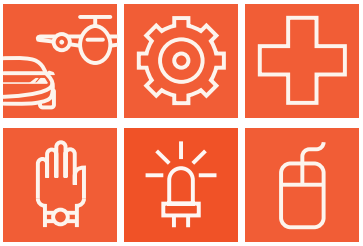
Vertical measurement methods using direct time-of-flight (dToF) sensors

Application Note

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Vertical measurement methods using direct time-of-flight (dToF) sensors

Application Note No. AN001102



Valid for:
TMF8X0X, TMF882X

Abstract

This application note explains the principles, methods, and considerations of using Time-of-Flight (ToF) sensors in measuring vertical targets. Time-of-Flight (ToF) sensors are optical distance measuring devices which measure the time it takes for light from an emitter source to reach a subject and reflect back. This note relates to vertical measurement approaches such as height measurement, clip detection, liquid level detection or positioning objects, where accurate vertical distances are desired.

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1 Introduction

Time-of-Flight (ToF) sensors are used to determine distances, and are applicable to numerous applications including robotics, automation, automotive, and consumer. The function of measuring the vertical distance could be a useful function in many application scenarios, such as indoor navigation, liquid level measurement and object detection. Based on the accuracy, speed and non-contact quality, ToF sensors are highly qualified for such applications.

A vertical measurement setup requires accurate measurements to be captured along the Z-axis, often in complex and constrained environments. Therefore, for optimal system design, it is important to understand how ToF sensors work in such configurations.

Table 1: Target applications

Target applications (Non-exclusive)		Functionality	Comments
	Home and service robots	Floor / stair / cliff detection	Accurate on dark/bright floor, fast response
	Consumer drones	Altitude hold / landing assist	Stable hover; reliable on any surface
	Smart appliances	Liquid level sensing	Works with glossy, transparent, plastic or metal
	Logistics / warehousing	Height sensing	Safety for users
	Smart home	Human distance to device	No false triggers - accurate in ambient light

1.1 Ordering information

Ordering code	Description
Q65113A9062	TMF8806-1AM 500 pcs reel
Q65113A8036	TMF8806-1A 5000 pcs reel

2 Approach description

dToF sensors can be integrated into systems to perform accurate vertical measurements in different ways. Below are several methods that can be implemented depending on the application requirements:

- **Fixed position measurement**
  - **Setup:** The dToF sensor is mounted at a fixed height above the ground or reference surface.
  - **Application:** Ideal for applications like level measurement in tanks, height monitoring in warehouses, and obstacle detection in robotics.
  - **Advantages:** Simple setup, continuous monitoring, and high accuracy.
- **Dynamic position measurement**
  - **Setup:** The dToF sensor is mounted on a moving platform, such as a drone or robotic arm.
  - **Application:** Suitable for mapping terrain, inspecting infrastructure, and monitoring crop heights in agriculture.
  - **Advantages:** Flexibility in measurement, ability to cover large areas, and adaptability to various environments.
- **Multi-zone system**
  - **Setup:** Multiple dToF sensors are arranged in an array to cover a larger vertical area.
  - **Application:** Used in applications requiring detailed 3D mapping, such as autonomous vehicles and advanced robotics.
  - **Advantages:** Enhanced coverage, improved resolution, and detecting blind spots.

3 Considerations for vertical measurement with TMF8X0X/TMF882X sensors

3.1 Sensor alignment and mounting

Proper sensor orientation ensures accurate vertical measurements. Misalignment can lead to miss detection, especially when measuring distances at angles other than directly up or down.

3.2 Measurement range, environment and accuracy

Depending on application-range, environment and accuracy, choose the proper device from our portfolio such as:

- Long range: TMF8806 (10m mode)
- High accuracy in short range: TMF882X (short range mode)
- High ambient light environment (outdoor): TMF8801 (single zone) and TMF882X (multi zone)
- Multizone application:TMF882X
- Touch detection with dark surfaces: TMF8701 (0 cm – 60 cm)

3.3 Environmental factors

Ambient light can influence the detecting performance. A high ambient light especially with a IR amount is increasing the optical noise and leads to a reduced maximum detectable distance. Temperature influences are compensated by internal on-chip algorithm.

In the following measurement with **TMF8806** three different targets (grey target with 20% reflectance, white target with 90% reflectance and black target with 5% reflectance) with two different ambient light scenarios (office light with no IR amount and 830 LUX halogen light).

The 2.5m mode was used for best accuracy.

