DT0156
Design tip

Guidelines for the integration of a far-infrared (FIR) sensor optical lens and cover window based on the STHS34PF80

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Main components	
Reference documentation	
DS13916	Low-power, high-sensitivity infrared (IR) sensor for presence and motion detection
AN5867	STHS34PF80: low-power, high-sensitivity infrared (IR) sensor for presence and motion detection
AN5983	Hardware implementation guidelines for the STHS34PF80 infrared sensor
ST sensor	
STHS34PF80	Low-power, high-sensitivity infrared (IR) sensor for presence and motion detection
Fresnel Factory lens	
TMOS63-10	Long-distance, narrow FoV lens
TMOS10-12030	Long-distance, wide FoV lens
TMOS00-03	15.1 mm cover cap
TMOS00-04	2.3 mm cover
TMOS00-05	4 mm cover

Purpose and benefits

The purpose of this design tip is to provide essential integration guidelines for an industrial design applicable to the optical lens or cover window used with the STHS34PF80 infrared sensor. The document provides detailed recommendations on optical lens and cover window selection along with design requirements for optimizing the overall system performance.

This design tip was created in collaboration with Fresnel Factory Inc., an ST Authorized Partner.

Description

The STHS34PF80 infrared sensor has been designed to measure the amount of IR radiation emitted from an object within its field of view in the operating wavelengths between 5 µm and 20 µm. The information is digitally processed by the ASIC, which can be programmed to monitor the motion and presence of a person as well as an ambient overtemperature condition.

Thanks to its exceptional sensitivity performance, the STHS34PF80 can detect human presence at a distance up to 4 meters without the need of an optical lens.

However, while the device can work without an additional optical lens, the STHS34PF80 is typically used in conjunction with an optical lens or window covering for several important reasons. The lens or window covering serves the following purposes:

- Provides physical protection against environmental factors such as dust ingress, moisture, and physical damage
- Provides optical control of the module, which can increase or decrease the distance and field of view of the detection coverage area
- Provides flexible aesthetic options with different color matching for seamless product integration and matching overall industrial design

Optical lens requirements, design, and mechanical considerations

Proper integration of optical components is crucial for maximizing the sensor's capabilities. There are several important factors to consider when designing an optical stack for the infrared sensor:

- Properly defining the application requirements and features for developing the lens or cover window in a system
- Choosing high-transmittance material around 5 to 20 µm wavelength
- Choosing stable and UV-resistant materials
- Managing less than ±0.1 mm tolerance in sensor and optical alignment
- Addressing any gaps between the simulation and real product

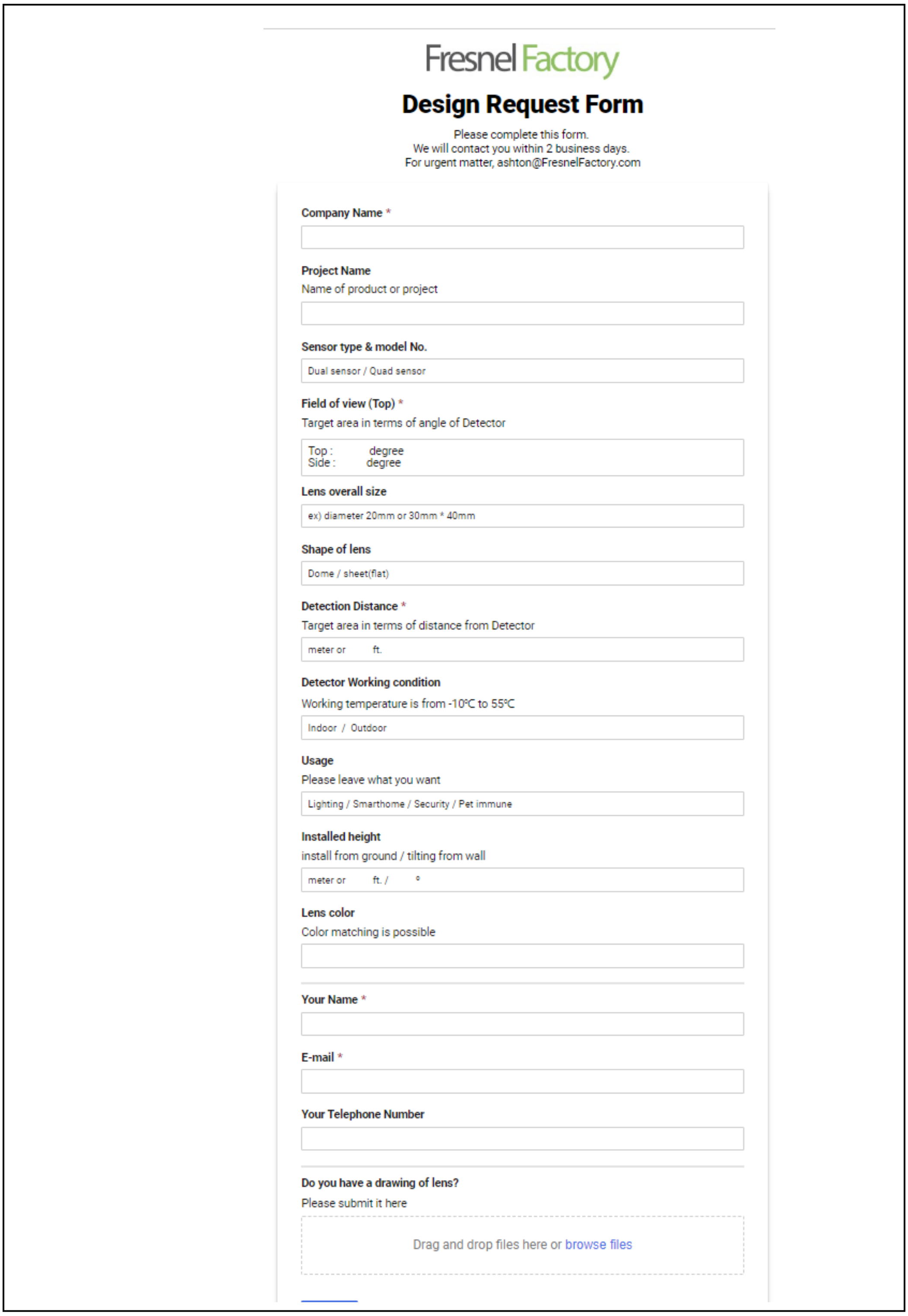
1. Properly defining your application requirements and features for developing a lens or cover window in a system

