13-Po13

Detection and timing of laser pulses from Lunar Reconnaissance Orbiter

Szymon Stuglik
Internship project conducted at NASA Goddard Space Flight Center,
contact@szymonstuglik.com

Abstract.
In space calibration of optical instruments such as laser altimeters is currently being investigated at NASA GSFC. The calibration requires complex aperture for detecting and time tagging of the laser pulses emitted by space born Lidar on the ground. This paper sumarizes the attempt of detecting the Lunar Reconnaissance Orbiter laser at NASA Goddard Space Flight Center.

Introduction

In order to confirm that the laser altimeter is pointing in the right direction it's necessary to record the times at which the pulse was emitted by the instrument and later on detected on the ground. Knowing the pulse departure/arrival times and spacecraft exact position allows to calculate whether the instrument is pointing in the right direction. The signal time tags were recorded using the GuideTech GT668-PCI Continous Time Interval Analyser card, custom software for time tags recording and referencing to absolute UTC time along with the experiment setup are described in following sections.

Experiment setup

The first and only attempt[1] (during the internship period) of detecting LOLA pulses occurred on the 28th of June 2013. The LRO active raster scan was scheduled for 3:30 AM. The hardware configuration block diagram is illustrated on Figure 1.

The optical power meter was connected to the computer 1 and mounted on top of the telescope, its aim was to measure the Moon brightness every second over a duration of approximately 1 hour starting from 3:00 AM. The gathered measurements would be then used to estimate the atmospheric transmission by comparing it to the data published by V.V. Korokhin et al. (2006) and/or Adair P. Lane, et al. (1972) regarding the dependence of brightness of the lunar surface.

The telescope mount was connected and controlled by the HP Compaq Laptop. During that attempt the telescope pointing was done manually by assigning the azimuth and elevation values. In order to improve the pointing efficiency it was decided to switch to the automatic mode for the next attempt, however this approach required verification, hence two testing sessions were conducted prior to second attempt.

The detector for registering LOLA pulses was also mounted on top of the telescope. The signal from the detector was split and connected to the Channel A of Time Interval Analyzer card installed in the Computer 4 for time tagging the signal and to Computer 3 for recoding the signal waveform.

[1] Second experiment was scheduled for 30th and 31st of July, however due to bad weather conditions and unexpected LRO operations schedule change the tests were postponed to the end of August.