Figure 1: Measured distance vs. set distance grey card office light

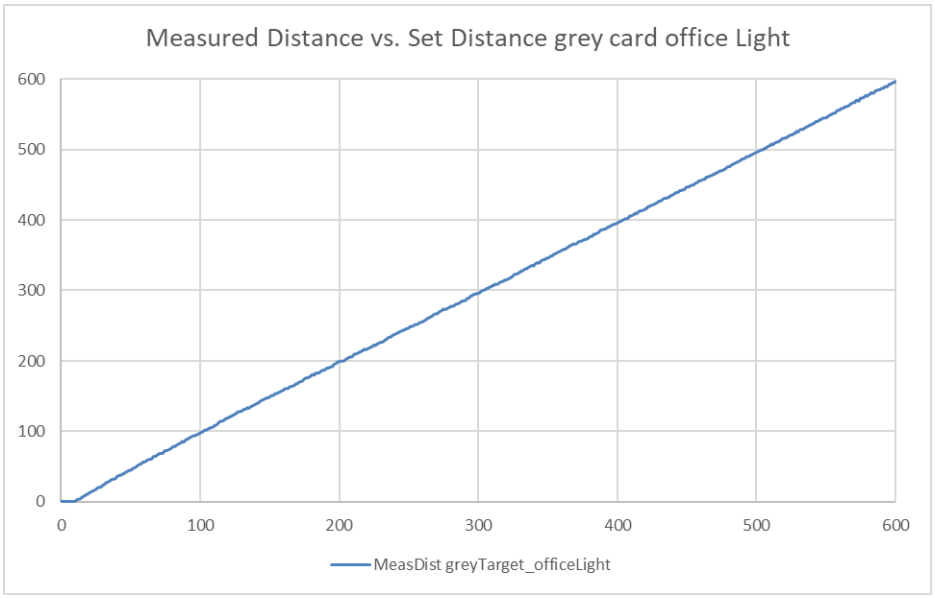


Figure 2: Error in [mm] vs. set distance grey card office light

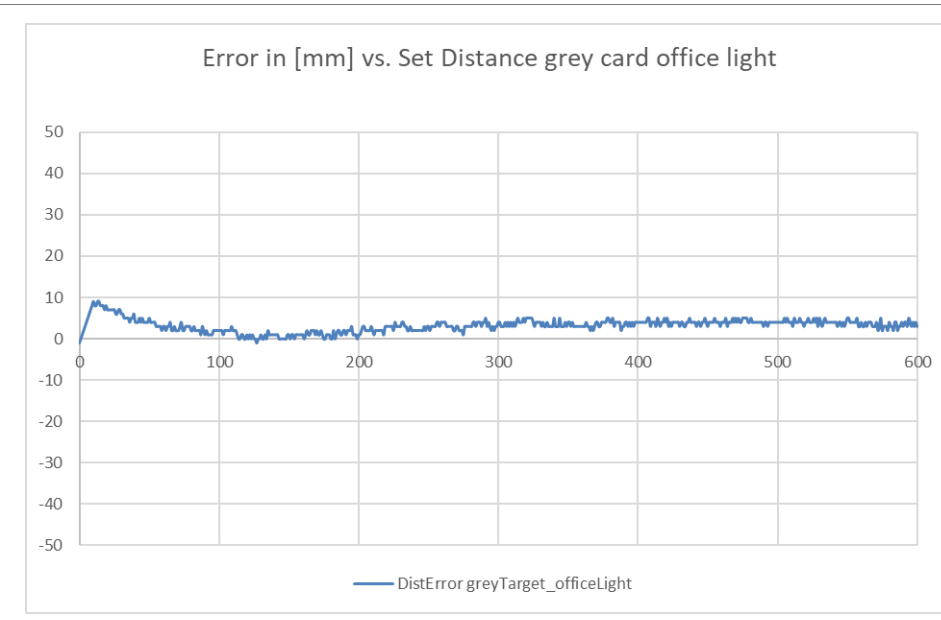


Figure 3: Measured distance vs. set distance grey card 830 Lux halogen

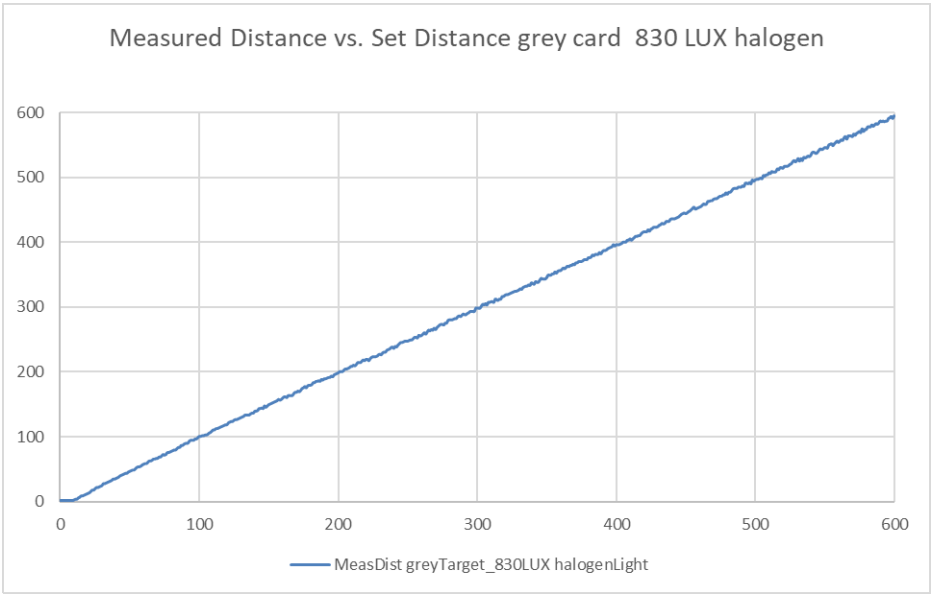


Figure 4: Error in [mm] vs. set distance grey card 830 Lux halogen