It is crucial to tailor the optical system to your specific application requirements to achieve optimal performance. There are several factors to consider for designing either a lens or a cover window with the far-infrared sensor (TMOS) as summarized below:

- Device application (for example, UI display, lighting, portable device, and so forth)
- Industrial design
- Operating temperature
- Target features (for example, motion detection, presence detection, pet immunity)
- Sensor mounting orientation / height
- Lens material, mechanical size, shape, and color
- Distance / FoV in horizontal / vertical orientation

As an example, Figure 1 depicts the Fresnel Factory's design request form which captures the information described above.

Figure 1. ST official partner – Fresnel Factory Design Request Form



Fresnel Factory

Design Request Form

Please complete this form.
We will contact you within 2 business days.
For urgent matter, ashton@FresnelFactory.com

Company Name *

Project Name
Name of product or project

Sensor type & model No.
Dual sensor / Quad sensor

Field of view (Top) *
Target area in terms of angle of Detector
Top : degree
Side : degree

Lens overall size
ex) diameter 20mm or 30mm * 40mm

Shape of lens
Dome / sheet(flat)

Detection Distance *
Target area in terms of distance from Detector
meter or ft.

Detector Working condition
Working temperature is from -10°C to 55°C
Indoor / Outdoor

Usage
Please leave what you want
Lighting / Smarthome / Security / Pet immune

Installed height
install from ground / tilting from wall
meter or ft. / °

Lens color
Color matching is possible

Your Name *

E-mail *

Your Telephone Number

Do you have a drawing of lens?
Please submit it here
Drag and drop files here or browse files

From inception, it’s crucial to consider the interplay between the optical and industrial design. Lenses or cover windows typically need exposure on the product's front to cover the intended detection zone. This necessitates careful consideration of the product's overall design.

It's essential to define the key industrial design (ID) aspects before initiating the optical design process. Even if only a preliminary ID draft is available, consulting with an optical designer at this stage is crucial. It ensures optimal integration of optical components while balancing aesthetics and functionality, which in turn minimize design iterations in later development stages.

The size and shape of the lens are determined by various optical performance factors, including required detection distances, intended installation environments, and desired detection angles. These parameters significantly influence the overall product design.

2. Choosing high-transmittance material for 5-20 µm wavelength

System performance is a function of both sensor capabilities and optical stack design. Optimal lens transmittance in the far-infrared (FIR) spectrum is critical.

For example, the typical FIR transmittance rate of a lens composed of material nontransparent in the FIR wavelength is less than 10% at FTIR measurement. While the STHS34PF80 can detect human presence up to 4 meters without an optical stack, the system performance with this example using suboptimal material will achieve less than 10% of the original device sensitivity detectable from the infrared sensor, ultimately causing suboptimal detection performance.

Additionally, thickness of the material and transmittance has a strong correlation, as the lens material typically has higher transmissivity the thinner the material. You want to properly size the thickness in a way that ensures mechanical structure integrity while maintaining high transmissivity in FIR wavelengths.

