National Aeronautics and Space Administration

NASA Langley's

Laser Linear Frequency Modulation System

Improved accuracy in light detection and ranging and other optical measurement arrays

NASA Langley Research Center has made a breakthrough improvement in laser frequency modulation. Frequency modulation technology has been used for surface mapping and measurement in sonar, radar, and time-of-flight laser technologies for decades. Although adequate, the accuracy of distance measurements made by these technologies can be improved by using a high-frequency triangular-waveform laser instead of a sine waveform or lower frequency radio or microwaves. This new system generates a triangular modulation waveform with improved linearity that makes possible precision laser radar (light detection and ranging [lidar]) for a variety of applications.

Benefits

- Precise measurement of target distance and speed to 1 mm and 1 mm/s
- Ability to measure air velocity, ground velocity, target distance and velocity, aircraft altitude, angle of attack, and atmospheric wind vector in one system
- More accurate and reliable than current pitot-tube aircraft instrumentation that can ice up and requires frequent calibration
- Order of magnitude improvement in accuracy over time-of-flight laser pulse systems, and multiple orders of magnitude improvement as compared to radar systems for distance and velocity measurements
- Generation of a laser frequency modulation triangular waveform with improved linearity

partnership opportunity

Figure 1. A Coherent Doppler Lidar developed for planetary landing applications utilizing a linear frequency modulation technique.

Applications

- Space—Spacecraft landing and docking, planet topography measurement
- Manufacturing and construction—Precision alignment of large structures
- Robotics—Movement accuracy and maneuverability in confined spaces
- Aerospace—Replacement of pitot-static instrumentation systems for air velocity, ground velocity, altitude, and attitude measurements; target ranging, and 3-D visualization of structures and surfaces
- Surveillance and security—Movement detection and target visualization
- Military—Ground and target imaging
- Spectroscopy—Molecule identification

The Technology

For decades, frequency modulation has been used to generate "chirps," the signals produced and interpreted by sonar and radar systems. Traditionally, a radio or microwave signal is transmitted toward the target and reflected back to a detector, which records the time elapsed and calculates the target's distance. Reflected signals can be heterodyned (combined) with output signals to determine the Doppler frequency shift and the target velocity. Accuracy of these systems can be enhanced by increasing the bandwidth of the chirp, but noise generated during heterodyning at high frequencies decreases the signal-to-noise ratio, increasing measurement error.

Previous attempts at laser frequency modulation that relied on adjusting the laser cavity length have resulted in only sine wave or imperfect triangle waveforms. Heterodyning of imperfect, non-linear waveforms or sine waveforms will significantly degrade the effective signal-to-noise ratio, making such systems impractical. In contrast, the current technology produces a single, high-frequency laser that is passed to an electro-optical modulator, which generates a series of harmonics. This range of frequencies is then passed through a band-pass optical filter so the desired harmonic frequency can be isolated and directed toward the target. By modulating the electrical signal applied to the electro-optical modulator, a near perfect triangular waveform laser beam can be produced. Transmission and detection of this highly linear triangular waveform facilitates optical heterodyning for the calculation of precise frequency and phase shifts between the output and reflected signals with a high signal-to-noise ratio. By combining this information with the time elapsed, the location and velocity of the target can be determined to within 1 mm or 1 mm/s.

The technology portfolio includes U.S. patents 6,147,747.

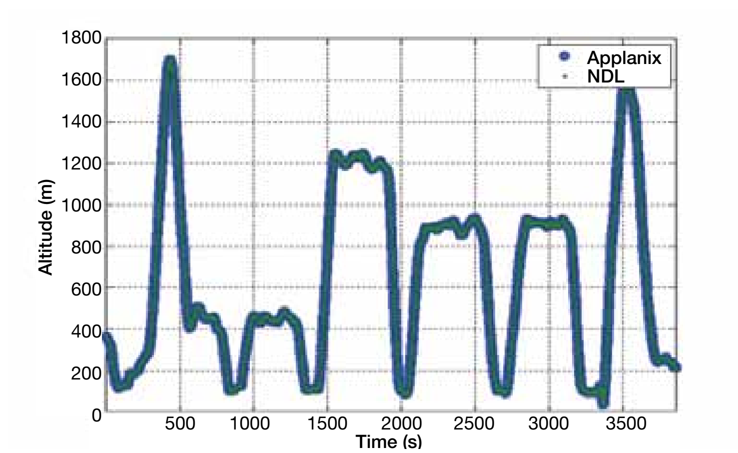

Figure 2. Altitude measurement from a helicopter using a Linear Frequency-Modulated Laser system shows excellent agreement with a high-grade Inertial Measurement/Global Positioning Systems Unit (Applanix Corporation).

For More Information

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

The Technology Gateway

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