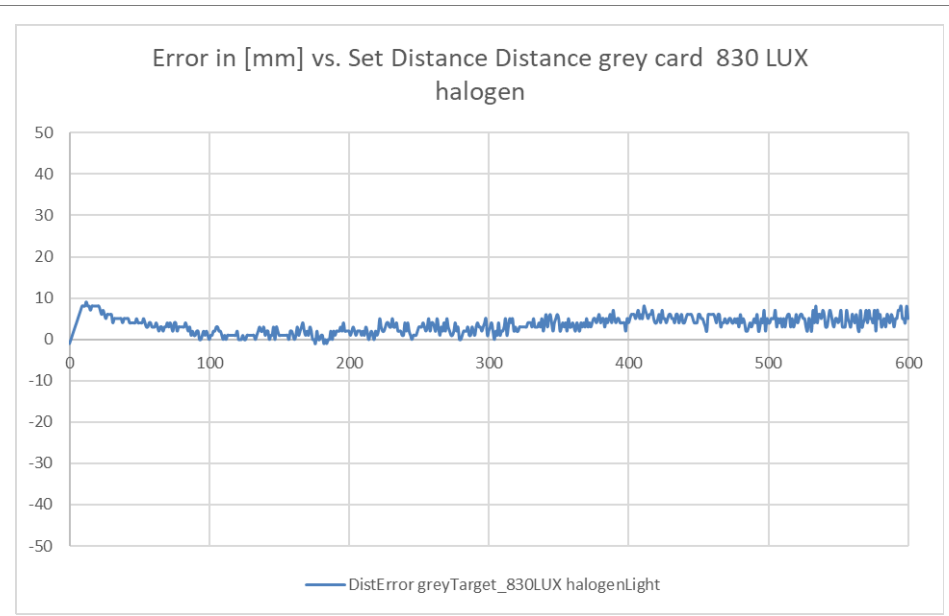


Figure 5: Measure distance vs. set distance black card office light

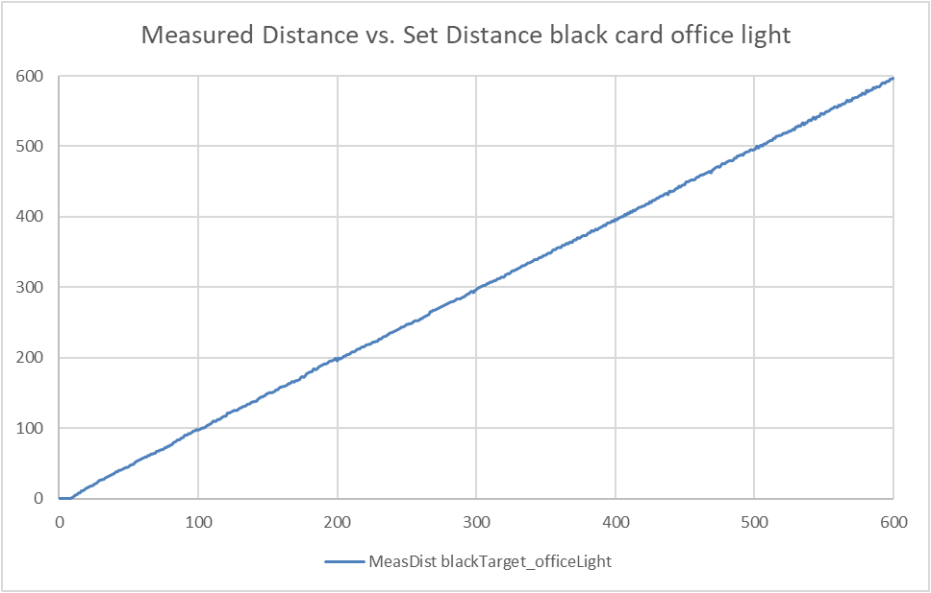


Figure 6: Error in [mm] vs. set distance black card office light

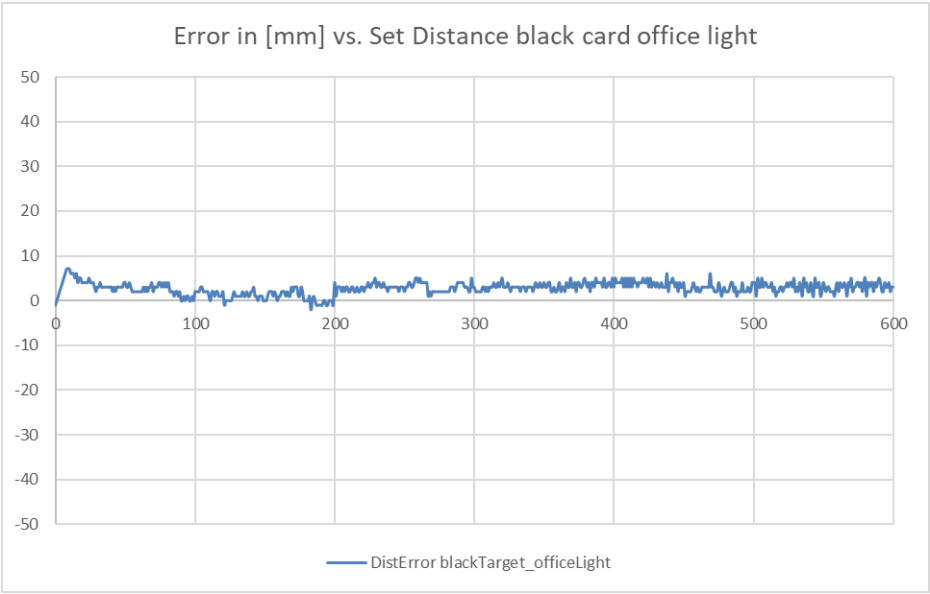


Figure 7: Measured distance vs. set distance black card 830 Lux halogen

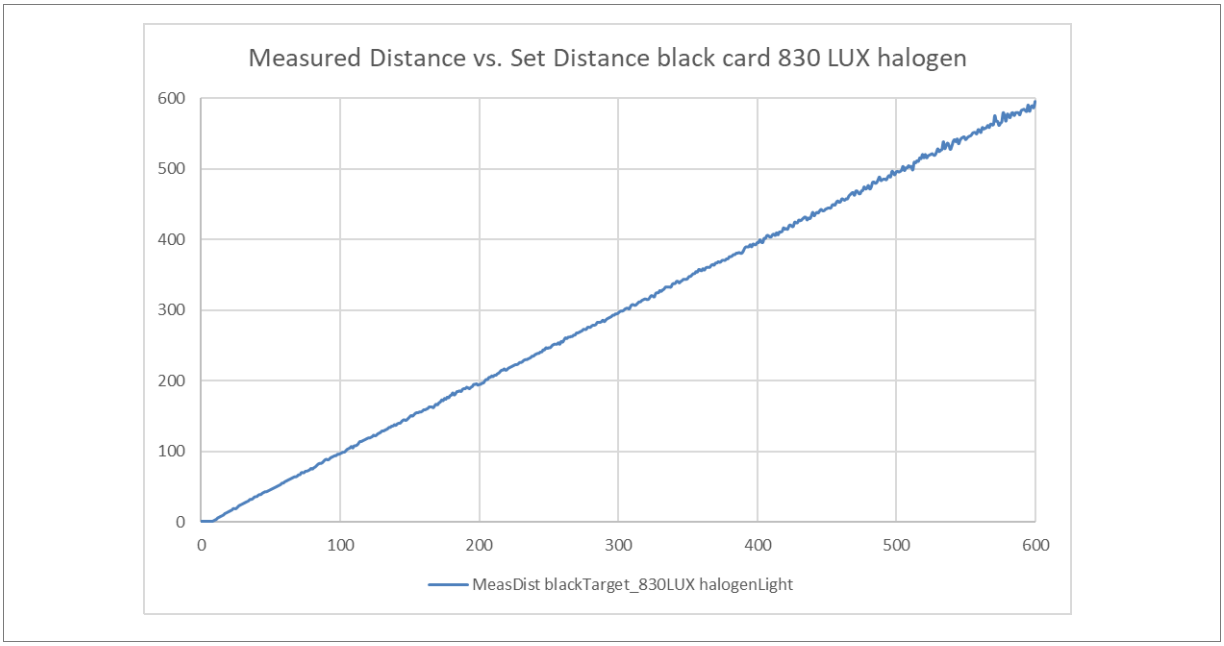


Figure 8: Error in [mm] vs. set distance black card 830 Lux halogen

