
Timing System for the Laser Altimeter for Planetary Exploration Technology Demonstrator

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Abstract

We are presenting the design, construction and tests of the timing system for the Bepi Colombo Laser Altimeter (BELA) technology demonstrator. BELA Timing System (BTS) is an universal timing system for laser ranging in ground-ground, air-ground and ground-satellite experiments. It is dedicated to measure precise time interval with subnanosecond resolution. The device for advanced range gating is included. The unit is interfaced to a host personal computer via a serial data link for control, two way data transfer and diagnostics.

The entire BTS has been designed and constructed on the basis of the Portable Calibration Standard (PCS) for satellite laser ranging, which has been developed in our labs within the last ten years. To reduce the complexity, costs, weight and power, considering the modest timing resolution requirements, the sub-nanoseconds instead of picoseconds resolution of the time intervals, the timing part of the original device has been replaced by the Mini counter. The overall design philosophy, the operational control software, the epoch timing, the range gate generation have been preserved along with the concept of the host computer software package for data acquisition, control and data analysis including the communication protocol, data and command formats etc. The use of well tested concept of both the HW and SW enabled to shorten the design, construction and testing phase of the final device down to several weeks.

The BTS consists of the Mini Counter module, the epoch timing and range gate generator module, the control processing unit, the input / output circuits and of the power supplies. The entire control logic hardware including the epoch timing and range gate generator and the input/output board logic is based on the FPGA (ispGAL) programmable logical arrays. There is a significant array capacity still available for future functional extensions and device upgrades, the arrays are field programmable. This fact ensures the maximum device flexibility and upgradability. The main parameters are : resolution 0.25 ns, linearity and stability better than 0.1 ns and 0.1 ns per K and per hour resp. The laser fire epoch resolution is 100 ns, the range gate is programmable in 40 ns steps. The device is small (2 kg), low power, it is capable to operate 3 hours on eight AA batteries.

Goals

- Technology demonstrator of a Compact Laser Rangefinder applicable in future space projects :
 - Mercury planet altimetry
 - Lunar altimetry and surface mapping
 - on-board optical transponder(s) for Earth orbiter(s)
 - airborne range finder
 - ground based Satellite Laser Ranging (SLR)
- Main altimeter parameters:
 - one meter ranging precision
 - multiphoton approach
 - diode pumped laser, ns pulses,
 - modular construction
 - existing / available technology

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Philosophy

- Technology demonstrator of a Compact Laser Rangefinder
- modular construction
- existing / available technology
- test bench at the Satellite Laser Ranging site Wettzell, WLRS
- applicable in various ground and space projects :
 - Mercury planet altimetry
 - Lunar altimetry and surface mapping
 - on-board transponder for Earth orbiters
 - ground based Satellite Laser Ranging (SLR)
 - airborne range finding

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Schedule & responsibilities

| | | |
|-------------|-------------------------------|------------|
| July 31 st | decision, proposal, quotation | CTU Prague |
| August 31st | DLR acceptance, contract | DLR |
| October 30 | first version operational | CTU Prague |
| November | on-site testing | CTU / DLR |
| November 30 | delivery | CTU |
| December 15 | integration at DLR | CTU / DLR |

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Altimeter Timing System Requirements

- GENERAL
 - universal timing system for laser ranging with sub-ns resolution
- FUNCTIONS
 - determining the epoch of laser fire
 - measuring the time-of-flight of the laser pulse
 - generating the range gate pulse for the echo signal detector
 - data acquisition and process control.
- PROPERTIES
 - compact, low power (battery operated), low cost
 - based on field - proved components HW & SW
 - simple to integrate into final device