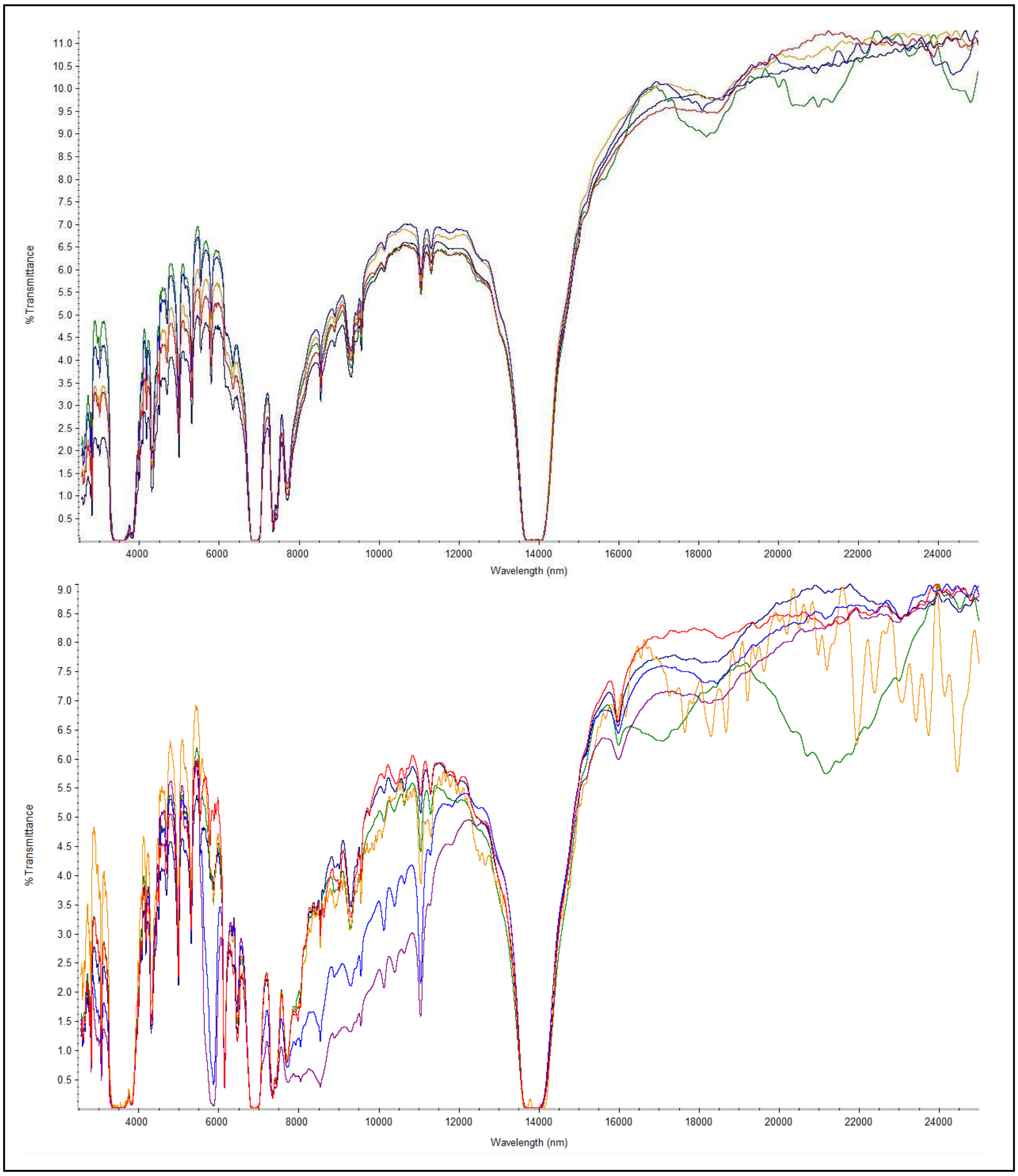
Some recommended materials with relatively high transmittance for 5-20 µm wavelengths include high-density polyethelyne (HDPE), silicon, germanium (Ge), zinc selenide (ZnSe), and chalcogenide glass. For most applications, HDPE-type cover material is suitable from a cost, mechanical, and design perspective.

3. Choosing stable and UV-resistant material

When integrating the STHS34PF80 sensor, optimizing material selection for optical components is crucial to maximize its embedded functionalities. While high transmittance in the 5-20 µm (FIR) range is paramount, it's equally important to consider material stability factors. Developers must evaluate the effects of additives such as pigments, antioxidants, and UV stabilizers on optical properties. Characterization methods such as FTIR spectroscopy and accelerated weathering / UV tests are essential for comprehensive material evaluation. Key performance metrics to monitor include changes in transmittance, refractive index, and mechanical properties over time.

When selecting materials for the HDPE lens or cover, consider pre-compounded options such as SBK150 that integrate necessary stabilizers, but evaluate the trade-offs between optical performance and long-term stability. Implementation should involve establishing baseline optical performance with pure materials, systematically evaluating additive effects on FIR transmittance, optimizing additive concentrations, and validating selections through prototyping and accelerated life testing. This rigorous approach ensures optimal long-term performance of the STHS34PF80 sensor with the optical stack across diverse environmental conditions. The first graphic in the following figure shows minimal reduction in performance with UV treatment on Poly FIR200 material with pigment, while the second graphic shows significant reduction in transmittance with conventional HDPE with pigment.

Figure 2. 5-year UV HALT vs. material transmittance



4. Managing less than ±0.1 mm tolerance in sensor and optical alignment

The STHS34PF80 infrared TMOS sensor is characterized by its highly compact form factor, which necessitates precise tolerance management during lens integration. To ensure optimal performance, it is recommended to maintain a total assembly tolerance of ±0.1 mm or less for the lens stack-up to ensure proper optical focus.

Tolerance analysis is essential for ensuring that your design is robust, guaranteeing manufacturability within specified tolerances and optimizing system performance. This analysis involves modeling the effects of various factors, including post-molded shrinkage for plastic lenses. Based on these results, design adjustments can be made to minimize any negative impacts.

Due to the compact form factor of the infrared TMOS sensing element, along with the higher precision required for enabling true presence detection compared to motion detection on PIR sensors, tighter tolerances are required for the lens and housing. It is generally recommended to keep the tolerance to ±0.1 mm to maintain detector specifications and ensure optimal performance.

