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Data Acquisition, Diagnostics & Controls (DAQ)

System Acceptance Testing

Annual NSF Review of Advanced LIGO Project

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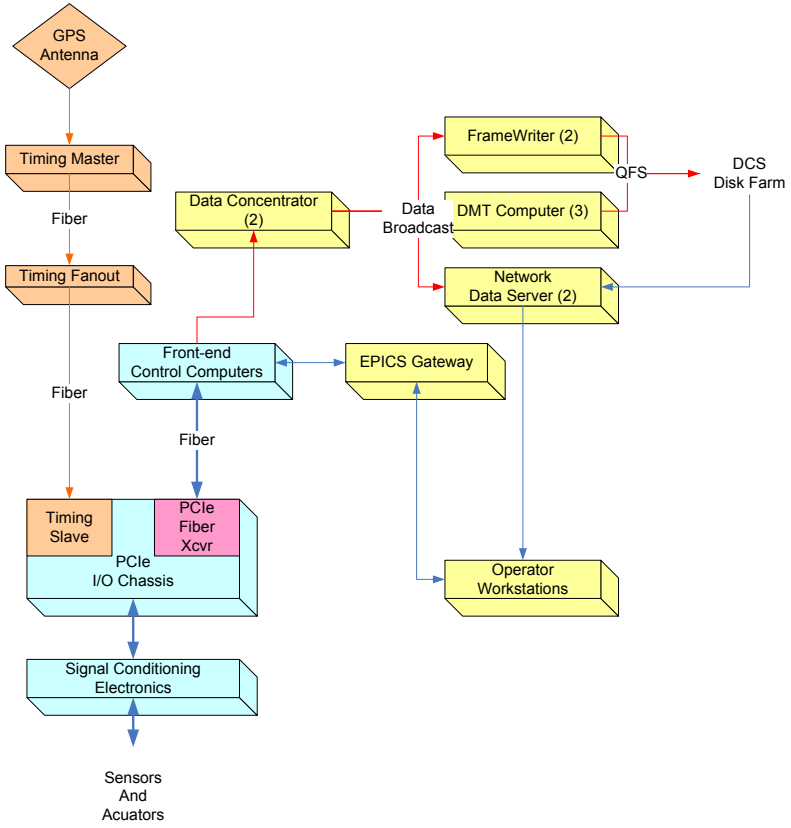
DAQ Scope

- Provide core software for real-time control and data acquisition
  - » Standard application development environment
  - » Common software to perform real-time scheduling and I/O functions
- Provide a Timing Distribution System (TDS) to synchronize all control and DAQ systems to GPS
- Provide real-time data acquisition software/hardware for Physical Environment Monitoring (PEM) sensors.
- Provide system to acquire, store and distribute data from real-time control systems

DAQ System Design Overview

- Timing Distribution System (TDS), slaved to GPS, provides clocks to PCI Express (PCIe) modules in I/O chassis.
- PCIe modules interface to control computer via PCIe fiber link.
- Control computer acquires data and transmits to DAQ data concentrator (DC) via network.
- DC assembles data from all controllers and broadcasts full data blocks every 1/16 second.
- FrameWriter computers format data and write to disk (64sec. data frame)
- Network Data Server (NDS) provides data on demand either live or from disk.



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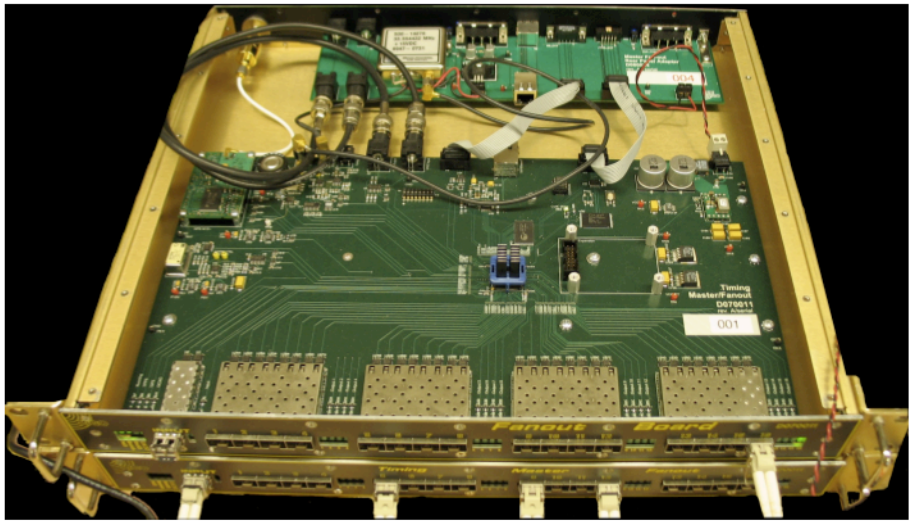
DAQ Test Facilities

