Driverless Anything and the Role of Lidar

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• What is lidar
• How lidar works
  • Signal
  • Scanning methods
  • Lasers
  • Detectors
• How lidar is integrated into autonomous cars
• The future
What is Lidar?

Lidar system components:
- Laser transmitter
- Receiver
- Signal processing
- Scan Optics

Diagram showing transmitted beam, reflected beam, target, and 3-D point cloud.
Where is Lidar Used Today?

- Automated Guided Material Handling Robot
- Lidar Robotic Vacuum
- Lidar Robotic Delivery Vehicles
- Lidar Robotic Security Robot
- Drone Navigation and 3-D Mapping
- Humanoid Robots and Cobots
- Lidar Surveillance Systems
- Autonomous Vehicle Navigation
Laser Transmitter

Long range direct time of flight

10s to 100s of Amps

nanoseconds

Amps to 10s of Amps

Short range indirect direct time of flight

10s to 100s of MHz

10s to 100s of MHz
Lidar Scan Methods

https://spectrum.ieee.org/tech-talk/semiconductors/optoelectronics/mit-lidar-on-a-chip
Lasers

Edge-emitting laser

a) VCSEL array cross-section
b) VCSEL array top view


VGEN-SP
LIDAR Ytterbium Pulsed Fiber Lasers
Detectors

- Photodiode
- Avalanche Photo Diode (APD)
- Geiger-Mode APD
Value of eGaN® Devices

• Long range lidar (scanning and spinning)
  • Very small with very high peak current
  • Very, very fast

• Short range lidar (ToF camera)
  • Very small size
  • Very high frequency capability

• eGaN integration reduces size, increases speed, and reduces cost
Direct Time of Flight (DToF)

EPC2001C
Quad laser (all 4 in parallel)
OSRAM SPL S4L90A_3 A01

- \( V_{bus} = 75 \text{ V} \)
- \( I_{LASER,peak} = 135 \text{ A (total)} \)
- Current \( t_{pw} = 2.51 \text{ ns} \)
- Optical \( t_{pw} = 2.85 \text{ ns} \)

EPC2001C
Discrete Dual Channel IC
IToF @ 200 MHz @ 9 A

EPC21601 integrated laser driver
The Pathway to Self Driving Cars

LiDAR Covers All Levels of ADAS Automated Safety

- **Driver Only**: Driver Undertakes Lane Holding and Lane Changing Activities
- **Assisted Driving**: Driver Carries Out All Lane Holding or Lane Changes in a Special Application Case
- **Partly Automated**: System Handles Lane Holding and Lane Changes in a Special Application Case
- **Highly Automated**: Driver Needs No Longer Continuously Monitor the System. Must Potentially Be Available to Take Over
- **Fully Automated**: No Driver is Necessary in Special Application
- **Driverless**: System Can Handle All Solutions Automatically Throughout the Trip. No Driver Needed

LiDAR is Essential Part for ADAS

Source: Frost & Sullivan; VDA Automotive SYS Konferenz 2014

Frost & Sullivan
What is Required for Autonomous Cars?

300 meters (approximately 11 seconds at 60 mph)

- Higher output lasers
  - Going to longer wavelengths (1440 nm vs 903 nm) allows for higher output power without danger to the human eye
    - 1440 nm lasers are more expensive
  - Edge emitting LEDs are more efficient than VCSEL and have superior columnation
    - VSEC lasers can be lower overall cost, but shorter range

- More sensitive detectors
  - Geiger mode can detect single photons but takes time to “reset”
How Waymo’s Self Driving Car “Sees”

One of Waymo’s three lidar systems that shoots lasers so the car can see its surroundings. Waymo says this lidar can detect a helmet two-football fields away.

A forward facing camera works with 8 others stationed around the car to provide 360 degrees of vision.

Radar sensors can detect objects in rain, fog, or snow.

Waymo’s self-driving sensors are tightly integrated into the hybrid minivan created by Fiat Chrysler.

Source: Waymo
How Audi’s ADAS 3 A8 “Sees”

http://images.car.bauercdn.com/pagefiles/74157/audi_a8_level3_01.jpg
How Lidar Might be Deployed

Shadow Zone
Lidar Myths

- *Lidar can’t see in fog, snow, or rain*
  - Lidar can see as well as, or better, than a human
- *Spinning disk lidar is unreliable*
  - There are lots of reliable spinning disks in every car
- *Lidar is too expensive*
  - Flash lidar is much less expensive than spinning lidar
  - Automotive companies have a way of grinding down cost
The Future

• Lidar will be used on all cars and lots of robots and UAVs
• Lidar will be about as expensive as a headlamp
• Lidar (scanning) + lidar (flash) + camera will be able to handle most autonomous functions