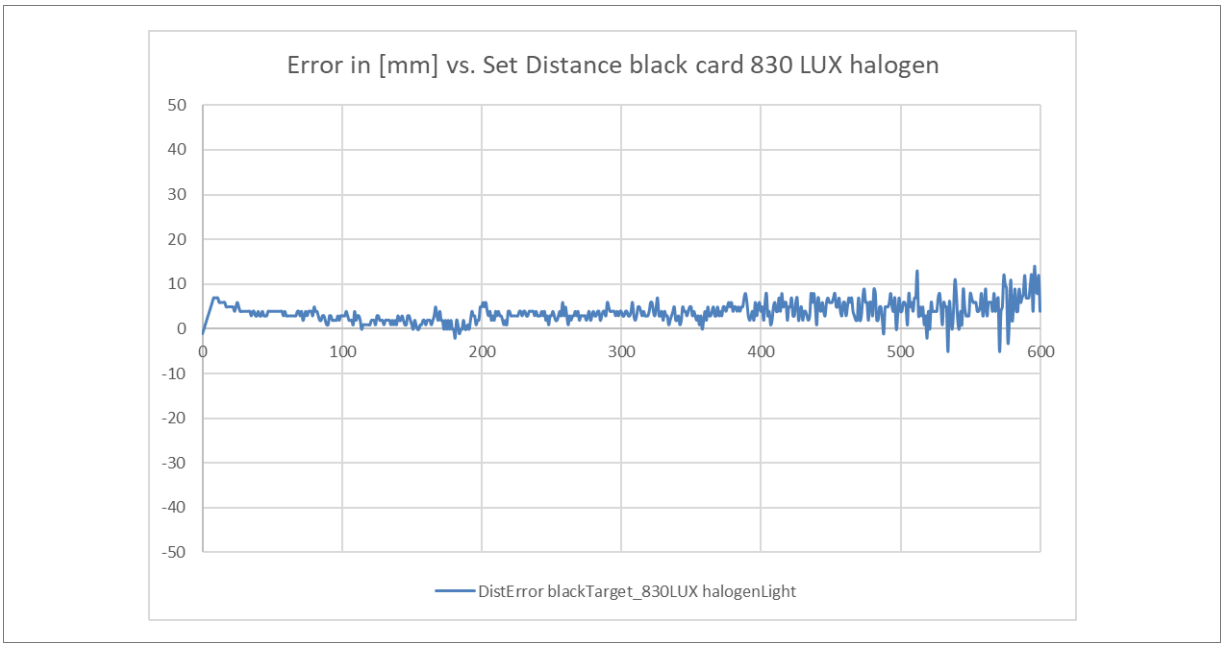


Figure 9: Measured distance vs. set distance white card office light

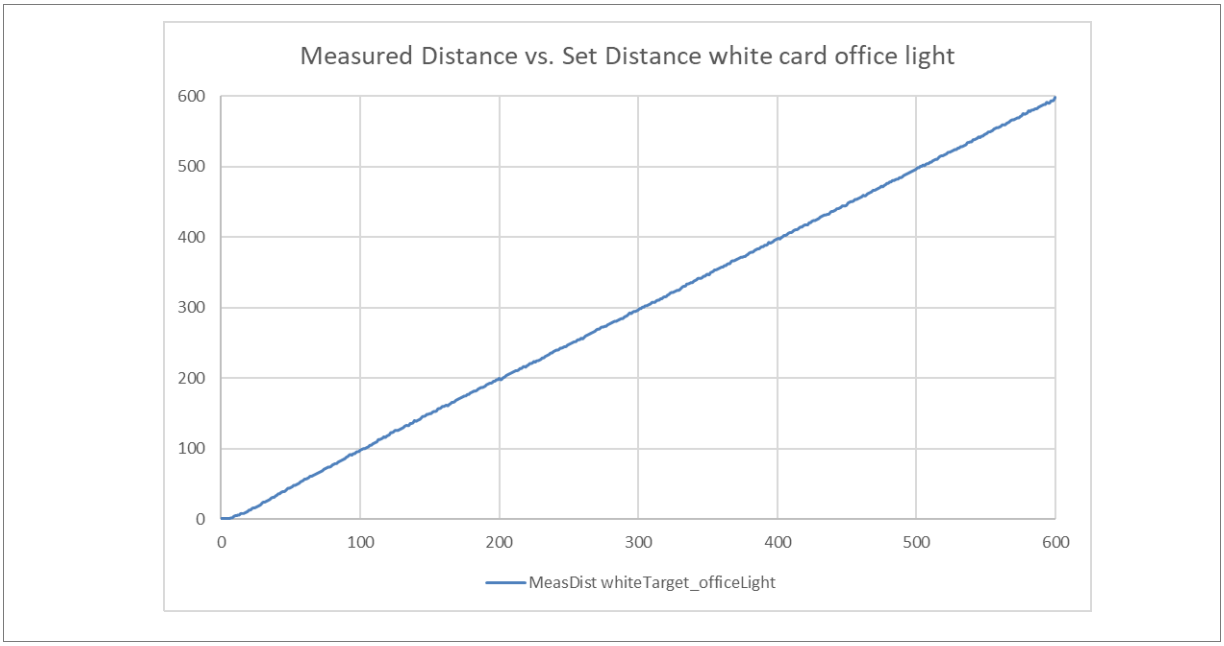


Figure 10: Error in [mm] vs. set distance white card office light

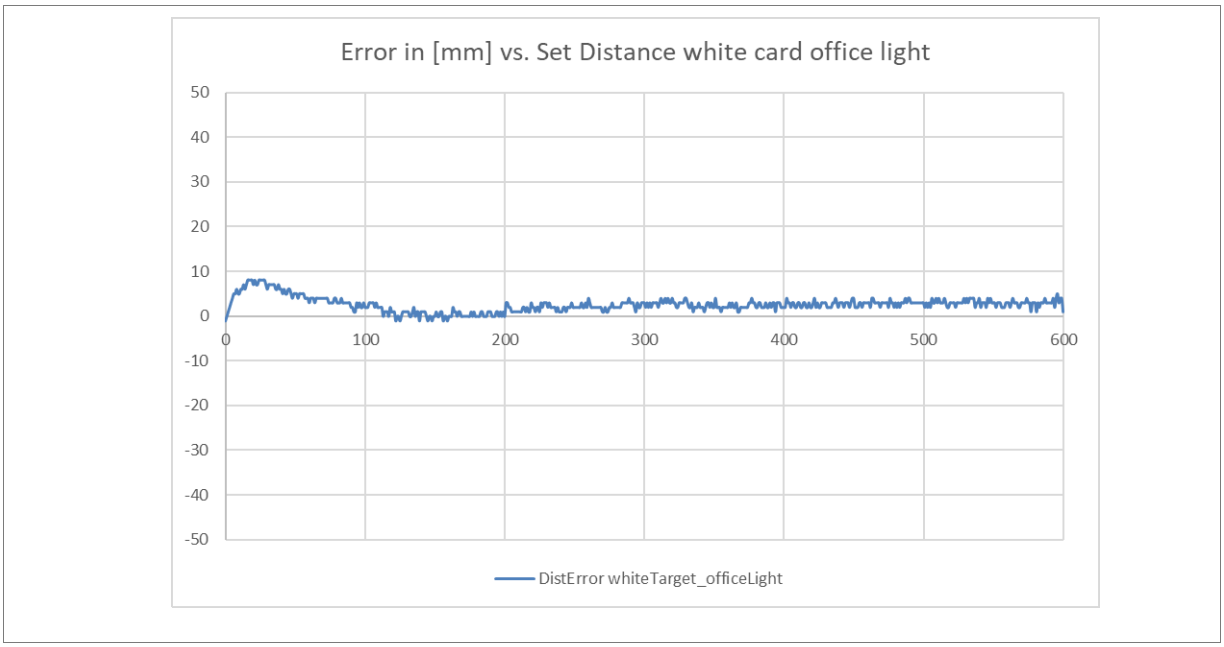


Figure 11: Measured distance vs. set distance white card 830 Lux halogen

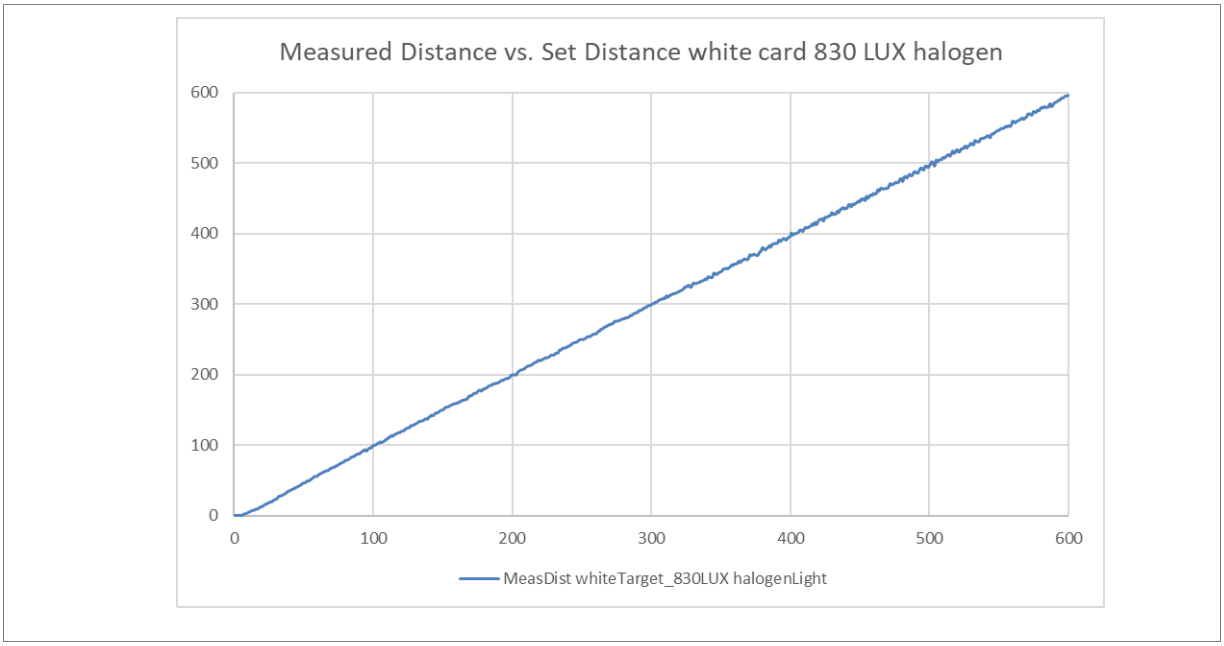