As best practices for tolerance management, below are some tangible tips to consider:

- Perform comprehensive tolerance stack-up analysis: Perform a careful analysis of all the components in the optical stack, including the sensor, lens element, spacers, and housing.
- Use advanced modeling tools: Employ optical simulation software to model the effects of tolerance variations on system performance.
- Implement tight manufacturing controls: Work closely with lens and assembly housing contract manufacturers to ensure they can meet required tolerances.
- Consider active alignment techniques: For high-volume production, automated active alignment systems can help achieve and maintain required precision.
- Conduct thorough testing/quality check: Implement rigorous testing procedures to verify that assembled units meet performance specifications across entire tolerance ranges.

5. Addressing any gaps between simulation and real product

Even with highly skilled optical designers and mold injection experts, discrepancies between the predicted and actual performance are common in optical manufacturing. These discrepancies can often exceed as much as 30% in presence / motion detection performances, stemming from various factors:

- Interdisciplinary knowledge gaps: Optical designers may lack in-depth understanding of mold design and injection processes, while mold and injection experts may not fully grasp optical design principles.

- Production variables: Fluctuations in production conditions and the use of different additives can introduce an additional ~5% or more variation in performance.

- Material behavior: Differences between simulated and actual material properties, especially in response to temperature and pressure during the molding process.
- Tolerance stack-up: Cumulative effects of tolerances across multiple components in the optical system.

To minimize these gaps in performance, it is important to conduct thorough testing of the manufactured optical components to assess their actual performance characteristics and compare to simulation results, taking into consideration how optics would be integrated into the final device. Based on this analysis, one should determine whether the manufactured optics and the integrated system meets the original design specifications and performance targets. With this analysis, one can make informed decision on making any adjustments to either software, optical or overall system to achieve desired performance and features.

Cover window design and mechanical considerations

For details on designing cover window hole exposure, optical alignment of sensor package, and additional design guidelines specific to the STHS34PF80 infrared IR sensor, please refer to our application note AN5983: Hardware implementation guidelines for the STHS34PF80 infrared sensor

Optical lens and cover window supplier - Fresnel Factory

Fresnel Factory Inc. is part of ST's partner program and is a leading global company specializing in the design, simulation, and manufacturing of Fresnel optics. They offer customized lens design and manufacturing services tailored to meet your specific technical requirements.

At present, Fresnel Factory utilizes five different methods of Fresnel technology for production, namely hot-press, injection, casting, roll-to-roll, and hot-embossing. Each method offers unique advantages in terms of precision, mass production, faster R&D time, and price.

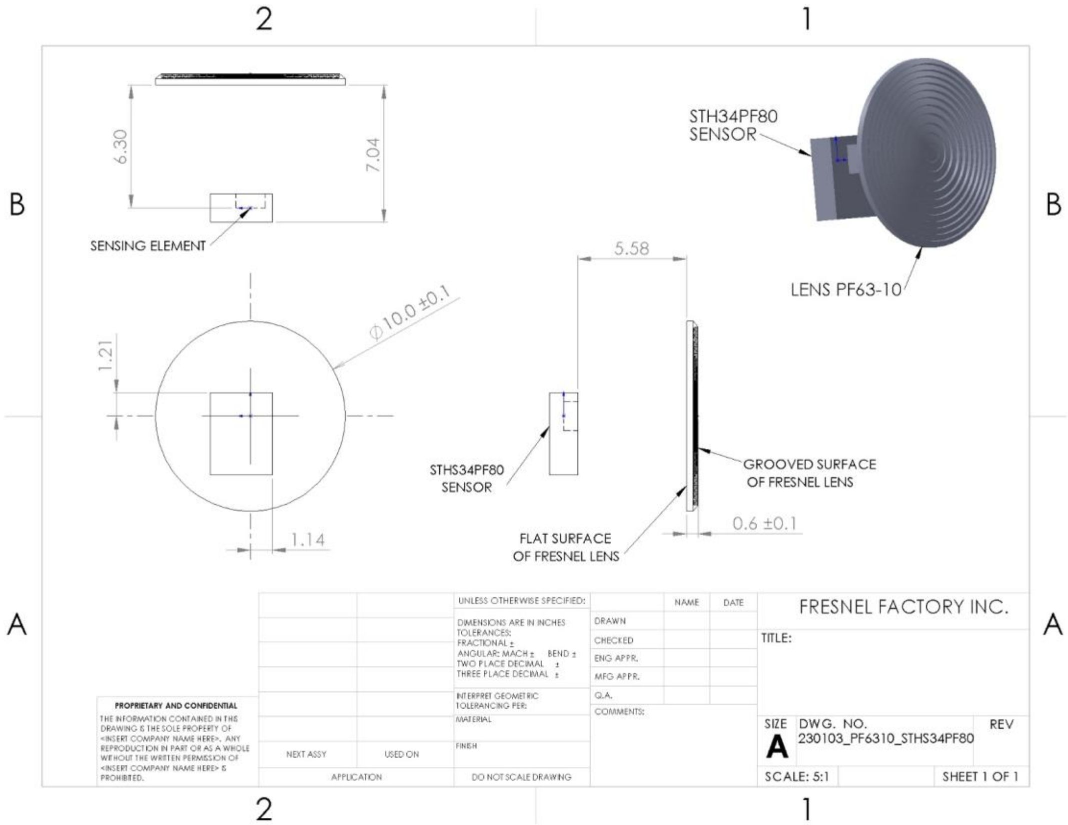
We propose several different custom designed cover and lens to introduce different protective cover options as well as Fresnel lens design for enabling a longer distance of detection and/or wide FoV. Links for each of the reference lens design can be found in the Support material at the end of this design tip.

