LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Interferometer Diagnostics Conceptual Design

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1 INTRODUCTION

1.1. Purpose

During the commissioning and operation of LIGO, various diagnostic capabilities must be developed to understand and optimize interferometer performance. The purpose of the Interferometer Diagnostic System (IFODS) is to provide an infrastructure into which such interferometer diagnostics and tests may be incorporated.

1.2. Scope

The scope of this document is to describe the basic concepts to be used in the development of diagnostic systems for LIGO interferometers. Since the details of many diagnostic tests are not yet defined, it is not within the scope of this document to present design details of specific diagnostic tests. Rather, this document is intended to show general designs of an infrastructure into which specific tests can be designed in the future. As such system tests are defined, they will be documented elsewhere.

1.3. Definitions

1.4. Acronyms

- ADC: Analog to Digital Convertor
- AVS: Advanced Visualization System
- CDS: Control and Data System
- CMS: Control and Monitoring Systems
- DAQS: Data Acquisition System
- EPICS: Experimental Physics and Industrial Control System
- FCR: Facility Control Room
- GPIB: General Purpose Interface Bus
- Hz: Hertz
- IFODS: Interferometer Diagnostic System
- TBD: To Be Determined
- VME: Versa Modular Eurocard

1.5. Applicable Documents

LIGO T950120-C Global CDS Control and Monitoring Conceptual Design

LIGO T9600010-C LIGO Data Acquisition System Conceptual Design

LIGO T960107-C IFODS Design Requirments Document

2 OVERVIEW

2.1. Product Perspective

The IFODS is an integral part of the LIGO CDS, along with the other major components as shown in Figure 1: CDS Components. These components provide the following functionality:

- Control & Monitoring Systems (CMS): Provides for the control and monitoring of LIGO interferometers and other scientific instruments, along with the LIGO vacuum systems. It also provides the basic infrastructure for the CDS, which includes such functions as networks, timing, and operator stations.
- Data Acquisition System (DAQS): Provides for the acquisition of all LIGO data integral to gravitational wave analysis and data for use by the IFODS.
- IFO Diagnostics System (IFODS): Provides on-line processing and display of data from the control & monitoring and data acquisition systems for the purposes of diagnosing, characterizing and improving interferometer performance; provides various automated test routines and virtual test instruments.

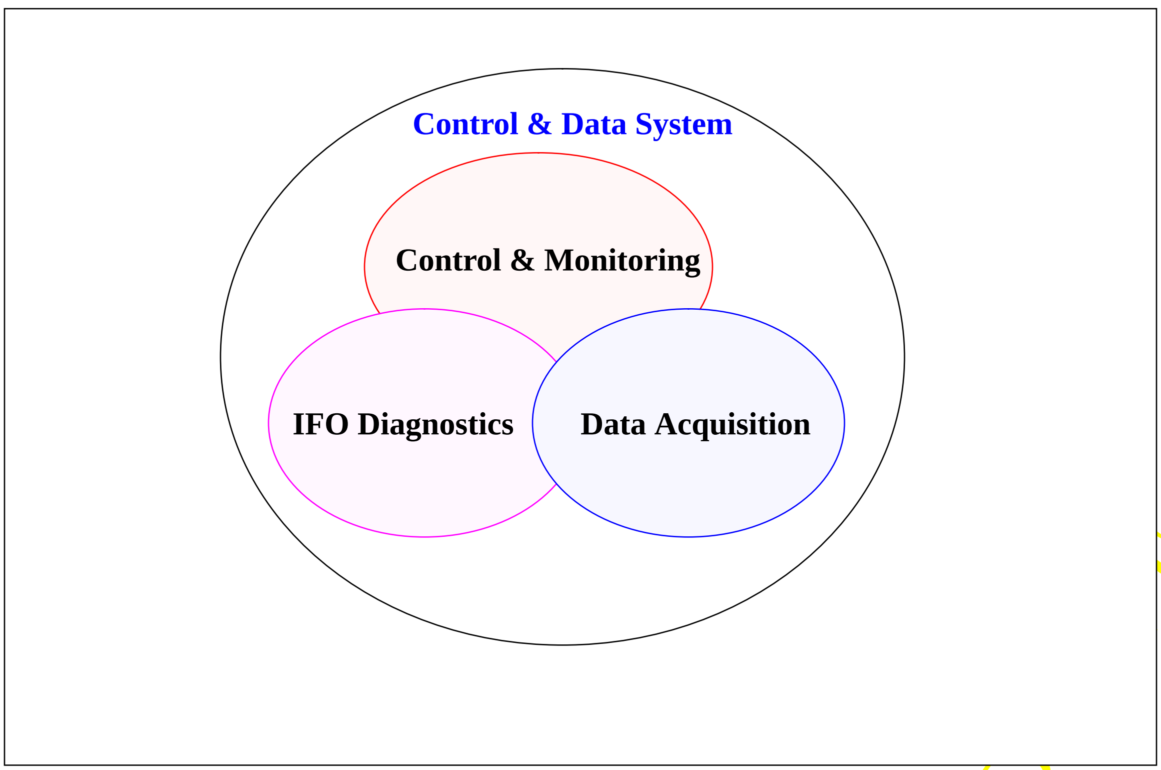

Figure 1: CDS Components

2.2. Functionality

The primary functions of the IFODS are to:

- Interface to the DAQS and provide data analysis and presentation to LIGO operators.