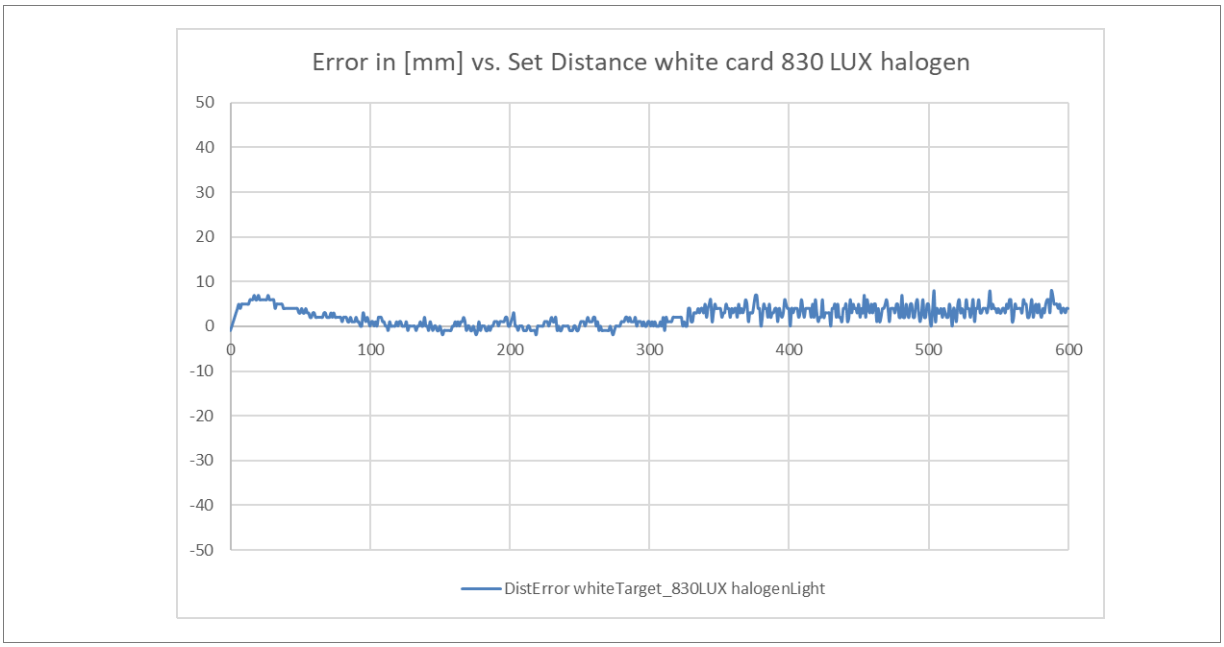


Figure 12: Error in [mm] vs. set distance white card 830 Lux halogen



3.4 Target material and surface

Reflectivity of the target material influences measurement performance. High reflective surfaces, such as mirrors or shiny surfaces, can lead to multiple reflections and unpredictable results. Low-reflective(e.g. dark black targets...) are less detectable in distance.

