Technology Brief

Overview

PulsedLight's distance measurement technology was developed to meet three important objectives;

- A solution that has the lowest complexity hardware enabling the smallest possible size, low power consumption and lowest cost.
- The adaptability to trade between accuracy, operating range and measurement time under software control.
- A processing method ultimately reducible to a single System-on-Chip (SoC) solution.

By meeting these objectives, PulsedLight has created a technology that unlike competitive solutions is revolutionary not evolutionary. The design flexibility and hardware simplicity associated with implementation of our technology enables systems which can be packaged on a board space of under one square inch for single beam applications and only a few square inches for high resolution imaging applications.

History

The time-of-flight technology used in optical sensors generally falls into two camps; High accuracy phase-based measurement based on the transmission and reception of a continuously modulated, typically red, pointing and measurement beam or long range low accuracy pulsed measurement using the delay between the transmission and reception of higher power, short duration, infrared pulses. Openings discovered by PulsedLight in the IP landscape offered an opportunity for us to establish a defensible and relatively open patent position by creating from-the-ground-up technology combining attributes of phase and pulsed technology.

Time-of-flight distance measurement is typically used to provide long range operation often out to a kilometer or more with lower accuracy on the order of a meter or less. This technology, originating in military applications, has been adapted to a wide variety of consumer and industrial applications. These systems transmit relatively high power infrared pulses using a laser diode with distance estimated by measuring the time delay between the transmitted pulse and the detected return pulse. Since these systems use an invisible measurement beam they are best suited for applications incorporating a sighting optic or for sensor applications requiring only initial set-up of the pointing location.

The high peak power, short optical pulses used in these pulsed systems can allow the use of a smaller receiver optic, simpler analog hardware and the potential to use lower cost optical components. Unfortunately added complexity and cost to obtain significantly better accuracy or to use signal processing (attributes common in phase systems) for improved range performance has limited applicability to high performance, high cost, applications such as in military rangefinders.

The received sensitivity of direct detection systems is often limited due to an inability to process pulse signals embedded in noise using averaging. These solutions use detection criteria requiring the signal to be sufficiently above the system noise to minimize the number of false pulse detections. This hard threshold results in complete signal loss when the signal strength is too low, thus limiting the ability to trade increased measurement times for improved sensitivity and range.

Improved sensitivity can be achieved by effectively averaging the signal before detection. In high performance, high cost systems this has been accomplished by digitizing the return signal and averaging the digital representation of the received signal prior to detection using a stable reference on the waveform. The digitization has been implemented using expensive and power hungry analog-to-digital converters to digitize the signal at rates up to one billion samples per second or specialized IC's that capture the signal at a higher rate and digitize at a lower rate to reduce the cost of the converter.

Achieving improved accuracy required the development of a signal digitization technique without the complexity and cost of direct analog-to-digital conversion. High measurement accuracy was achieved by using a low-cost signal digitization approach based on a single-bit comparator with an adjustable threshold reference. Processing was suitable for implementation in high performance FPGA's (Field Programmable Gate Arrays) allowing a high level of hardware integration and low cost.

Two years was invested in developing a new signal processing approach to optical distance measurement which still allowed implementation using a very simple hardware configuration while eliminating the time consuming and processing intensive signal reconstruction of previous approaches. Previously, stored statistics of the detections produced from the comparison level successively moved through the signal envelope required the mathematical weighting based on the data accuracy at each comparison level to reconstruct a composite waveform. In our new approach, signal shape is reconstructed based on the difference between rising and falling edge statistics to allow a very simple method for signal reconstruction.

A following series of innovations applies the edge based signal reconstruction method to optical rangefinders incorporating signal correlation processing to perform a "signature match" between a captured transmit signal record and the received signal. A specialized signal correlation method was then developed to enable a single-chip processing solution (also known as System-on-Chip or SoC) using programmable logic chips suitable for low cost, ultra-small optical distance measurement sensor implementations.

Our present family of SoC devices can be rapidly updated to increase performance, reduce size or add new features to pursue unique applications performance requirements.

PulsedLight’s new approach enables the development of a new class of optical distance measurement sensors with accuracy of 1cm with a single board implementation in less than 1 square inch of board space. An added benefit of our approach is efficient averaging of low-level signals allowing the use of relatively low power optical sources such as LED's or VCSEL's (Vertical-Cavity Surface-Emitting Lasers) for short range applications and for improved range when using high power sources. This approach can also be optimized for ultra-low power consumption for battery-powered applications.

Innovation Summary

- The use of a signature matching technique (known as signal correlation) that estimates time delay by electronically sliding a stored transmit reference over the received signal in order to find the best match.
- Operation of the infrared LED or laser in short bursts allowing a 100:1 advantage in peak output power over measurement systems using a continuous beam.
- Decreased measurement times down to a millisecond or less allows significant power consumption advantages and high repetition rates for scanning applications.
- We have developed novel current driver technology with nanosecond signal transition times at high peak currents to produce high power transmit burst sequences.
- Our signal processing approach is implementable in a single programmable logic chip or System-on-Chip (SoC) to allow deployment without the costly development of custom processing chips.
- For high-volume, low margin applications the SoC solution enables technology implementation of less than ten dollars. There is no comparable competitive optical sensor solution.
- Detector switching technology allows multiple detectors to be processed by a single signal-processing channel. Enabling compact multichannel systems deployable in under one square inch of board space
- Multiple digital processing cores implementable in a single cost effective programmable logic chip
- Optical scanner technology to multiply low-resolution electronic scanning to higher resolutions.