NASA NGSLR Precise (~ 1 ns) Transmit Epoch Timing to On-Station Time Reference for LRO Transponder Support

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Abstract

The LRO transponder measurement requires the participating ranging stations to time tag the data to the station very accurately and peg the timing measurements to a stable clock that has excellent short term stability of <5 ns over the lunar orbit period of ~1 hour. The latter capability is achieved using a free running Cesium clock that has demonstrated excellent short term stability. This paper highlights the accurate time tagging to better than 1 ns to the station 1pps timing standard. For LRO transponder measurements, NGSLR uses a multimode, 50 mJ, q-switched laser that has a pulse width of 5.5 ns. NGSLR uses a standard high speed photodiode for its START detection and a Quad MCP-PMT based single photoelectron threshold receiver system for its STOP detection with a single photoelectron jitter of ~30 ps. However, the use of the above laser results in a significantly larger (>1ns) 1- for all timing measurements performed with this STOP receiver. Furthermore, Quad MCP-PMT at the high gain setting is extremely sensitive to large photon flux with adverse impact on its lifetime. We have devised a technique to precisely measure the timing and time tagging using the START photodiode as the common detector. Using this technique, measurements done on the external target can be transferred to an internal target for routine performance monitoring. This technique allows the operator to monitor the station performance during the 1-way ranging and ensure that the on-station time tagging is performing smoothly through the real-time internal calibration performance monitoring. The NGSLR had multiple path ways for performing the time tagging measurement; although both gave stable results within the error budget, the new pathway that was laid out was superior to the existing one as it provided a single stable unambiguous Transmit-Receive reference point for the eye-safe kilohertz laser and the high energy LRO laser. These measurements show that accurate sub-nanosecond time tagging is possible and the primary limitation is strictly the short term stability of the clock over the time interval of interest for the transponder. Details of the technique and the results are included.

The poster can be viewed at http://lrolr.gsfc.nasa.gov/lrolr_pubs.html.