100mJ, 1Hz Nd:YAG laser using Laser ALTimeter (LALT) for SELENE lunar orbiter

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### Overview of LALT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>1,064 nm</td>
</tr>
<tr>
<td>Ranging distance</td>
<td>50 to 150 km</td>
</tr>
<tr>
<td>Pulse repetition rate</td>
<td>1 Hz or 0.5Hz</td>
</tr>
<tr>
<td>Laser Output Energy</td>
<td>100 mJ</td>
</tr>
<tr>
<td>Pulse Width</td>
<td>17 nsec</td>
</tr>
<tr>
<td>Receiver diameter</td>
<td>100 mm</td>
</tr>
<tr>
<td>Receiver field of view</td>
<td>1 mrad</td>
</tr>
<tr>
<td>Transmitting beam divergence</td>
<td>0.4 mrad</td>
</tr>
<tr>
<td>Ranging accuracy</td>
<td>+/- 5 m</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
</tr>
<tr>
<td>Transmitter/Receiver</td>
<td>15 kg</td>
</tr>
<tr>
<td>Control Electronics</td>
<td>4 kg</td>
</tr>
</tbody>
</table>
Structure of LALT (1)

Lunar surface

Laser Transmitter/Receiver: LALT-TR

Control Electronics: LALT-E
Structure of LALT(2)

LALT-TR

Receiver telescope

45 degrees mirror

Receiver detector (APD)

Transmitter detector (PIN-PD)

Laser oscillator

Transmitter telescope

Q-SW driver

Ranging counter

High voltage power supply

LD driver
Structure of Laser Oscillator

<p>| | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td><strong>Wavelength</strong></td>
<td>1.064mm</td>
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<tr>
<td><strong>Pulse Repetition Frequency</strong></td>
<td>1Hz</td>
</tr>
<tr>
<td><strong>Output Energy</strong></td>
<td>100mJ</td>
</tr>
<tr>
<td><strong>Pulse Width</strong></td>
<td>17nsec</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>150 x 170 x 83mm</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>1.6 kg</td>
</tr>
</tbody>
</table>
Characteristics of Laser Oscillator

(Atmospheric Temperature and Pressure)
Result of 1st thermal vacuum test

Laser pulse wave form.
(normal conditions)

Wave form in vacuum after the low temperature test;
Free running oscillation for bad extinction ratio of pockels cell(LiNbO$_3$)

Pumping duration 200$\mu$s
The extinction ratio of the pockels cell was measured by using YLF laser. The directions of polarization of YLF laser can change (vertical and horizontal) by the $\lambda/2$ wave plate. The maximum and minimum of the transmission beam detected the peak of transmission beam.
Design change of LALT-TR

*the heater was added to a laser oscillator

*Storage temperature (in vacuum) of a laser oscillator was changed:

\[ \begin{align*}
\text{before} & : -30\text{deg} \sim +60\text{deg} \\
\text{currently} & : +20\text{deg} \sim +37\text{deg}
\end{align*} \]
Conditions of the environmental test for LALT-TR

Vibration test

Sweep-Sine vibration
- X,Y-axis: 5 to 50 Hz, 12.5G
- 50 to 100 Hz, 7.5G
- Z-axis: 5 to 100 Hz, 12.5G

Random wave vibration
- X,Y-axis: 8.54 Grms
- Z-axis: 12.49 Grms

Thermal vacuum test

- Low temperature: -26deg (@base plate)
- High temperature: +47deg (@base plate)
- Degree of vacuum: 133x 10^{-5} Pa
Vibration test procedures

Survey 1
- Sine wave vibration

Survey 2
- Random wave vibration

Survey 3

Electro-optical test

- Command/Telemetry
- Laser power
- Ranging test
- Boresight check

X,Y,Z each axis
Thermal vacuum test (LALT-TR)

Vacuum chamber

LALT-TR is surrounded by the shroud which liquid nitrogen was used for. An IR panel is installed in the aperture and the beside LALT-TR.
A Cassegrain telescope is placed in front of LALT-TR. The pinhole of the receiver telescope in LALT-TR is lighted with a 1μm CW-laser. The image of the pinhole and the transmitting beam are monitored by a CCD camera to observe the boresight.

A frequency standard signal is connected to delay generator. Ranging distance is changed by the timing delay generator.
Boresight alignment

LALT-TR is placed in front of the Cassegrain telescope to adjust the boresight alignment.
Ranging simulation

LALT-TR which attached the head of the ranging simulation equipment for ranging test.

In the ranging simulation, the equivalents distance is changed by the timing delay generator. And a laser wave form is monitored by the oscilloscope.
Targets ranging

Targets are the wall of building, steel tower, and the range calibration target in factory. Ranging distance are 5.1km, 8.3km and 0.45km, respectively.
Conclusion

Laser oscillator

Measurement results in normal conditions

- Output energy: 100mJ/pulse @ 794mJ input energy
- Pulse width: 17nsec @ 794mJ input energy

In environmental tests (Thermal vacuum, Vibration)

- Laser Output fluctuation: 10% or less

Laser altimeter (LALT)

- Proto-flight test for LALT-TR/E was finished in Apr. 2006
- LALT is being installed to SELENE