- Provide the interfaces into standard test equipment, such as control and spectrum analyzers and oscilloscopes, with data presentation to operators.
- Provide for the injection of test signals into control system test points and provide any necessary high speed data acquisition as necessary to analyze the test results.
- Provide automated test setup facilities and the ability to communicate appropriate setup commands to the DAQS and control and monitoring systems.
- Provide for video capture and display.
- Provide for the presentation of data as audio outputs for use by operators in quickly analyzing interferometer performance.

3 DESIGN

3.1. DAQS Interface and Data Analysis

3.1.1. Interface

The interface to the DAQS will be a processor located within one of the DAQS VME crates located in the mass storage room of the OSB (Figure 2: IFODS/DAQS Interface). The processor has access to all DAQS data in real-time as the reflected memory modules shown are in the loop with the DAQS reflected memory networks. The processor then connects to operator stations and other processors requesting data via the CDS fibre channel networks. This processor would also provide real-time coordination of data acquisition for automated tests which require data from the DAQS.

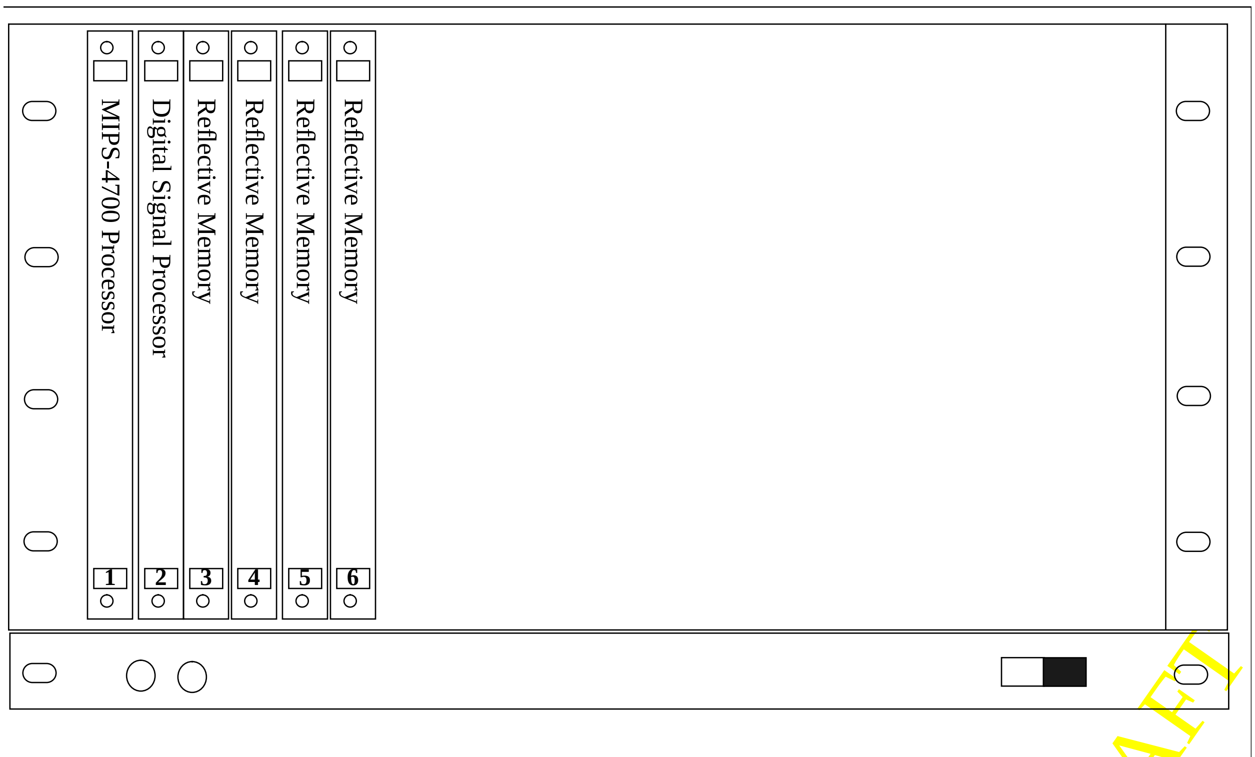

Figure 2: IFODS/DAQS Interface

3.1.2. Data Analysis

The IFODS will provide several data analysis options. For real-time analysis, DSP modules will be placed in the VME crate to act as a co-processor for the control processor. Typical DSP units available today can perform such functions as a real, 1024 point FFT in ~400usec. Initial tests with the Baja4700 general purpose processor (shown in the figure) indicate that it takes about 10 times longer than the DSP to perform this function. In general operation, the CPU would control the operation of the DSP, pulling data sets from the reflected memory, sending it to the DSP for analysis, then retrieving the results and making them available to the CDS networks for presentation to operators or other on-line analysis software.

For the development of software for the DSP, several commercial software packages will be evaluated. More graphical tools for building DSP applications are coming on the market, which limit the need to write custom assembly code. These in particular will be closely looked at.

For analysis and presentation of data which has been stored to DAQS short term storage, several commercial packages will be tested during following design phases. One option is the Advanced Visualization System (AVS), in use by the LIGO data analysis group, as various analysis software is builtin. Others, such as DaDisp, which already contain both analysis and presentation software, will also be evaluated.

3.2. Test Equipment Control

Various special test equipment will be employed to analyze interferometer subsystems. To provide remote control of these devices from the FCR, the IFODS will employ two methods.

Where only remote control and visualization of test equipment is required, a standard commercial package, such as LabView or DaDisp, will be used. The interface with typically be via a GPIB connection to one of the Sun workstations located at various points in the laser and vacuum equipment areas.

Where such test equipment must be synchronized at part of an automated test sequence, control will be via CDS standard EPICS software running on one of the CDS control processors. This may be either directly through a GPIB module in a VME crate, or indirectly through the same commercial packages used for general purpose control, with an EPICS software interface into it.