Figure 13: Grey marble stone



Figure 14: Measured distance vs. set distance marble

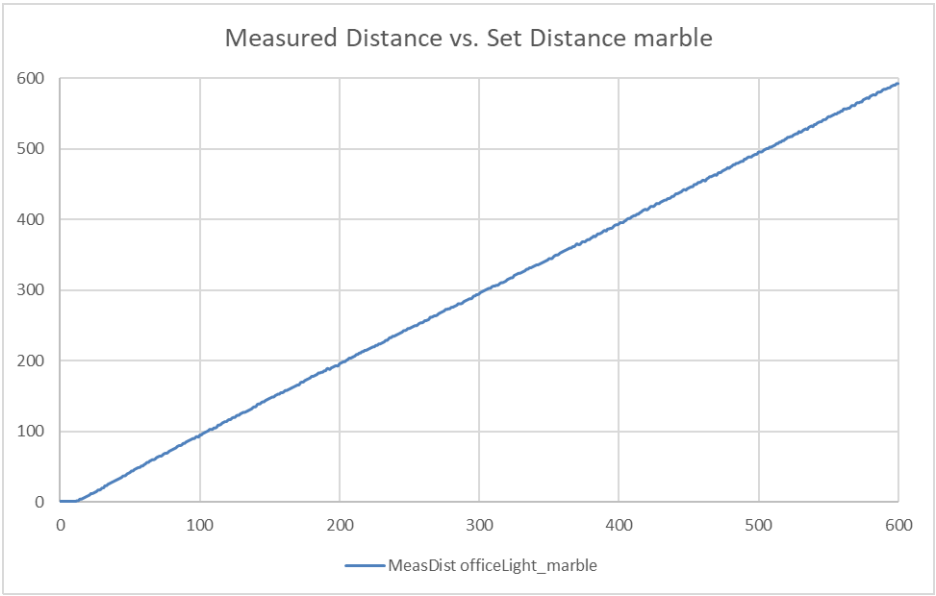


Figure 15: Error in [mm] vs. set distance marble

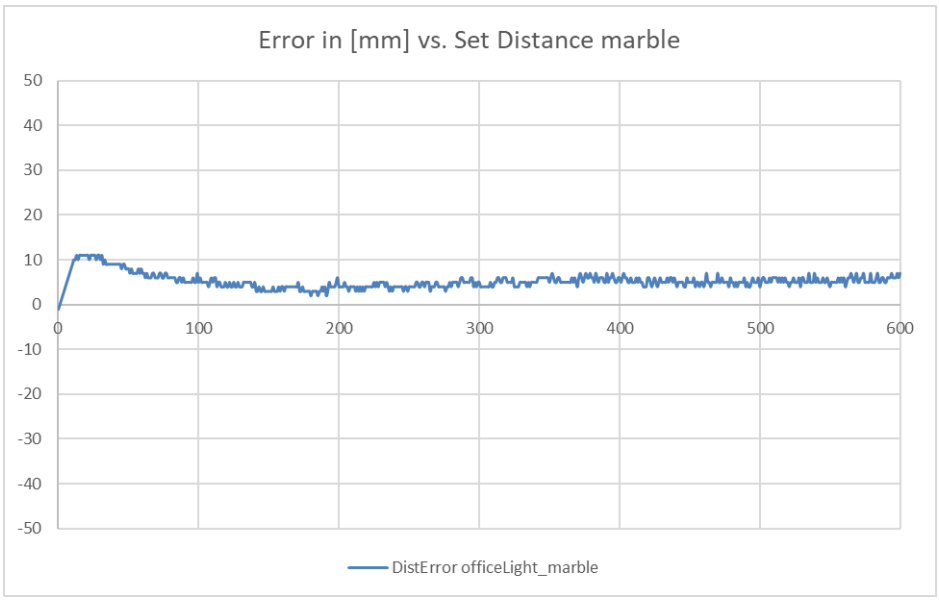


Figure 16: Wood panel



Figure 17: Measured distance vs. set distance wood

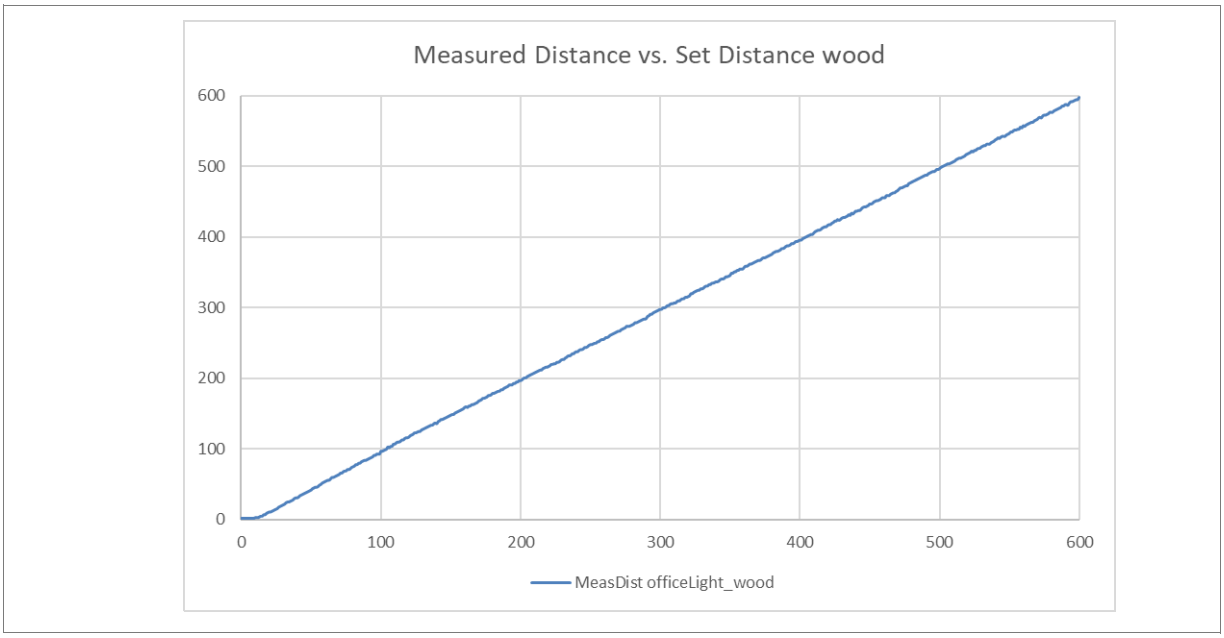


Figure 18: Error in [mm] vs. set distance wood

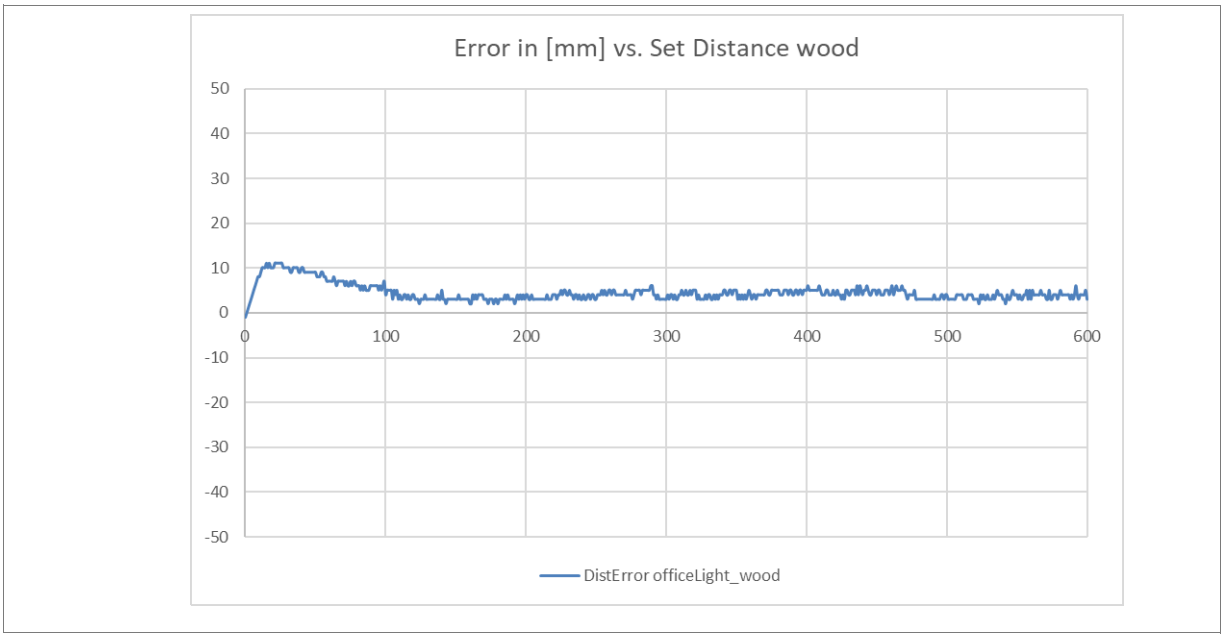


Figure 19: Mirror

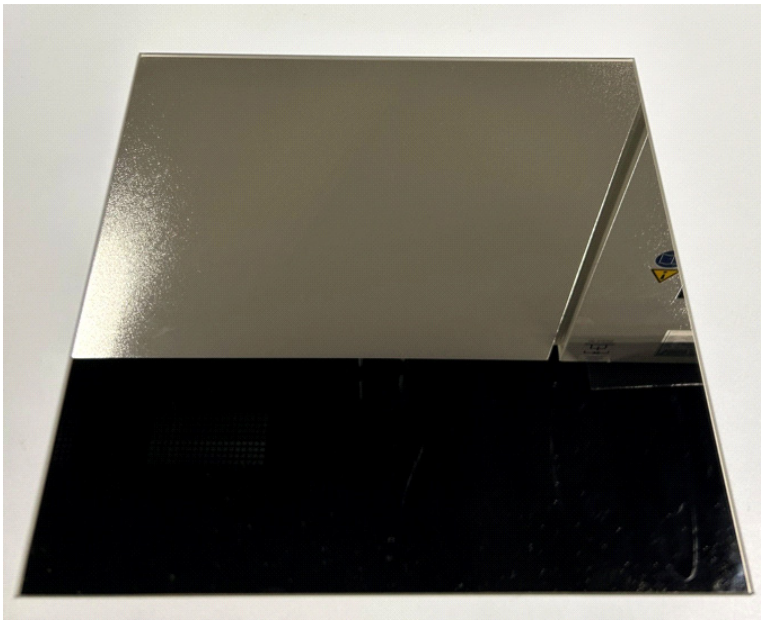


Figure 20: Measured distance vs. set distance mirror



Figure 21: Error in [mm] vs. set distance mirror