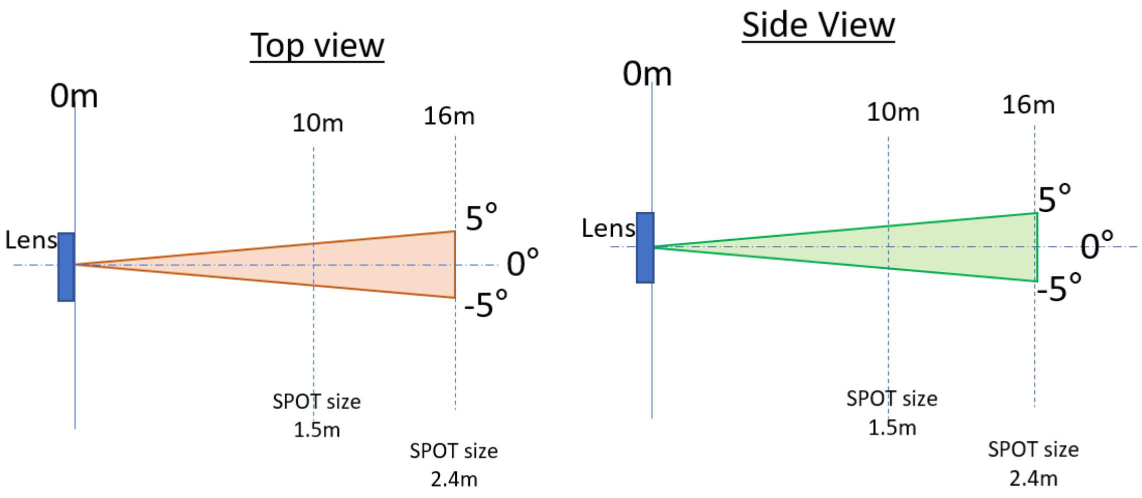
1. TMOS63-10: long distance and narrow FoV lens

With the TMOS63-10 lens, you can achieve long-distance detection with a narrow FoV. Some application use cases include presence and motion detection in narrow hallway detection, people counting, access control, and many more. This lens comes also included in the STHS34PF80 infrared sensor reference evaluation kit called STEVAL-MKI231KA.

The mechanical dimensions as well as FoV/distance of detection of this lens can be found in the following Figure 3.