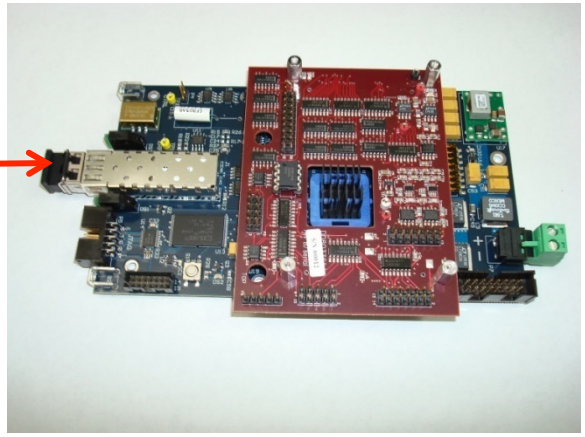
- Dedicated DAQ Test Stands (DTS)
  - » Scaled versions of production systems
    - – Caltech, LHO, LLO
    - – Testing performed using automated regression test software
      - Described in LIGO-T1300721
      - Testing includes both hardware and software
- Employed in various interferometer R&D systems
    - – Caltech 40m lab
    - – MIT LASTI
    - – AEI (Hannover, Germany) laser and 10m labs

Timing Distribution System (TDS)

- Contracted to Columbia Univ. for manufacture and test after a joint development effort. Design described in the journal *"Classical and Quantum Gravity" under Imre Bartos et al., 2010 Class. Quantum Grav. Vol. 27, No. 8, 084025*



IRIG-B Timing Fanout
Provides accurate time information to computers.



Timing Slave provides accurate clocks At 65536Hz to ADC/DAC modules.

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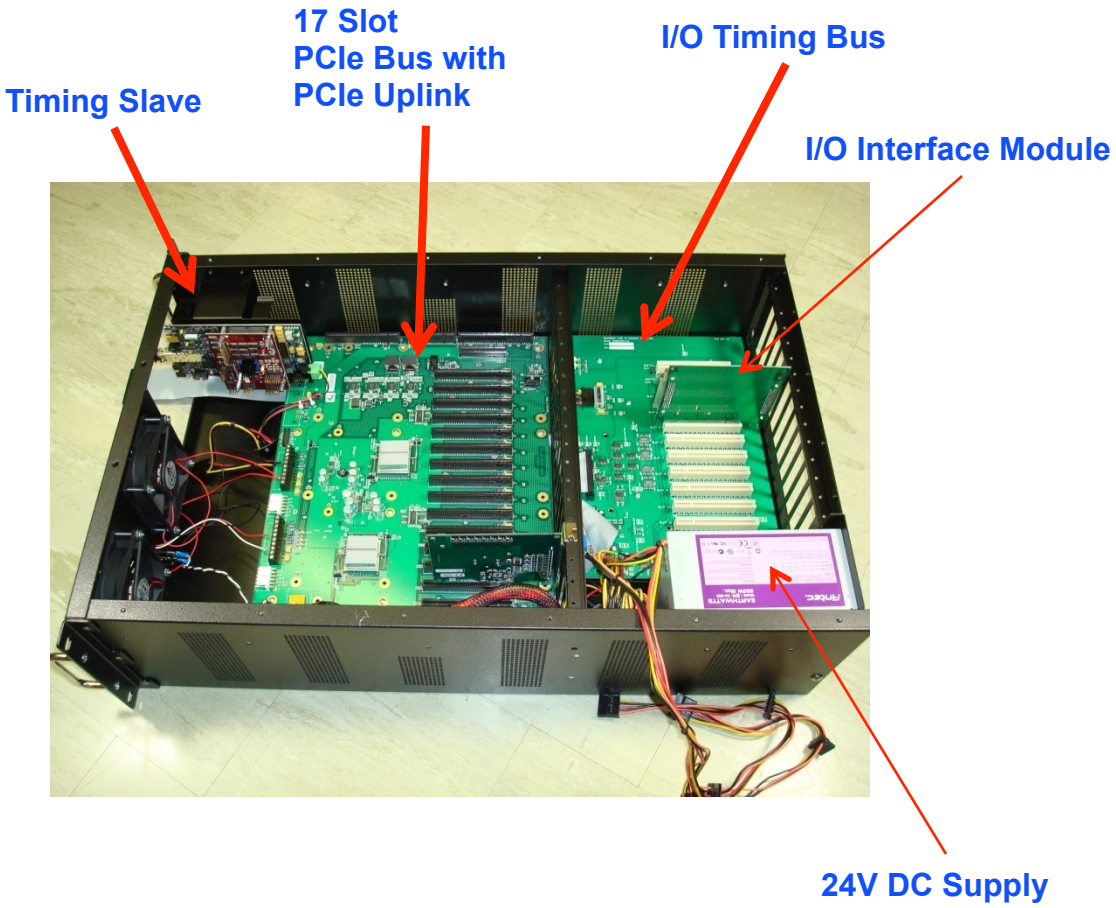
TDS Testing