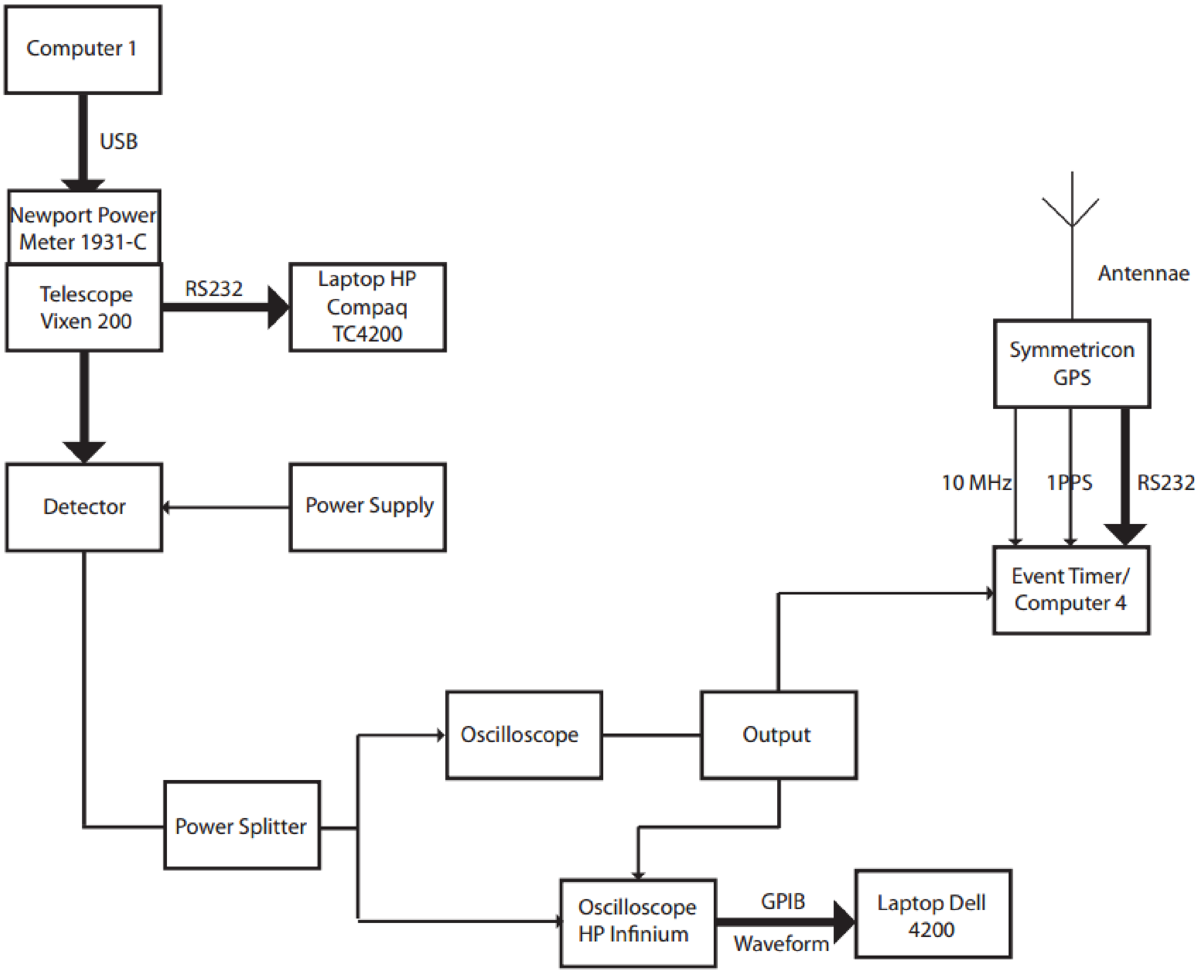

Figure 1 Block diagram of LOLA-Earth Active Scan Ground Station Setup

The LRO active raster scanning started at 3:30 AM, the signal time tagging started few minutes before and continued few minutes after LRO finished the scanning. Analysis of collected time tags showed that no actuall LRO laser pulses were recorder.

Time tagging and referencing software

GT668 Time Interval Analyzer card from GuideTech is high accuracy time and frequency measurement instrument capable of taking millions of measurements each second. Due to the high measurements rate GT668 allows to analyze the input signals in greater depth (dynamical frequency change can be observed). The high level operating logic of the card is fairly simple- whenever the signal energy crosses predefined threshold the card records (time tags) the time of this event. Although the manufacturer provided sample programs for operating the card, it was still necessary to develop custom software in order to satisfy all requirements imposed by the experiment.

Complete application schema is depicted on Figure 2. The Event Timer is interacting with TIA card through an external API provided by the manufacturer along with the driver. Multithread architecture separates the UI operations from the time tags acquisition and processing, hence the TIA worker thread is solely responsible for initializing the measurements by calling appropriate TIA driver method as well as reading the time tags from PC RAM memory and saving them to the hard drive.

Both main UI and TIA controller modules are connected to GPS module (used for referencing the time tags to absolute UTC time), first module establishes the connection with GPS receiver over RS232 port, second queries the GPS before and after the first time tagged GPS pulse.