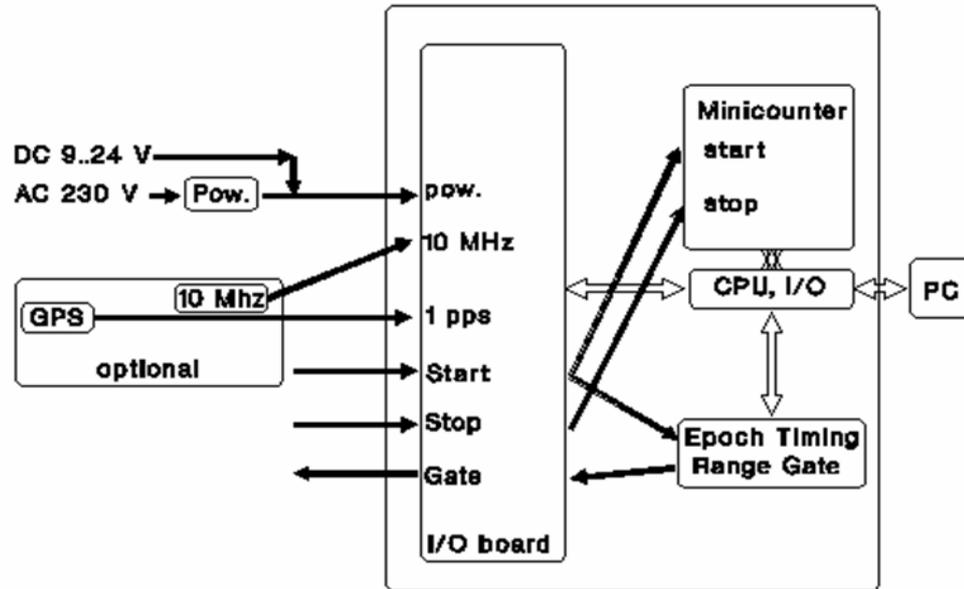
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Altimeter Timing System Concept

- Based on P-PET hw and sw concept, the Dassault modules are replaced by integrated TDC chips .
- The timing system consists of the range counter module, the epoch timing and range gate generator module, the control processing unit, the input / output circuits and of the power supplies.
- The entire control logic hardware, epoch timing, range gate, and input/output board is based on the FPGA (ispGAL) programmable logical arrays. This ensures the maximum device flexibility and upgradability.

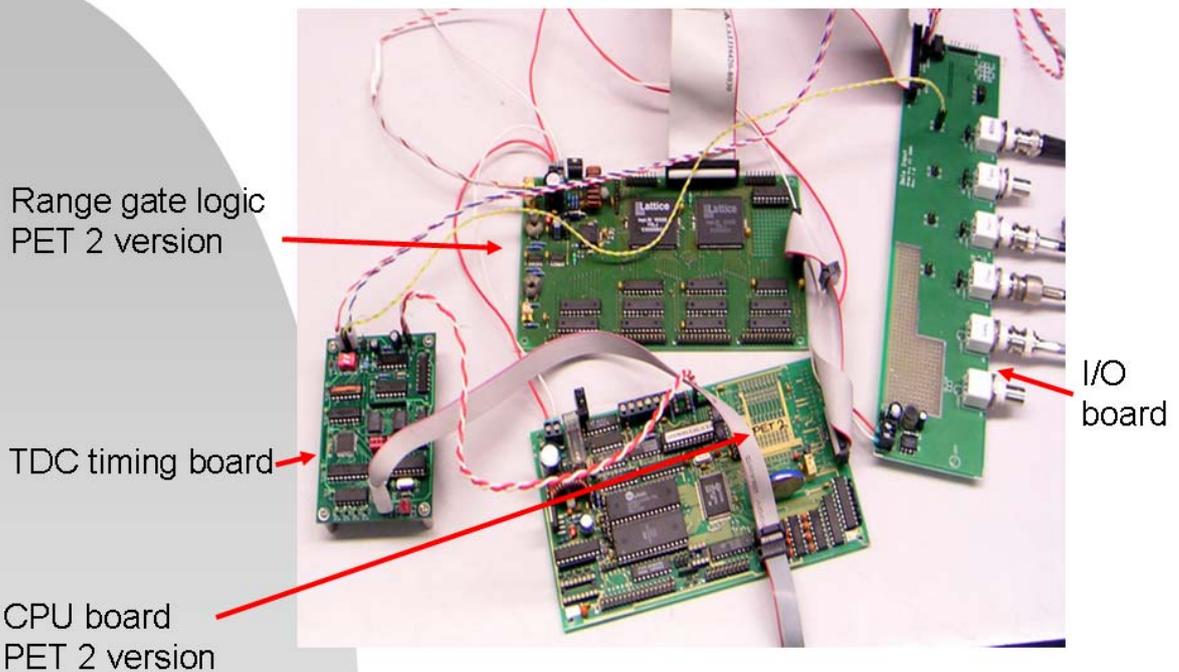
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Timing System Technology Demonstrator Block scheme