- Individual TDS chassis tested prior to delivery, each in accordance with its own test procedure.
  - » Overview contained in LIGO-T0900050
  - » List of all documentation linked from LIGO-E090003
- Continuous on-line verification
  - » Each real-time control computer verifies timing via TDS duotone and IRIG-B signals.
  - » TDS comparators report diagnostics as compared to atomic clock.

PEM Equipment

- For PEM, DAQ only provides the interface to the DAQ system ie does not provide any of the sensing instruments.
- For each IFO, DAQ provides:
  - 3 Standard I/O chassis
  - 4 ADC modules and associated Anti-Aliasing (AA) chassis
- All AA chassis tested in accordance with test plan T1000673.
  - Reports attached to equipment traveler documentation.
- All I/O chassis tested in Caltech DAQ test system using automated script.
  - Reports auto generated and attached to equipment traveler documentation. (linked to LIGO-E1200651).



DAQ Computing / Storage Equipment Design Overview

- Data Concentrator (DC) (2)
  - » Collects data from all real-time control computers via 1GigE to 10GigE Ethernet switch and broadcasts data to separate 10GigE network.
  - » One unit on-line, second hot backup
- FrameWriter (2)
  - » Receives data from DC
  - » Formats data into LVC standard Frame format
  - » Writes data to disk
    - – Local
    - – Data Analysis group disk farm
- Network Data Server (NDS) (2)
  - » Provides real-time or stored data on request to various control room software tools
    - – NDS clients also developed for Perl, Python and Matlab
- Two computers running Solaris operating system to connect disk systems via QFS.
- 24 TByte Local Disk

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DAQ Primary Requirements

- Support the following continuous data acquisition rates:
  - » 4MByte/sec from each real-time control application, up to 20MByte/sec from each real-time control computer.
    - – Verified in both off-line and on-line testing
  - » Aggregate data rate of up to 30MByte/sec from all real-time control computers.
    - – Total of data to be archived plus user selected test point data.
    - – LHO system presently running at 62MByte/sec
  - » Write data to disk at 10MByte/sec (compressed)
    - – LHO system presently running at 26MByte/sec
      - 16 Mbyte/sec commissioning frame
      - 10 Mbyte/sec science frame
- Provide capability to access data, live and archived, from various control room operations support tools.

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Software Testing

- Primary development project for DAQ is software.
- Software test progression:
  - » Off-line test system
  - » R&D lab installation
  - » Production system installation
- Off-line test systems employ the Jenkins continuous integration tool for test management.
  - » Code checked out nightly from SVN repository
  - » All user applications recompiled.
  - » Representative set of user applications and test applications started on the real-time control computers.
  - » Test programs run to verify proper operation.
  - » Test reports auto-generated using doxygen tool.

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Continuous On Line Testing

- Real-time control and acquisition systems continuously run various diagnostics as described in LIGO-T1100625
- DAQ performs various data integrity checks.
  - » CRC checksum sent with all data at each interface, with receiving code performing CRC checksum calculation and verifying match.
  - » Each DAQ application performs a CRC checksum on the data channel list to verify channel to data ordering is correct.
  - » CRC checksums of frame files written by both frame writers compared to verify that they are identical.

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DAQ Status

- Installation complete
- In continuous operation at both sites for several years
- Formal fabrication acceptance review complete
  - » Documentation linked from LIGO-E1200645
- All 3rd Interferometer equipment inventoried and committed to long term storage.