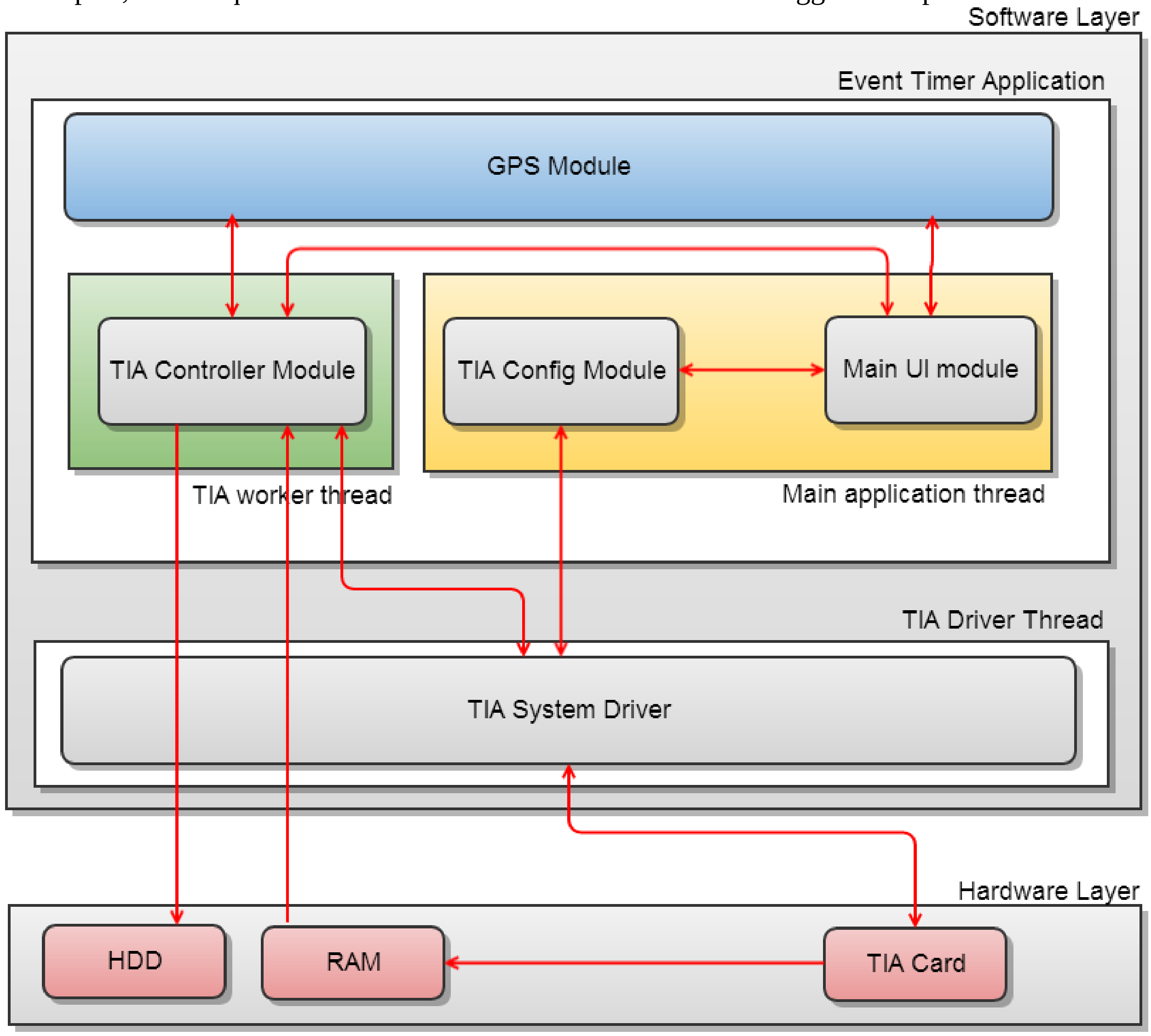

Figure 2 Event timer application architecture

The Time referencing method is depicted onFigure 3. The TIA card is characterized by very high accuracy (1 Pico second), however it outputs relative time of an event, meaning the time between the start of the measurements (indicated as the blue line) and event occurrence (pulses). It is crucial to know the exact time at which the laser pulses emitted by space Lidar were recorded in order to perform successful calibration and recreate the pulse waveform. To reference the time tagged signal to absolute UTC time, the event timer application measures the GPS 1 pulse per second (PPS) signal. The pulses always occur at equal second, however it's impossible to derive the absolute time directly from the 1 PPS signal, hence the application queries the GPS receiver just before starting the measurements (time T1) and right after registering the first pulse (time T2) on channel B where GPS signal is connected.

