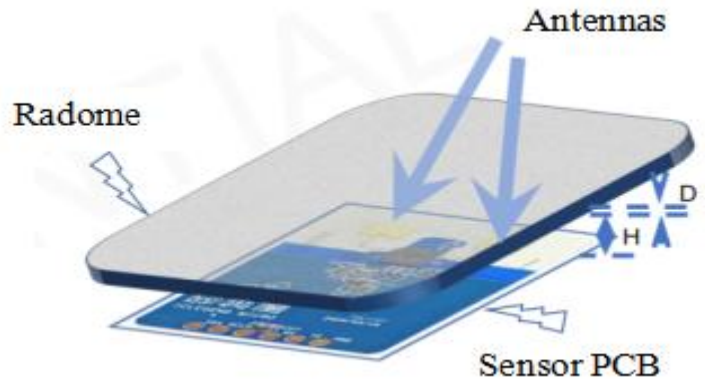
Impact of Radome on HMMD-mmWave-Sensor Performance

- Radar waves reflected at the radome edge
  - ✧ Loss in the total power radiated or received by the radar;
  - ✧ Reflected waves enter the receiving channel, affecting the isolation between the transmitting and receiving channels;
  - ✧ Reflections can degrade the standing wave ratio (SWR) of the antenna, further affecting the antenna gain.
- Radar waves attenuate when passing through a medium; theoretically, the higher the frequency, the greater the attenuation.
- Electromagnetic waves will undergo a certain degree of refraction when passing through a medium.
  - ✧ Affecting the antenna's radiation pattern, thereby impacting the sensor's coverage area.

Design Principle of Radome

- Structure and Appearance
  - ✧ Smooth and flat surface with uniform thickness is recommended. It can be planar or spherical, but should not be uneven;
  - ✧ If there is a surface coating, it must not contain any metal or conductive materials;
  - ✧ Design the radome above the antenna so that its surface remains parallel to the antenna plane.
- The distance from the antenna to the inner surface of the radome, denoted as H.
  - ✧ The ideal height is an integer multiple of the half-wavelength of electromagnetic waves in the air.

$$H = \frac{m}{2} * \frac{c_0}{f}$$



Where m is a positive integer, c0 is the speed of light in vacuum, and f is the working center frequency.

For example, at a center frequency of 24.125 GHz, the half-wavelength in air is about 6.2 mm.

- Thickness d of radome
  - ✧ The ideal thickness is an integer multiple of the half wavelength of electromagnetic wave in the medium.

$$D = \frac{m}{2} * \frac{c_0}{f\sqrt{\epsilon_r}}$$

Where m is a positive integer and ϵ_r is the relative constant of the radome material. For example, for ABS material, ϵ_r = 2.5 and its half wavelength is about 3.92 mm.

Common Materials

- Before designing, it's essential to understand the material and electrical characteristics of the antenna radome.
  - ✧ The table below is for reference only. Please confirm the actual value with the supplier.

Common material characteristics (based on 24.125GHz)

Medium	ϵ_r TYP.	Half wavelength (mm)	1/8 wavelength (mm)	1/10 wavelength (mm)
Air	1.00	6.20	1.55	1.24
ABS1	1.50	5.06	1.27	1.01
ABS2	2.50	3.92	0.98	0.78
PC material	3.00	3.58	0.89	0.72
PMMA acrylic 1	2.00	4.38	1.10	0.88
PMMA acrylic 2	5.00	2.77	0.69	0.55
PVC hard	4.00	3.10	0.78	0.62
PVC soft	8.00	2.19	0.55	0.44
High density PE	2.40	4.00	1.00	0.80
Low density PE	2.30	4.09	1.02	0.82
Quartz glass	5	2.77	0.69	0.55

- Height (H) from antenna to inner surface of radome
  - ✧ When space is allowed, 1 or 1.5 times wavelength is preferred.
  - ✧ For example, 12.4 or 18.6mm is recommended for 24.125GHz.
  - ✧ If space is not allowed, it is recommended to control it at half a wavelength.
  - ✧ If it needs to be controlled within half a wavelength, please make experimental adjustment during design.
  - ✧ Error Tolerance: within 1.2 mm.
- Radome Thickness D
  - ✧ Half wavelength is recommended, and the error should be controlled within 20%.
  - ✧ If the thickness requirement of half wavelength cannot be met, it is recommended to use low ϵ_r materials;
  - ✧ The thickness is recommended to be less than or equal to 1/8 wavelength in the medium.
- Non-uniform or composite materials can degrade radar performance, so it is advisable to make adjustments during the design phase to mitigate these effects.

FAQ

Q1

- Why is the thickness D of radome recommended to be half wavelength? If it cannot meet the thickness requirement of half wavelength, it is recommended to be less than or equal to 1/8 wavelength in the medium?

A1

- The recommended thickness of the radome is half the wavelength in the medium to ensure impedance consistency before and after the electromagnetic wave penetrates the casing, thereby reducing reflection and insertion loss.
- If the customer finds the half-wavelength thickness too thick, it is recommended to use a thickness equal to or less than 1/8 wavelength to minimize the path length of the electromagnetic wave through the casing, reducing the insertion loss.
- The thickness D of the antenna radome can also be an integer multiple of the half-wavelength.

Q2

- Will the designed radome have different effects if it is made of frosted material?

A2

- It is suggested that the radome should be made of smooth and uniform materials, and it is not recommended to use frosted materials, which will increase the reflection of electromagnetic waves and increase the loss and affect the antenna radiation patterns.