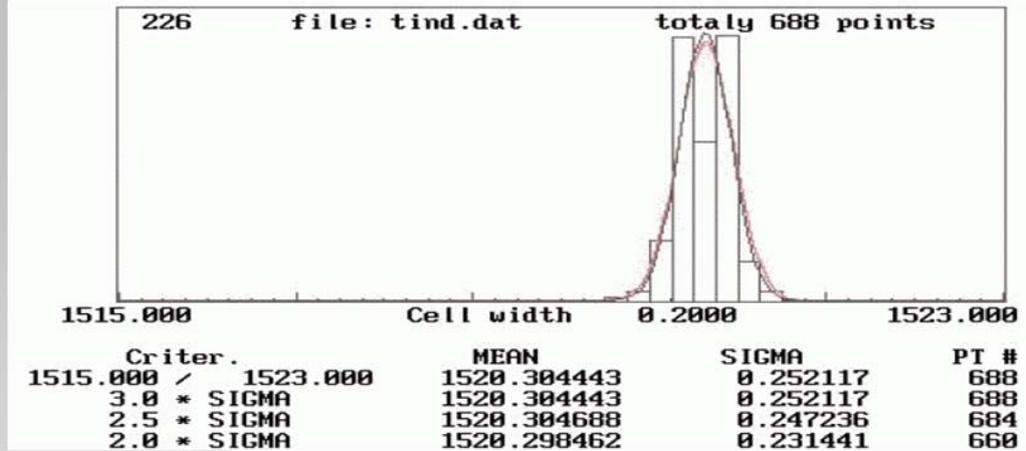
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Timing System Technology Demonstrator Electronics boards



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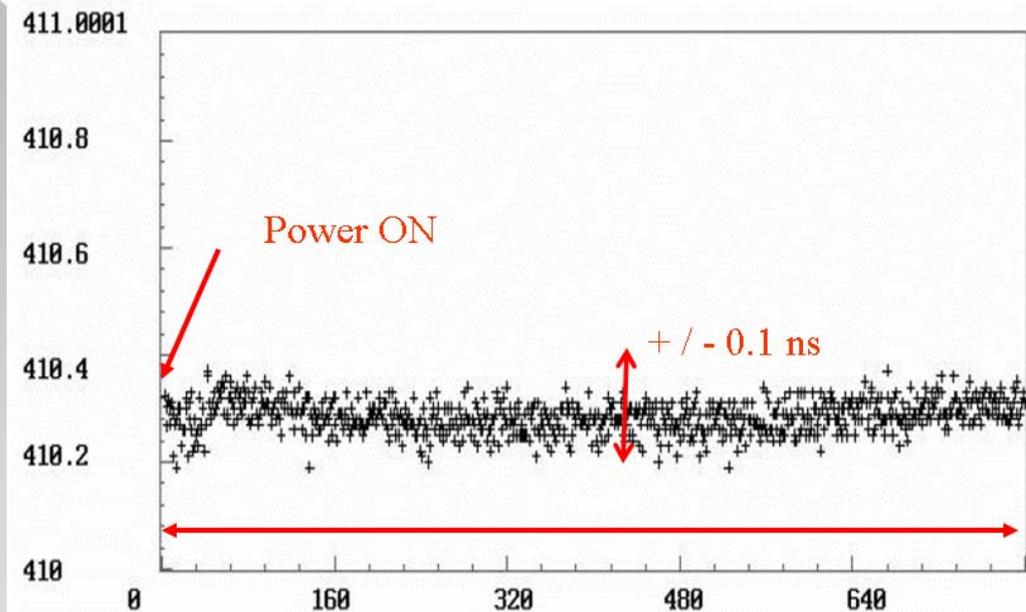
Timing System Technology Demonstrator Temporal resolution



measured time 1.52 μ s
 the timing resolution of 0.25 ns
 normal data distribution

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Timing System Technology Demonstrator Long-term temporal stability



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Timing System Technology Demonstrator Parameters

- universal timing system for laser ranging with sub-ns resolution



- resolution, precision 0.25 ns, 0.25 ns rms
- non-linearity, stability < 0.1 ns, < 0.1 ns/hour
- range gate delay, width 40 ns steps
- repetition rate 24 Hz max.
- mass 2.5 kg
- power DC 9-38 V, 7 VA
> 3 hr operation on AA cells (8x)

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Altimeter Timing System Technology Demonstrator Conclusion

- the universal timing system for laser ranging: ground-ground, air-ground and ground-satellite with sub-ns resolution has been developed and tested
- simple to implement: SW package identical to PET devices
- based on tested technology and components development period < 3 months :-)
- In perspective the Altimeter Timing System may be applied in deep space laser transponder experiments

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