Figure 3. TMOS63-10 lens datasheet



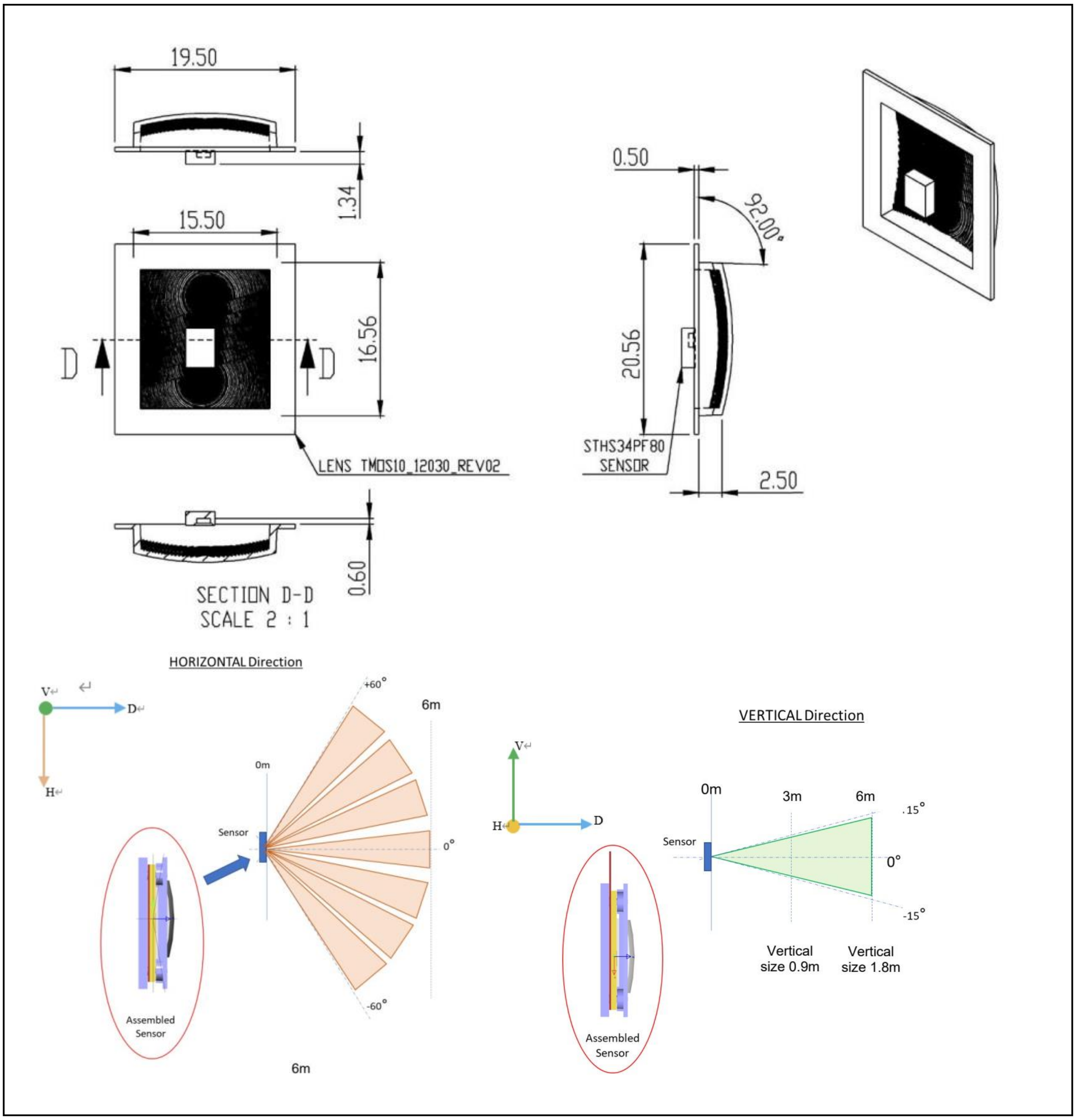


2. TMOS10-12030: wall-mount, wide FoV

Another lens developed specifically for the STHS34PF80 infrared sensor to support wider FoV and longer distance range of detection is the TMOS10-12030 lens. This lens is suitable mainly for wall-mounted applications for presence/movement detection, as it enlarges the horizontal FoV while reducing the vertical FoV compared to the infrared sensor without optical lens while increasing also the distance of detection.

The mechanical dimensions as well as FoV/distance of detection of this lens can be found in Figure 4 below.