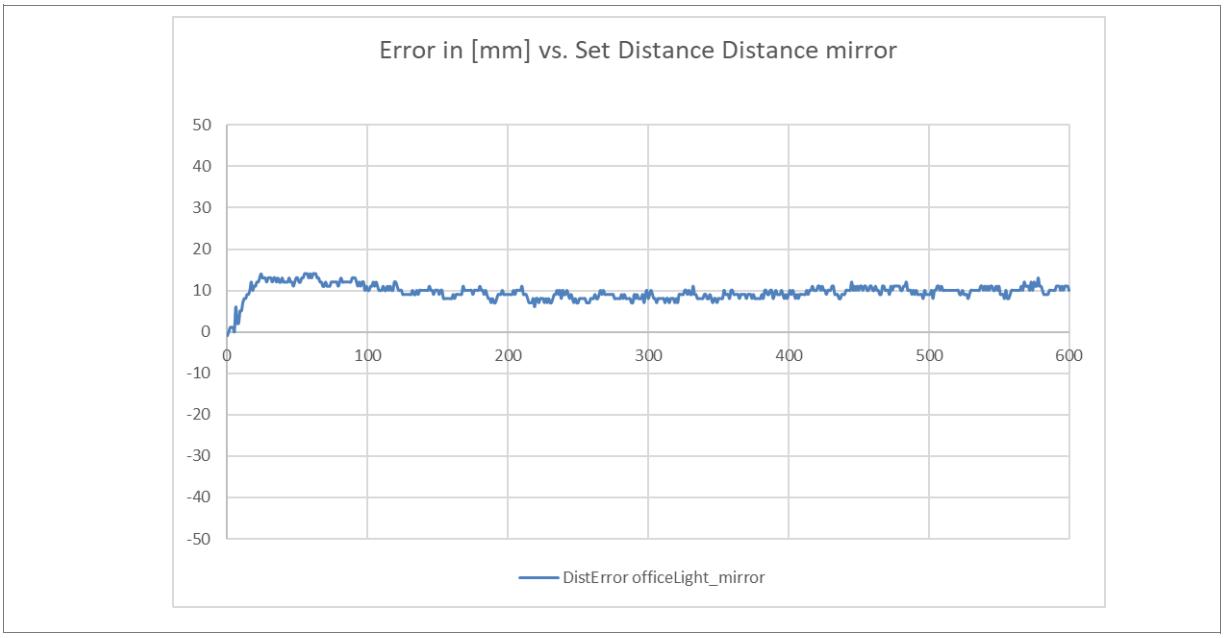


Figure 22: Glass



Figure 23: Measured distance vs. set distance glass

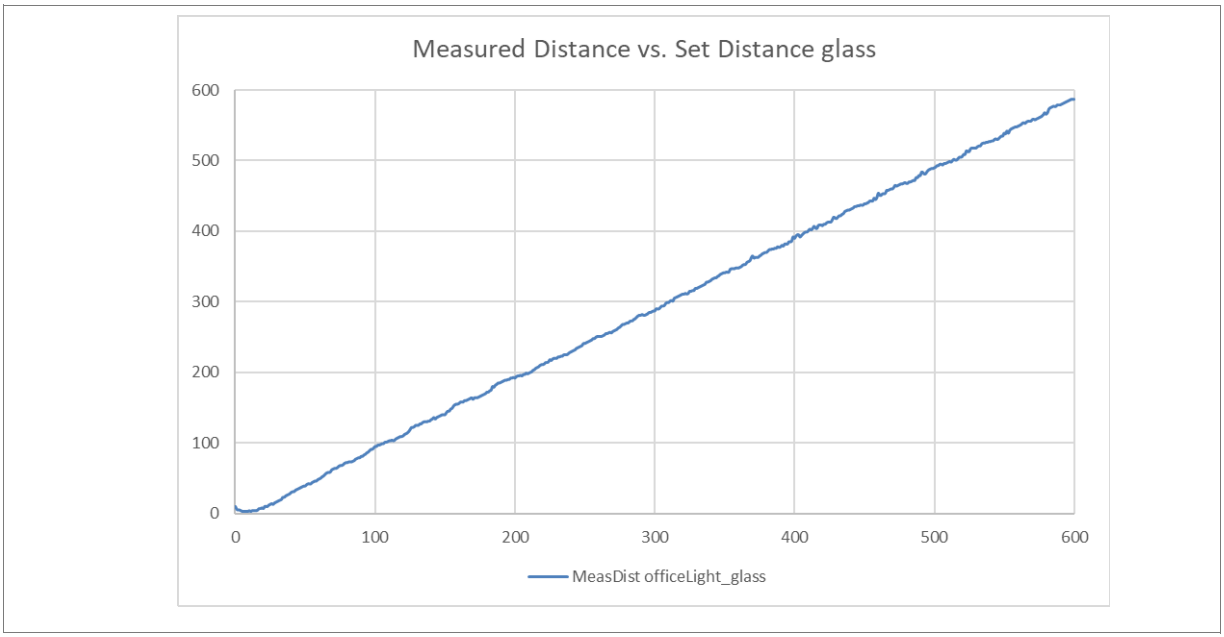


Figure 24: Error in [mm] vs. set distance glass

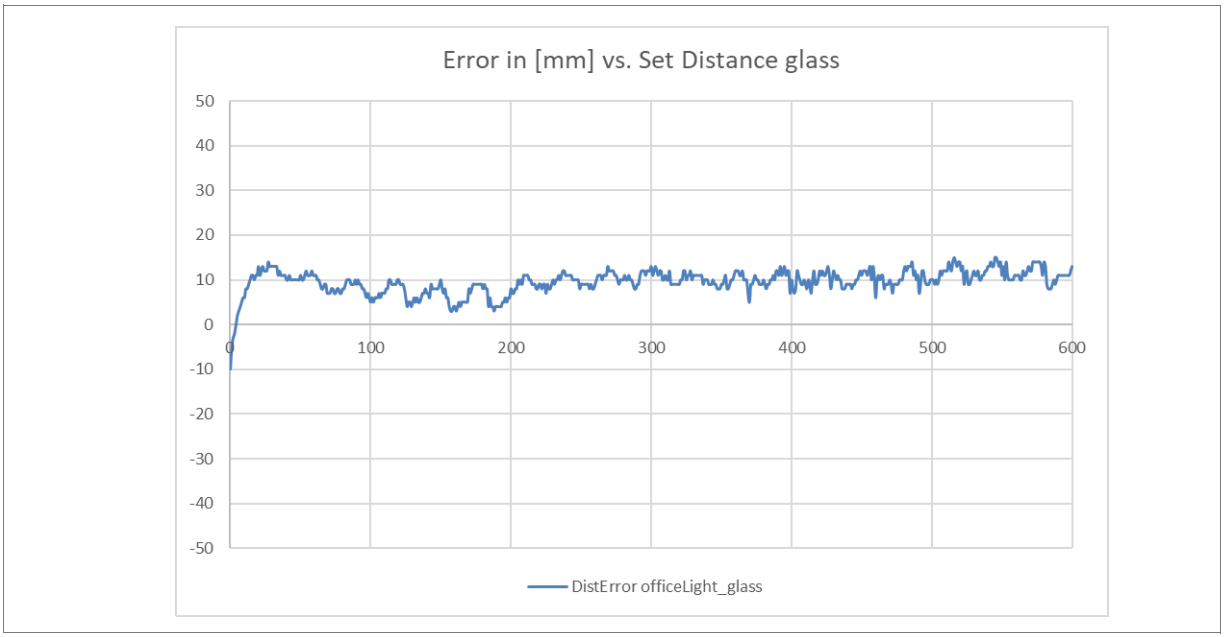


Figure 25: Water-level measurement

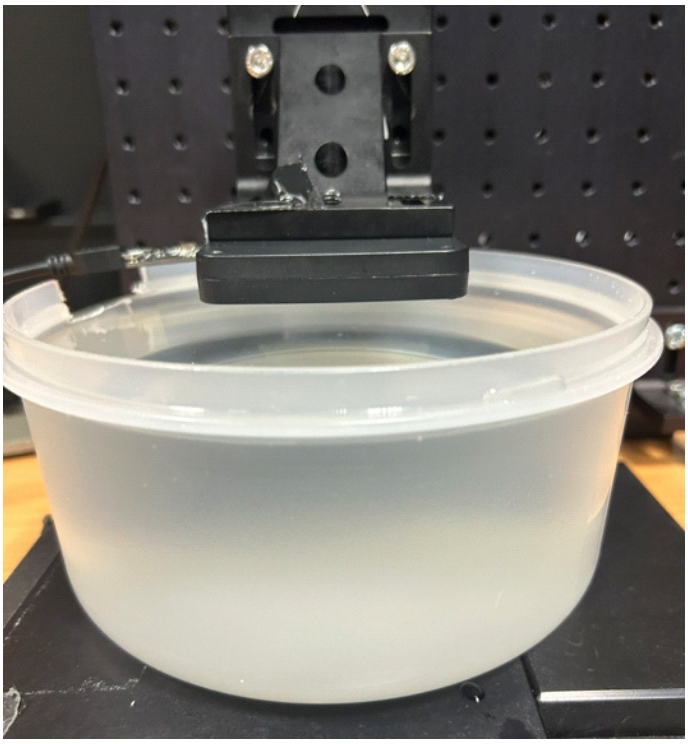


Figure 26: Measured distance vs. set distance water_DT=4

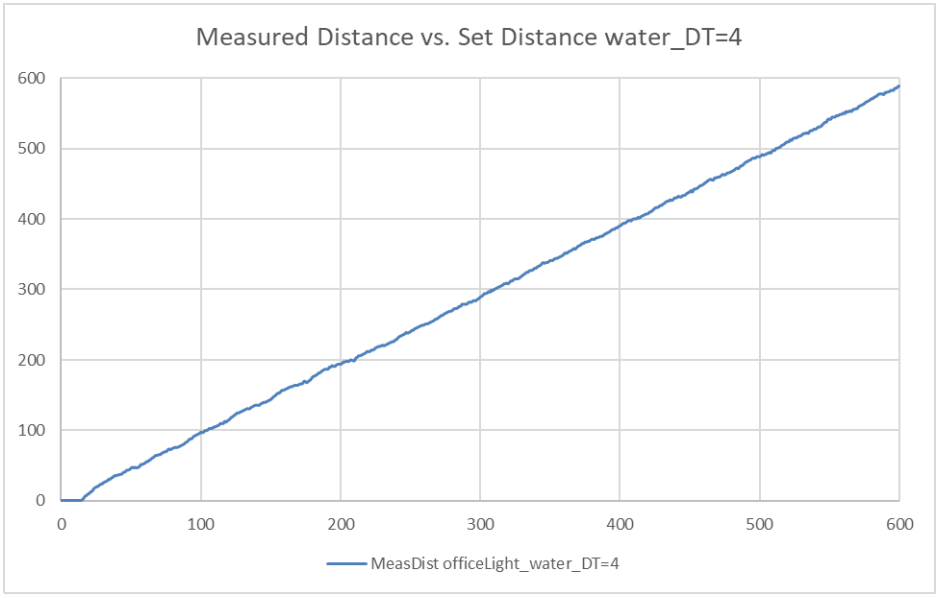
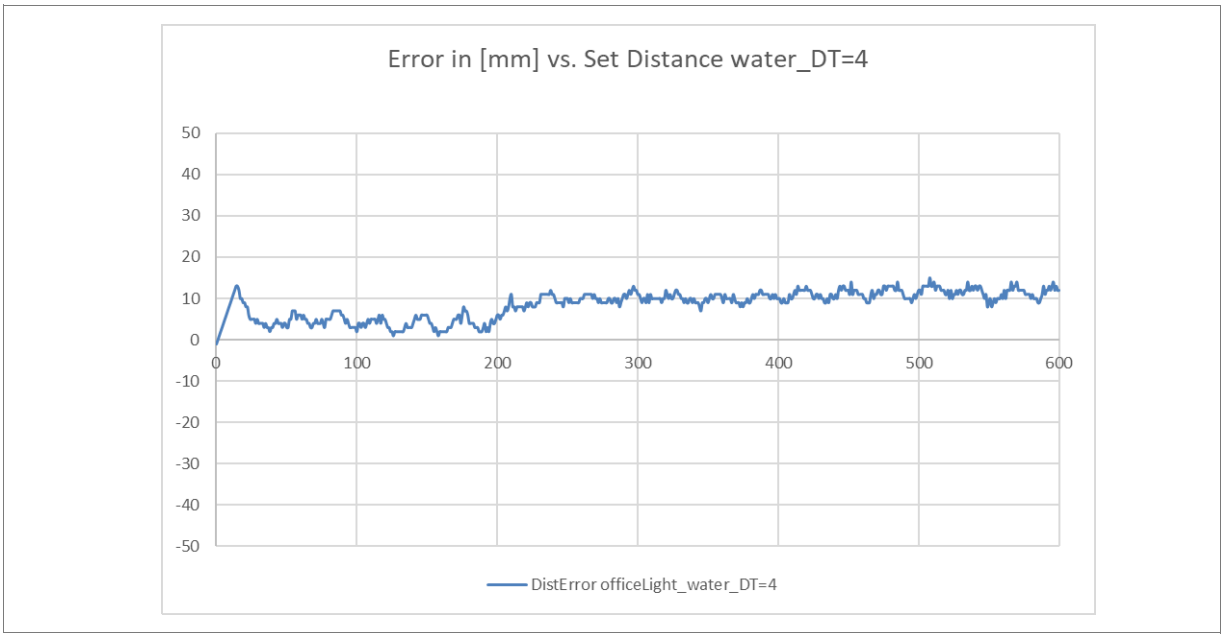


Figure 27: Error in [mm] vs. set distance water_DT=4



For measuring water levels, it is recommended to use a higher dead time to get better performance (i.e., less distance failures). A value of 4 was used for the dead time parameter in this measurement. The other target cases used a value of 0 for the dead time.

Dead time is a critical parameter in single photon avalanche diodes (SPADs). It describes the time after a photon detection event when the SPAD is unable to detect another photon.

4 Revision information

Changes to current revision v1-00	Page
Initial production version	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

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