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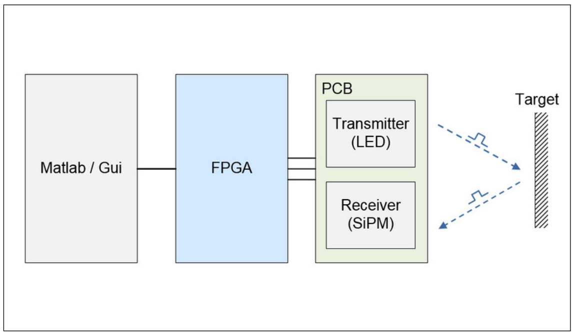
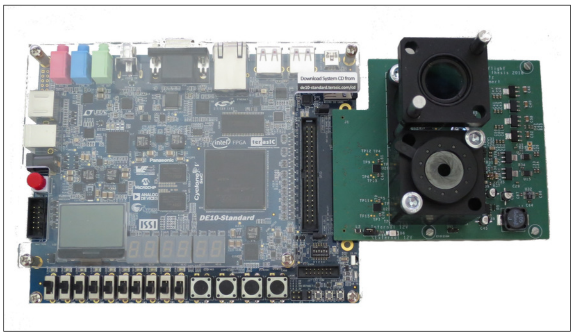
Subject Area	Sensorics
Project Partner	Baumer Electric AG, Frauenfeld, Thurgau

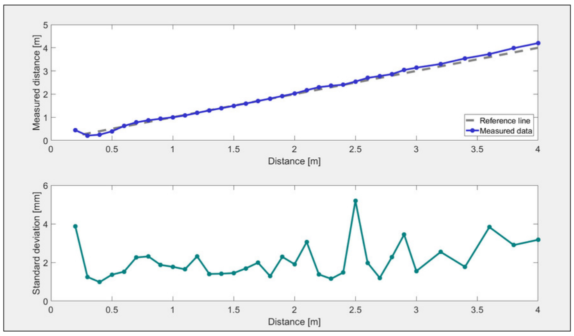
Time of flight distance measurement with silicon photomultiplier



Overview of the pulsed time of flight system



Time of flight PCB with an Altera DE-10 FPGA board



Distance linearity measurement results (top) with the measured standard deviation (bottom)

Introduction: Baumer Electric in Frauenfeld is a leading company in the field of industrial sensors. Currently, they are developing a new time of flight distance sensor. The time of flight technique is based on pulsed light. The distance is evaluated by measuring the time a light pulse needs to travel to a target and back to the receiver. This approach is challenging, since it takes light only one nanosecond to travel 30 centimeters. Due to this fact, high circuit requirements have to be satisfied to get a sufficient distance resolution.

Objective: The goal of this thesis was to build a fully functional time of flight system. The system consists of a pulsed light source, a light detector and a time measurement circuit. The pulsed light source, which is part of the transmitter, has to be realized with an LED. The wavelength of this LED should be in the visible range, therefore the point of measurement can be recognized. The main component of the receiver is a silicon photomultiplier (SiPM), which is used to detect the incoming photons.

Result: A fully functional time of flight measurement system with a SiPM as a receiver was implemented. The transmitter is capable of sending light pulses in the length of six nanoseconds and above. The SiPM output signal can be amplified with three different amplification options. To evaluate the signal, two comparators with different reference levels are used. The comparator output signals are used as stop signals for the time to digital converters. With the additional data acquired by the second level, a compensation algorithm could be implemented in the future. To reduce noise in the signal, the SiPM is switched to a lower voltage during the time when no measurement takes place. The developed setup is capable of measuring distances between 30 centimeters and four meters. Narrowed down to the optimal measurement range of one to two meters, the standard deviation is around 2 millimeters. Thus, with this standard deviation and a ranging offset of 2.25 percent, the developed system can keep up with similar commercial sensors. Overall, the objectives of this thesis were fully met.