

# Lidar Sensor

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## 1 Understanding the Technology Behind Autonomous Driving

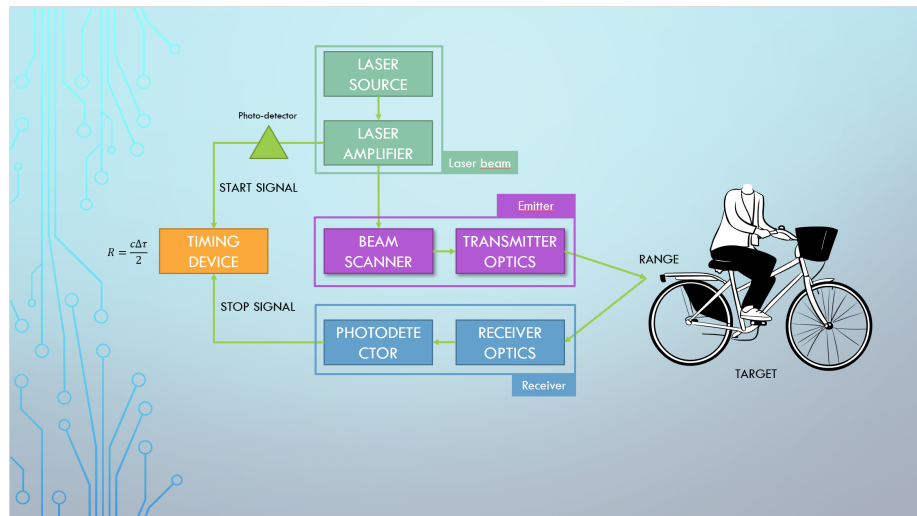
LiDAR (Light Detection and Ranging) is a vital technology in the development of self-driving cars. It enables these vehicles to accurately perceive their surroundings by emitting laser beams and measuring the time it takes for them to return after hitting objects. This article provides a technical overview of LiDAR sensors commonly used in autonomous driving.

A typical LiDAR sensor consists of several components, including a laser source, emitter, receiver, and timer. The laser source emits short bursts of laser beams, which are then amplified and directed into the atmosphere using a beam scanner and transmitter optics. When the laser beam hits an object, a portion of the energy is reflected back and collected by the receiver optics. This collected signal is then converted to a voltage signal and analyzed.

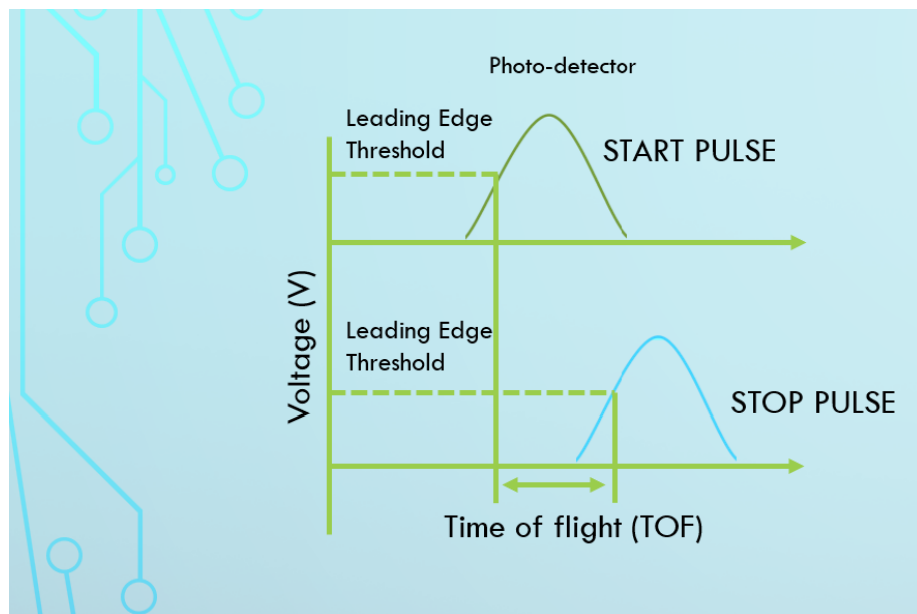
The range to the target can be computed using the equation:

$$R = \frac{1}{2n} c \Delta t$$

where  $R$  is the range,  $c$  is the speed of light in vacuum,  $\Delta t$  is the time of flight of the laser light, and  $n$  is the index of refraction of the propagation medium (for air,  $n$  can be assumed as 1.0).



To measure the time of flight accurately, a precise clock is essential. The timing device detects the moment when the laser pulse returns by using a leading edge threshold technique on the voltage signal. The resolution of the timing device determines the range resolution, with typical values in the range of 0.1 ns, resulting in a range resolution of 1.5 cm.



The maximum range at which a target can be detected depends on factors such as laser energy losses in the atmosphere and signal-to-noise ratio (SNR). The SNR is influenced by ambient noise and the return energy of the laser beam. Increasing laser energy and receiver sensitivity are two approaches to improving SNR, although eye-safety regulations limit the former.

Signal ambiguity is another consideration, ensuring that only one laser pulse is “in flight” at any given time. This allows unambiguous association of the received pulse with the previously emitted pulse.

The “LiDAR equation” relates the power of the laser beam returned to the receiver with various factors, including transmission power, target reflectivity, and atmospheric conditions. These factors play a crucial role in achieving a high SNR and accurate detection of the reflected laser pulse.

Understanding the components and principles behind LiDAR sensors provides valuable insight into their capabilities and limitations. By optimizing these sensors, autonomous vehicles can achieve better perception and make safer decisions based on their surroundings.