

Software-centric View on OVMS for LBT

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Abstract. The performance of infrared interferometry (IF) and adaptive optics (AO) strongly depends on the mitigation and correction of telescope vibrations. Therefore, at the Large Binocular Telescope (LBT) the OVMS, the Optical Path Difference and Vibration Monitoring System, is being installed. It is meant to ensure suitable conditions for adaptive optics and interferometry. The vibration information is collected from accelerometers that are distributed over the optical elements of the LBT. The collected vibration measurements are converted into tip-tilt and optical path difference data. That data is utilized in the control strategies of the LBT adaptive secondary mirrors and the beam combining interferometers, LINC-NIRVANA and LBTI.

Within the OVMS the software part is responsibility of the LINC-NIRVANA team at MPIA Heidelberg. It comprises the software for the real-time data acquisition from the accelerometers as well as the related telemetry interface and the vibration monitoring quick look tools. The basic design ideas, implementation details and special features are explained here.

1. Introduction

Vibration measurements taken at LBT in 2009 showed strong vibrations in the regime from 0 to 5 Hz and some peaks around 8 Hz for all optical components. The spectral analysis also showed different resonance frequencies for the optical components (Brix et al. 2008). This clearly has an impact on the performance of the telescope, especially on the interferometric capabilities of LBTI and LINC-NIRVANA, and the overall performance of the ARGOS system.

The LBT optical path difference (OPD) and vibration monitoring system (OVMS) is designed to measure vibrations on the different components of the telescope at a level sufficient to calculate the displacements and variations of its optical path (Kürster et al. 2010) (Brix et al. 2010). It is a distributed system that is composed of a real-time data acquisition device from United Electronics Industries (UEI), 45 PCB 393B05 accelerometers distributed over the optical elements of the telescope, and a set of software tools to monitor, setup, and control it (Borelli et al. 2010). These software tools are subject of this paper.

2. Conceptual Design

The basic conceptual design of the OVMS software system is shown in Figure 1. A real-time data acquisition service collects vibration data from the different accelerom-

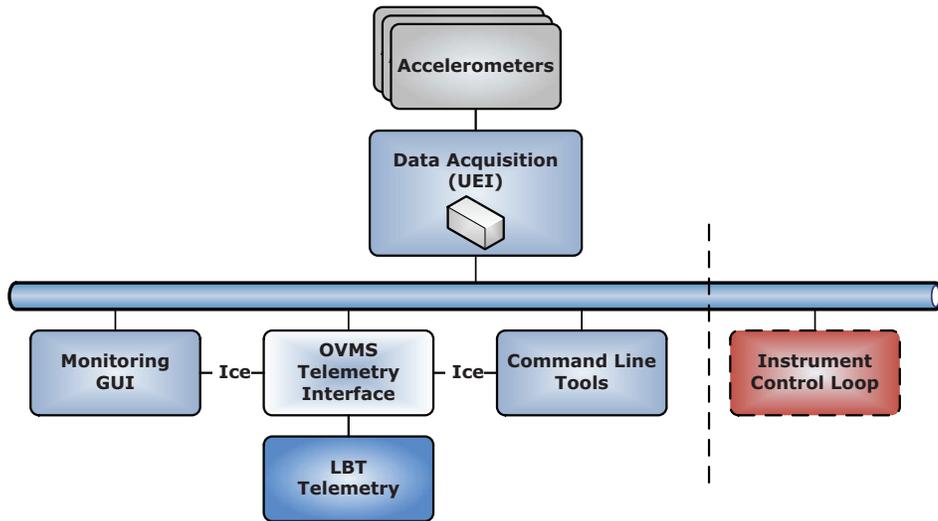


Figure 1. The OVMS conceptual design. The vibration data is acquired from the accelerometers and is made available for clients via a multicast node. Each client receives exactly the same data and can process it as needed.

eters. It generates a related time stamp for that data based on the LBT NTP time and finally broadcasts this time-stamped data through the network using a multicasting protocol. Different clients join the related multicast node in order to retrieve the vibration data stream. The advantage of this mechanism is that it allows to have several clients receiving exactly the same data, reducing the network traffic and any possible timing issue.

The OVMS software is implemented using known software packages such as Qt3, Qwt, Ice, or Boost. Additionally special packages like the LBT TCS telemetry and the UEI software development kit are used. The build-in clients for the OVMS are the *Monitoring GUI*, the *OVMS Telemetry Interface*, and some *Command Line Tools*. The command line tools are used for configuration and debugging purposes. Each instrument control loop can connect to the vibration data stream and utilize the data in its control strategies.

3. Tasks and Features

The OVMS software carries out several tasks. The acquired vibration data is provided to possible clients via a multicast node. The raw data is monitored and processed so that it can be indicated when specified vibration thresholds are exceeded. Furthermore, the vibration data is written into the LBT telemetry system for later post-processing.