Figure 4. TMOS10-12030 lens datasheet

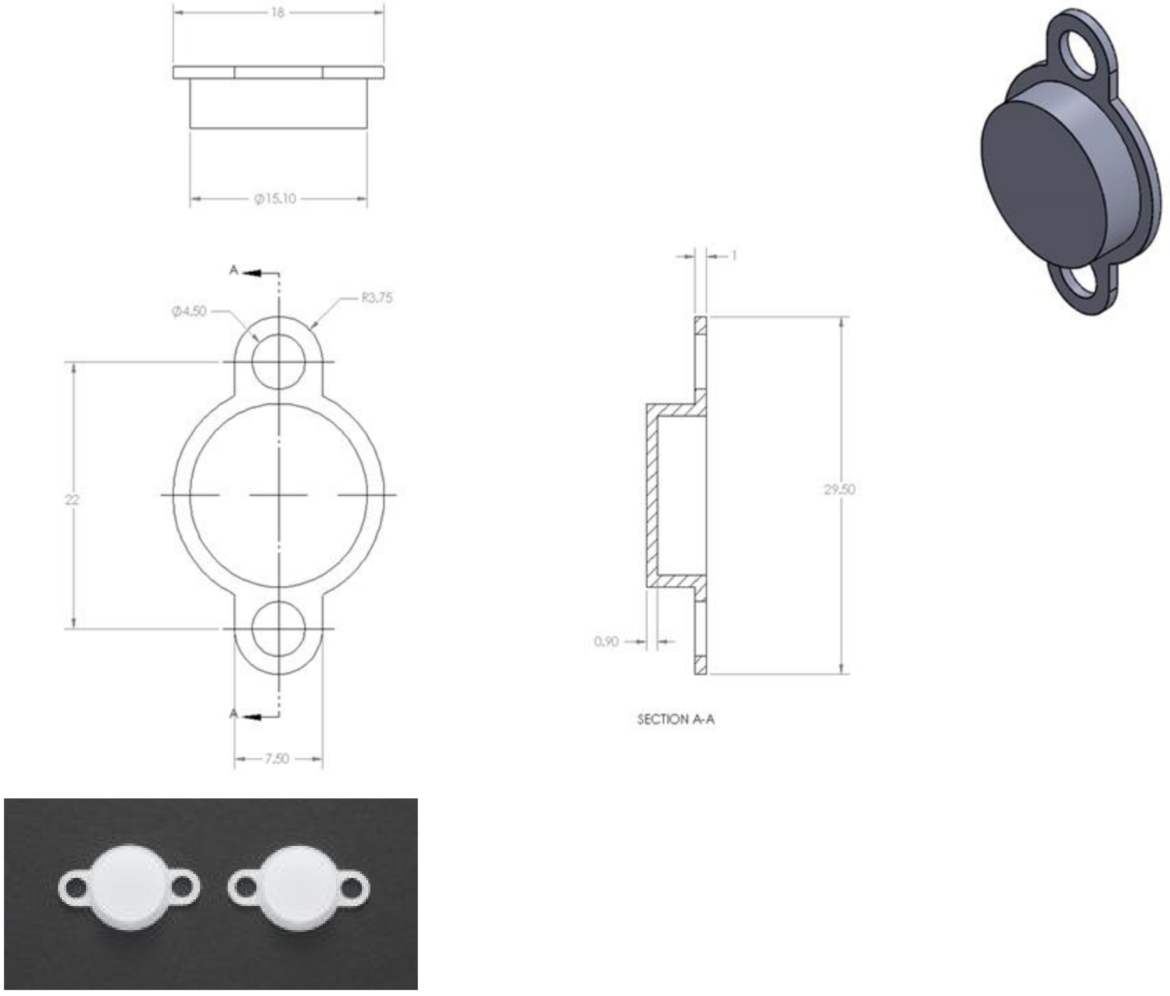


3. TMOS00-03: cover window

TMOS00-03 is a large protection cap mainly used for environmental/dust protection. We would advise to use this example cover for applications requiring a large opening with a thicker cover window, which you can use the mounting holes on the cover to mount directly onto the assembly or the PCB of the infrared sensor.

The mechanical dimensions of this cover can be found in Figure 5 below.

Figure 5. TMOS00-03 datasheet

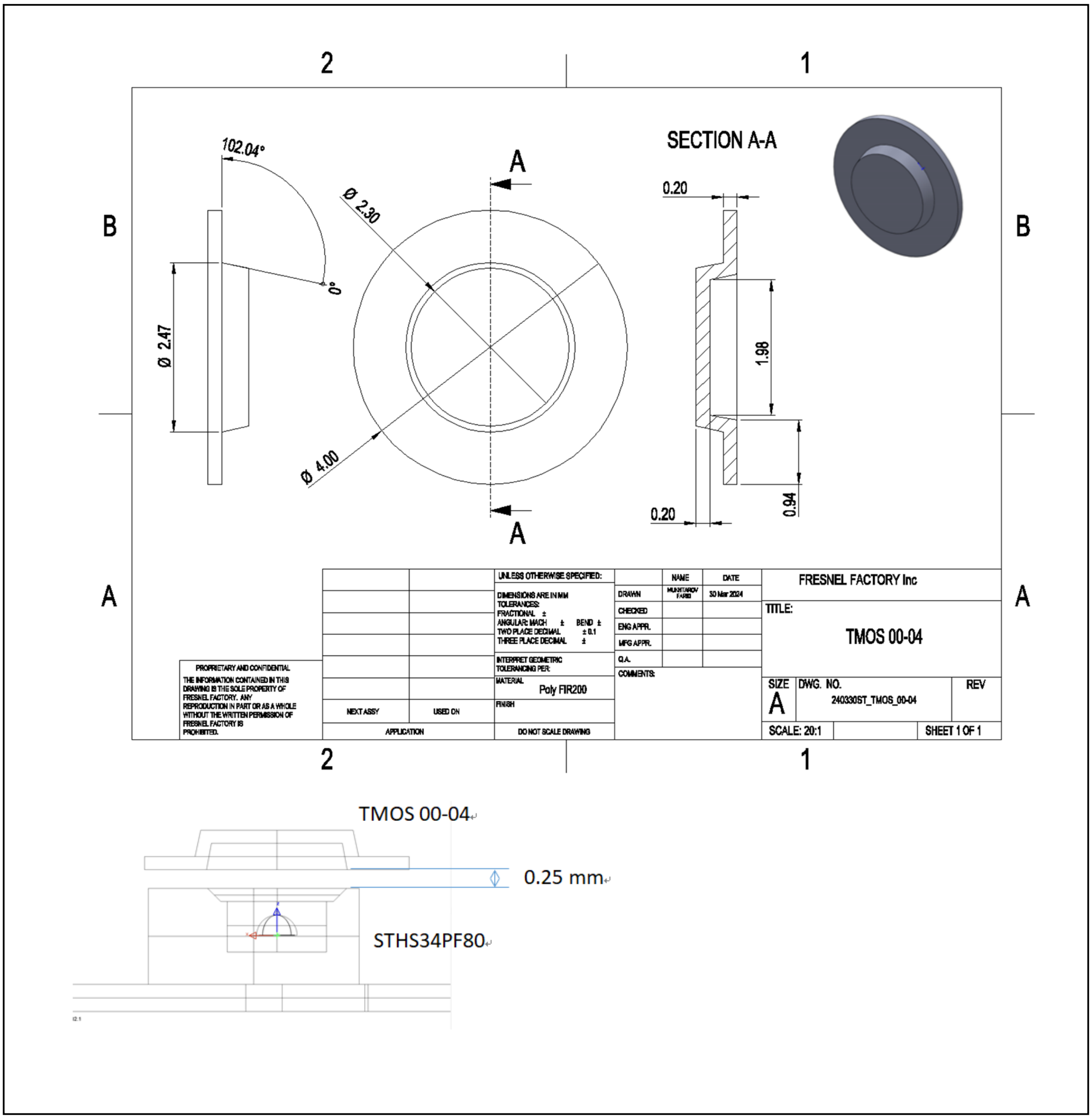


4. TMOS00-04: cover window

TMOS00-04 is a small and compact form factor cover with the opening size of just 2.3 mm. It is highly suitable for applications requiring a tiny opening as well as requiring high transmissivity due to its material and thickness.

