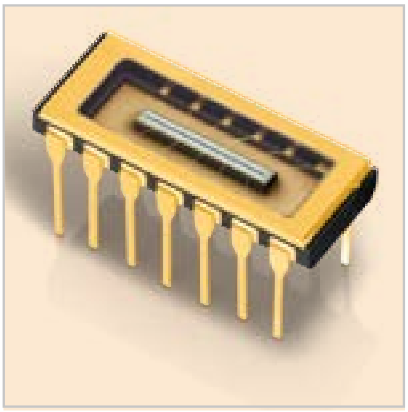
Drones Will Change the World

Optoelectronics Ensure a Safe Flight



Unmanned Air Vehicles (UAVs) are designed to navigate autonomously, delivering parcels and venturing into areas that are inaccessible, unsuitable or even unsafe for humans to enter. What may sound to some like science fiction is closer to reality than we think with scientists, manufacturers and politicians working hand in hand to turn this vision into a reality.

Extending the abilities of the remote-controlled devices of old, professional drones are required to navigate on their own and without any visual contact to the controller. This demands knowledge of the UAVs precise position in space as well as the ability to react to any external influences and obstacles that might enter into the airspace of the UAV. The process of flying requires highly functional sensor technology, and the requirements for steering and safety systems are even higher. The most demanding parts of a flight are right at its beginning and end. During the take-off and landing procedures, the UAV has only a few seconds to react to so-called "gust" effects. This can only be achieved if the vehicle can determine its own position in three-dimensions to at least centimeter accuracy. Satellite navigation and reference measures are very helpful, but the most crucial component is a seamless communication link between the flight computer, navigational electronics and air-data sensors.

Whilst in-flight, UAVs not only have to detect solid, stationary structures like trees or buildings. It is even more important that they are able to react to sudden obstacles such as helicopters or low-flying planes that may enter into the UAVs airspace without a lot of warning of foresight. This reaction can be achieved using distance sensors. Depending on distance and speed, RaDAR or laser-based LiDAR (Radiation / Light Detection and Ranging) systems could be the more feasible solution. It is highly probable that LiDAR will play a major role in near field navigation, when drones are flying near to – or even inside – buildings.

So far, autonomous drones are not used in everyday life, but scientists have already been able to achieve promising results with several research projects: In early 2016, Prof Dieter Moormann and his team from the Institute of Flight System Dynamics of RWTH Aachen, tested autonomous delivery for German parcel service DHL. On its 8-km flight from the Bavarian mountain community of Reit im Winkl to the remote

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Winklmoosalm, the UAV ascended 500 meters in altitude through quickly changing weather and temperature conditions. Urgent medication reached the DHL Skyport in just eight minutes where it would have been a 30-minute car drive on snowy mountain streets.

Since this flight was carried out without visual contact safety systems were in effect throughout the flight. The team also set up a long-range data link using radio communication and the mobile phone network. Delivery was also carried out intelligently with automated loading, unloading and even battery changing processes facilitating an immediate return flight. This project proved the technical feasibility of automated air delivery. DHL was the first parcel service in the world to test the extensive integration of UAVs into the package delivery (dpdhl.de/paketkopter).

In case of large-scale disasters such as forest fires or chemical accidents, autonomous drones could be used to scan areas that do not allow direct access for the emergency units. This kind of autonomous scouting requires swarms of several UAVs all able to communicate with each other, collect data and transmit it to the base station. Not only would they be able to locate casualties or leaks, but they could also detect invisible and dangerous substances and determine their concentration, thus enabling better coordination of rescue missions and more accurate forecasts for the spread of toxic clouds. Situations like these were the subject of the AirShield research project funded by the German Federal Ministry of Education and Research. IR Arrays and pyroelectric detectors by LASER COMPONENTS have already proved their worth in static applications and could well become part of these emergency drones in the near future.

One thing is clear: whatever the future might bring – drones will play an important part in it.

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LiDAR Systems for Obstacle Detection

For autonomous flight, UAVs must be able to independently detect obstacles and avoid them. Monitoring surroundings with LiDAR systems has many advantages: not only are they inexpensive, but they can also measure distances of up to several hundred meters.

The principle of optical ToF (Time of Flight) measurement can be explained easily: a pulsed laser diode (PLD) sends a single short light pulse which, ideally propagates undisturbed along the shortest path through the air until it meets an obstacle. At the obstacle, light is reflected and the pulse is returned to be detected by an avalanche photodiode (APD). The electronics connecting both elements measure the time Δt between sending and receiving the returned light pulse. Because the propagation speed of light is already known, the distance d of an obstacle can be easily calculated from measured time.

When used in drones, the optical impulse must be as short as possible so that the UAV may react to objects that suddenly appear in close proximity. Meanwhile, engineers have developed PLDs with pulses of only a few nanoseconds. It goes without saying that electronics and software must also be able to operate these short pulses.

Calculation example

Imagine a light pulse that is detected at $\Delta t = 500$ ns. The obstacle has a distance of d, the measured time refers to the two-way (back and forth) path of light (i.e., $2*d$).

You can calculate the distance in your head if you allow for the following approximate values:
- Light speed $c = 300{,}000{,}000$ m/s $= 3*10^8$ m/s (actually: 299,792,458 m/s)
- Refractive index $n = 1$ (in air actually 1.000292)

The following equation applies:
- $\Delta t = 2*d*n/c = 500$ ns $= 5*10^{-7}$ s
- $d = 0.5*(c*\Delta t)/n$

The distance can be calculated as:
- $d = 0.5*(3*10^8$ m/s$*5*10^{-7}$ s$)/1$
- $d = 0.5*3*5*10^1$ m
- $d = 75$ m

It is impressive to realize just how small the intervals are that are required for measurements at short distances. For shorter distances still, these intervals extend into the picosecond range (one trillionth of a second).