respect to the line is also adjustable. A second trigger output is provided, with additional delays of up to 33 ms, programmable in 1 μs increments.

The card allows the rep rate of the trigger pulse to be specified as 30, 15, 10, 5, 2, 1 Hz or single shot. The module also supports a local control mode which allows adjustments directly from knobs on the front panel. The output voltage pulses from this module are converted to optical pulses by a separate module for transmission to the laser and rf systems.

Imaging

Images from luminescent screen beam position monitors and streak camera based temporal diagnostics are captured using an Imaging Technology FG-100 video digitizer board with 512x512x8 bit resolution. The frame buffer can store 4 digitized images simultaneously. A real time (passthru mode) display of the digitized video signal is provided on a dedicated monitor. False color enhancement of images is available if desired.

An imaging software package (xframe) on the HP workstation has been developed. Xframe is used to retrieve image data from the FG-100 frame buffer for analysis, display and storage on disk (in either raw, GIF, or Postscript format). Some examples of the xframe image analysis features are found in reference [3].

An important function of the control system is to provide the sequencing of wakefield measurements. In a delay scan, the drive-witness delay is varied in programmable increments (typically a few ps) by simultaneously adjusting the witness gun rf phase and laser injection phase. For each delay an image is acquired of the witness bunch on a phosphor screen in the spectrometer focal plane. The frame is then transferred to the HP for storage and analysis as described above. The performance of the wakefield analysis software has been verified with AATF wakefield data.

Acknowledgement

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References

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[2] P.Schoessow, proceedings of the 1989 IEEE Particle Accelerator Conference, pp.1629-1630

[3] W.Gai, J.Simpson, N.Hill, C.Ho, P.Schoessow, these proceedings