3.3. Signal Injection and Acquisition

For various tests, the IFODS must inject signals at test points in the control systems and then acquire data at high rates (TBD Hz) for test analysis. For the injection of signals, the IFODS will provide VME-based arbitrary function generators. These would be setup and controlled via standard EPICS software. Specifications for a typical VME based unit being considered for use:

- Four output channels/module
- 16 bit DAC/channel
- Up to 2.5M samples/sec/channel
- Automatic Calibration with 24 bit ADC
- Continuous, single burst, or burst/idle/burst modes
- External clock and trigger inputs for each channel
- 65536 word waveform buffer/channel
- Bipolar and Unipolar outputs
- Optional plug in filter modules
- Start of waveform synchronization pulse output

For the acquisition of data at higher rates than provided by the DAQS, the IFODS will provide VME based waveform digitizers. Specifically for ringdown measurements, the IFODS will utilize 5MHz digitizers with the following specifications:

- Up to 4 ADC (12 bit) channels/module
- ADC sample rates to 5M sample/sec/channel
- Data skewing allows sampling of a single channel to 20M samples/sec
- On board storage for 64K samples/channel
- Dual ported VME memory

These same types of modules would be employed where data snapshots are to be taken for analyzing interferometer transients.

Since waveform digitizers are too expensive to dedicate channels to particular signals, the IFODS will also provide VME based multiplexors at the front end of these modules, where necessary.

3.4. Test Setup and Coordination Facilities

Interferometer diagnostic tests will be coordinated by applications developed using CDS standard EPICS software. Since all CDS systems use the common EPICS network protocol (Channel Access), the IFODS will have the ability to communicate with any and all other CDS processes. Synchronization will be accomplished via the GPS timing available at all CDS VME systems.

3.5. Video System

The IFODS is responsible for providing video systems to be used in LIGO for viewing of beam spots or for other purposes. To provide this functionality, the IFODS will employ commercial products which broadcast video via TCP/IP based networks. The implementation would be as follows:

- Multiplexors connect to camera systems.
- The multiplexors connect to video cards installed in each of the Sun workstations distributed in the various laser and vacuum equipment areas.
- Software within the workstations broadcast the video on their own “channel”.
- “Tuner” software installed in all CDS operator stations allows selection and presentation of the desired channel.

A separate EPICS based application will be provided to select the multiplexor channel to be delivered to the video cards.

The commercial software packages which provide video broadcast also come with other standard features, such as the ability to record video to Unix files for later playback or archival.

For analysis of video information, again many software packages are commercially available. These will be evaluated during later design phases.

3.6. Audio

For rapid analysis of interferometer performance, audio has been found to be valuable in LIGO prototypes. Therefore, the IFODS must provide the ability to present selected data channels to speakers in the control room and other TBD locations. To accomplish this, the IFODS will make use of the audio channels available on the video system described in the previous section or employ one of the many network audio broadcast software products which are commercially available.