Ultra-High Range Resolution Doppler Radar Front End With Quadrature-Less Coherent Demodulation

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OTHER INFORMATION

KEYWORDS

doppler radar, FMCW radar, quadrature demodulation, frequency modulation, vibrometer

CATEGORIZED AS

- **Optics and Photonics**
  - All Optics and Photonics
- **Engineering**
  - Engineering
  - Other
- **Imaging**
  - 3D/Immersive
- **Sensors & Instrumentation**
  - Physical Measurement

ABSTRACT

Researchers at the University of California, Davis have developed a Doppler radar front end to overcome detection nulls without quadrature demodulation.

RELATED CASES

2022-526-0

FULL DESCRIPTION

Doppler radars can determine the distance and speed of an object by sending a signal of a certain tone and observing the phase difference between the transmitted signal and its reflection off of an object. If the object's distance from the radar is a multiple of the signal wavelength divided by 4, detection nulls occur, and the gain of the radar becomes unusable. To overcome detection nulls, quadrature demodulation is commonly used to extract phase information received by the radar. However, quadrature demodulation requires highly precise matching circuitry and intensive digital signal processing. Such signal processing necessitates powerful onboard computers and negatively impacts the system's power efficiency. A Doppler radar that can overcome detection nulls without using quadrature demodulation would greatly improve performance and power efficiency.

Researchers at the University of California Davis have developed Doppler radar designs that simultaneously achieve ultra-low power consumption, ultra-low phase noise, free of detection nulls, and ultra-high displacement-sensing resolutions without using quadrature demodulation. The radar design uses low-noise sub-sampling phase-locked loops (SSPLLs) with the same reference (REF) signal to generate single-tone transmitted/radiated signal and a local oscillator (LO) signal. As a result, no quadrature demodulation is required, and the elimination thereof enables use of circuit design and hardware that are greatly simplified compared to conventional systems. A reflected signal (derived from an object) is downconverted into a time domain square wave, allowing for a simplified demodulation process and signal processing. A phase demodulator (PDM) is used to extract displacement-induced phase information from the square-wave signal and a PDM output is filtered to provide a signal proportional to vibration displacement of the object causing the reflected signal. With less computationally intensive digital signal processing, the power efficiency is improved compared to existing products. This radar is suitable for applications that require immense precision realized through its ultra-high-resolution capabilities.

APPLICATIONS

- Doppler radar to determine an object's distance and speed
- Replacement of laser Doppler vibrometers used in MEMS devices to measure vibration in extreme detail

FEATURES/BENEFITS

- Compact hardware design due to the removal of quadrature demodulation circuitry
- Enhanced power efficiency and signal resolution compared to existing continuous wave Doppler radars

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Published Application	20250052885	02/13/2025	2022-526
Patent Cooperation Treaty	Published Application	WO 2023/150799	08/10/2023	2022-526

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Reversed Feedback Amplifier Architecture

- Field Effect Bipolar Transistor
- Low Energy and Noise Sub-Sampling Phase-Locked Loop
- High-Frequency Imaging and Data Transmission Using a Re-configurable Array Source with Directive Beam Steering
- Hybrid Electromechanical Metamaterials for Optical and Electrical Devices
- Phased-Locked Loop Coupled Array for Phased Array Applications
- Scalable Phased Array Standing Wave Architecture
- Embedded Power Amplifier
- Reducing Electrical Current Variations in Phase-Locked Loop Systems

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