The mechanical dimensions of this cover can be found in Figure 6 below.

Figure 6. TMOS00-04 datasheet

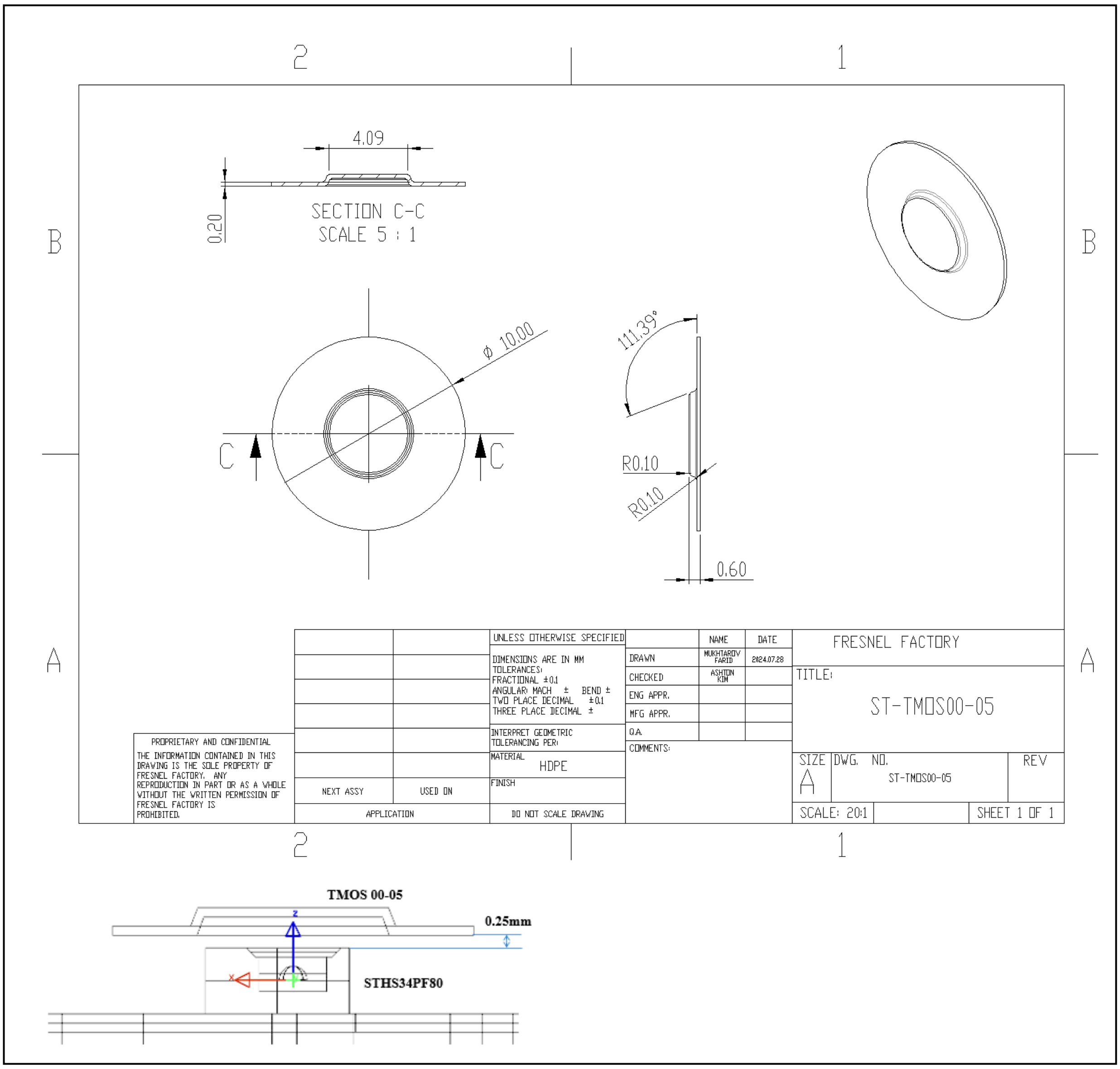


5. TMOS00-05: cover window

TMOS00-05 is slightly larger than the TMOS00-04 cover, but it is still a small and compact form factor cover with an opening size of just 4 mm. It is highly suitable for applications requiring a tiny opening as well as requiring high transmissivity due to its material and thickness.

The mechanical dimensions of this cover can be found in Figure 7 below.

Figure 7. TMOS00-05 datasheet



Support material

Related design support material
Evaluation kit, STEVAL-MKI231KA: STHS34PF80 infrared sensor evaluation kit
Fresnel lens, TMOS63-10: Long-distance and narrow FoV lens
Fresnel lens, TMOS10-12030: Wall-mount, wide FoV Fresnel lens
Cover window, TMOS00-03: Cover window
Cover window, TMOS00-04: Cover window
Cover window, TMOS00-05: Cover window
Documentation
Datasheet, DS13916: Low-power, high sensitivity infrared (IR) sensor for presence and motion detection
Application note, AN5983: Hardware implementation guidelines for the STHS34PF80 infrared sensor
Application note, AN5867, STHS34PF80: low-power, high sensitivity infrared (IR) sensor for presence and motion detection

Revision history

Date	Version	Changes
12-Feb-2025	1	Initial release