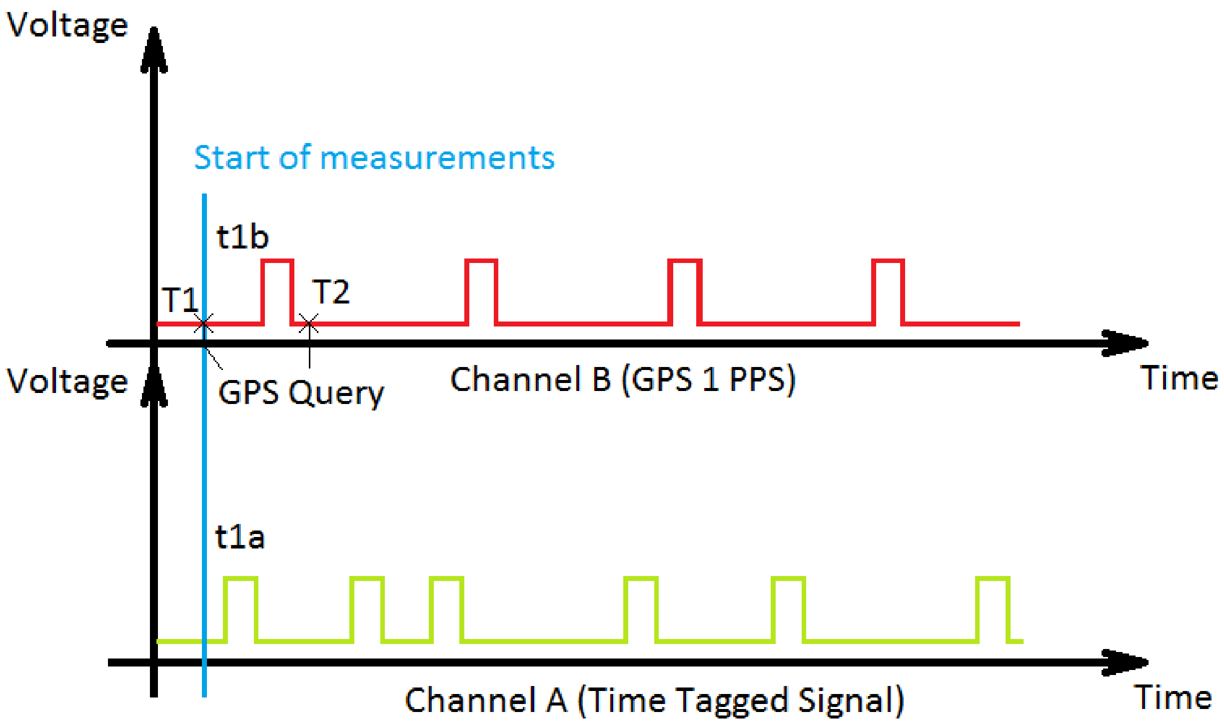

Figure 3 Time tags referencing to GPS time

Considering that the GPS pulses always occur on equal second, the absolute time of first detected GPS pulse is equivalent to the time obtained from the GPS receiver after the first pulse rounded to the nearest second.

Conclusions

This paper summarizes the attempts of detecting LOLA laser pulses on the ground for the calibration purposes. Unfortunately during the LOLA active raster scan the team didn't detect any pulses and hence any further data processing and analysis was impossible (it has been confirmed that LRO LOLA laser energy decreased much more than anticipated, hence the laser pulses detection on the ground will require much more resources and more advanced equipment). Prior to the second attempt significant improvements were introduced in the event time tagging software as well as telescope tracking system and procedure, yet again no pulses were detected due to experiment rescheduling caused by bad weather conditions and changes in LRO operations schedule. Following attempts are expected in second half of August 2013 and after. The software developed and described in this report as well as the work and research conducted is intended to help in achieving the end goal which is detecting the LOLA (or other laser altimeter) laser pulses.

References

Adair P. Lane, et al. (1972), 'Monochromatic phase curves and albedos for the lunar disk', The astronomical Journal, Volume 78 Number 3, April 1973

GuideTech, 'GT668 Time Interval Analyzer - Operating Manual'

V.V. Korokhin et al. (2006), 'The Phase Dependence of Brightness and Color of the Lunar Surface: a Study Based on Integral Photometric Data'