3.1. Acquisition

The data acquisition is carried out in real time by a service that runs on the UEI Rack-tangle device which is basically a *PowerPC* running a *Xenomai Linux*. The service is in charge of collecting and distributing the raw vibration data through the network

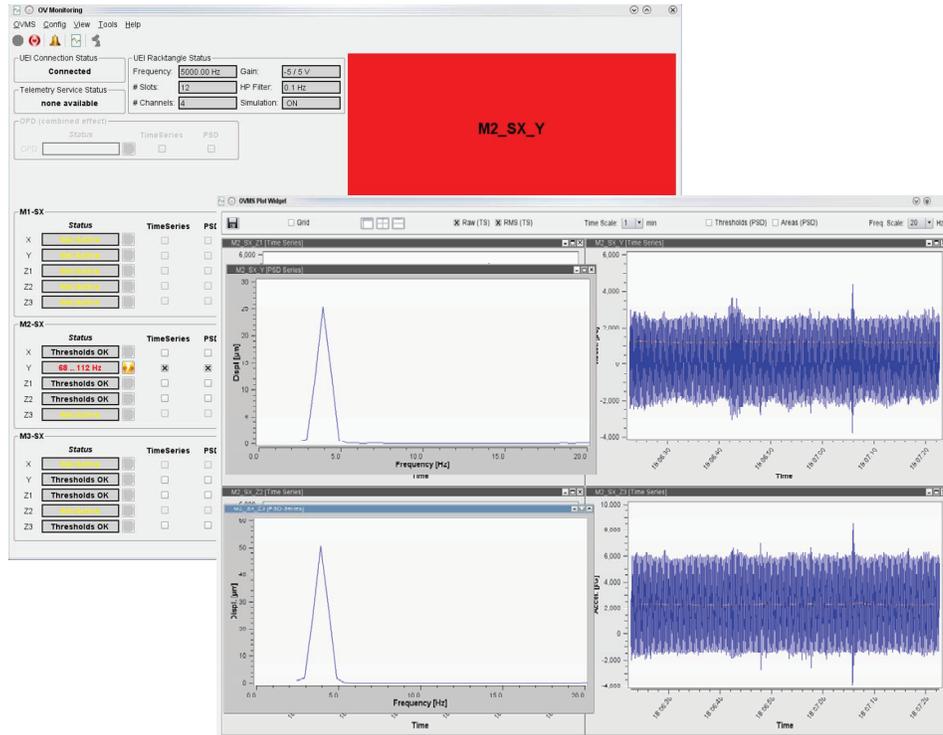


Figure 2. The OVMS monitor main gui with an active alarm warning for accelerometer M2_SX_Y and the quick look plot window with time series and PSD plots.

via a multicasting protocol. Several configuration parameters which can be selected at command-line start-up are supported. These parameters include the used ICP current in Ampere, the device's operation rate (default 5 kHz), the used Gain, the high-pass filtering type for the input cards, and the details for the multicast connection.

A command line acquisition tool can be used to check the connectivity with the UEI data acquisition system. It connects to the multicast node, reads the data stream, and prints out the time stamp and the raw vibration value of each accelerometer separated by space characters. This data can also be redirected from the standard output into a file, and later on, be analyzed using GNUPlot, Matlab, or similar tools.

3.2. Monitoring

The OVMS quick look tool allows the monitoring of the UEI device output in terms of raw acceleration data and/or PSD data plots for each accelerometer, as depicted in Figure 2 for accelerometer Y of M2 on the SX side ($M2_SX_Y$). The time window size for the acceleration plots and the frequency range for the PSD plots can be selected. Several display options are selectable for convenience. Single plots can be saved as an image.

The OVMS Monitor connects to the UEI device data stream and monitors its data output as well as its status. For each Accelerometer individual thresholds in the spectral

domain are specified for separate frequency regions. In order to check these thresholds an on-the-fly spectral analysis is performed. The acquisition sampling rate is around 5 kHz and 45 accelerometers need to be handled. Therefore, the monitor should run on a dedicated computer for performance reasons. Furthermore, quite a lot of memory is required since the data of about one hour needs to be buffered. Since the monitor is meant to be a quick look tool it handles the vibration data as single-precision only, uses internally only a sampling rate of 1 kHz, and utilizes a circular buffer for storing one hour of data of each accelerometer. Upcoming instrument control loop clients will most likely need higher rates and double-precision.

When a threshold value is exceeded the user (operator) will be informed by means of an easy recognizable alarm as shown in Figure 2. Details are logged to disk, so that it is easy to trace back what happened. The status of the Telemetry Interface Service is also monitored. In addition an engineering GUI for working with the Telemetry Interface Service can be called from the menu. It allows pausing, resuming, and shutting down of the service. The telemetry sampling rate can also be modified.

3.3. Telemetry

The telemetry interface is in charge of collecting the raw accelerometer measurements from the multicast node and storing them into the LBT telemetry subsystem with a sampling rate of about 1 kHz. It is divided into two parts, the stand-alone telemetry service and the clients. The service is basically a finite state machine that works in the background storing data and processing commands from clients (Borelli et al. 2010). It provides a simple set of commands that can be issued either from the OVMS monitor or from the corresponding telemetry client. This client controls the telemetry service from the command line console. Its purpose is to automatize some procedures, either using scripts or scheduled tasks.

4. Summary and Outlook

The OVMS software is build in a way that real-time vibration data is easy accessible by any client. Each client retrieves exactly the same data and can process it as needed. It provides various configuration possibilities and is easy maintainable. The monitoring feature not only includes an alarm-system but also has proven to be useful for engineering work at the telescope. It helps the observatory staff to ensure low vibration conditions by identifying significant vibration sources.

A first step towards the estimation of the movement of the telescope mirrors due to structural vibrations is already discussed (Engelke, S. et al., 2012, IMAC XXX, in preparation) It proposes to process the raw data based on a modal state-space observer model. It is tested with data already retrieved from the OVMS. The work is still ongoing and will be integrated into the OPD control strategies for the LINC-NIRVANA instrument.

References

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