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MANUFACTURERS & FABRICATORS OF ENGINEERED MATERIAL SOLUTIONS

THREE TIPS TO IMPROVE RADOME DESIGN

The function of a radome is simple. A radome is a radar antenna dome (Radar + Dome). It acts as a weatherproof enclosure designed to protect the antenna from sources that could cause physical damage or electrical interference. Radomes come in different shapes, sizes, and materials depending on the application's requirements, but they all serve the same primary function. This bulletin describes 3 key elements to consider when designing radomes in your application: Material Selection, Geometry, and Configuration.

1. Choose the Right Material

In general, under ideal conditions, a radome is electrically invisible. How well a radome accomplishes this depends on the design and material composition with respect the wave propagation at a given frequency. Parameters around electrical, mechanical, and physical properties within a material dictate these design elements.

Electrical Properties – Radome materials won't endure a current so not all insulative properties are key. Properties that do make a difference are those that make a signal susceptible to loss. Dielectric Constant (Dk) and Loss Tangent/Dissipation Factor (Df) are the biggest drivers. Dielectric constant represents a materials ability to store energy and loss tangent refers to energy loss to due physical properties. It is important to keep these values as low as possible to minimize signal loss

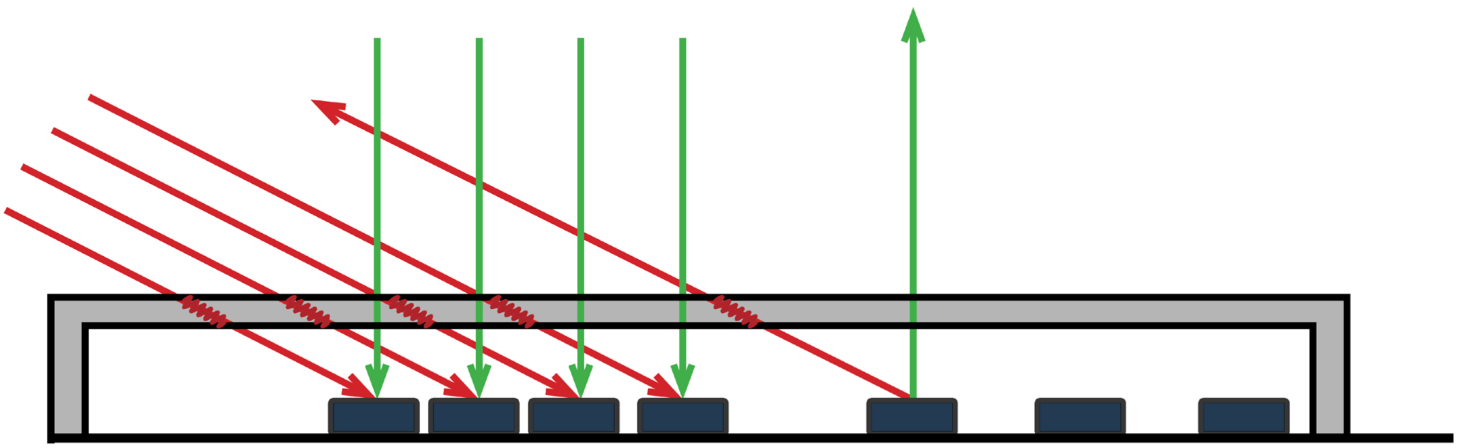
Mechanical Properties – Mechanical properties of the radome relate to physical protection of the antenna. Radomes with the correct properties may not improve the performance of an antenna directly, but failures of mechanical properties could affect the antenna negatively. High impact strength to prevent cracking from foreign objects, High flex strength to prevent deformation from loads, and sufficient hardness to prevent surface damage are all necessary for optimal performance

Physical Properties – A radome can be structurally sound and have great electrical properties, but still perform poorly or fail in time. Material degradation prevention is key to ensure the mechanical properties and electrical properties continue performing at a high level for a long period of time. Selecting a hydrophobic material to repel water or other liquids from accumulation helps prevent signal interference. Selecting a material with resistance to UV rays will prevent erosion in material performance.

2. Optimize the Radome Shape

Although a material with low dielectric constant and loss tangent, high mechanical strength, and excellent physical properties may perform well on paper, the potential of this material can only be realized when the radome is designed to minimize reflection of the incident wave. In theory, a material with a Dk or near 1 would not interfere with the wave passing through the material, but by itself, the material cannot dictate reflection of the incident wave. From a geometric standpoint, there are 3 key considerations: Radome wall thickness, distance from antenna to radome, and radome angle.

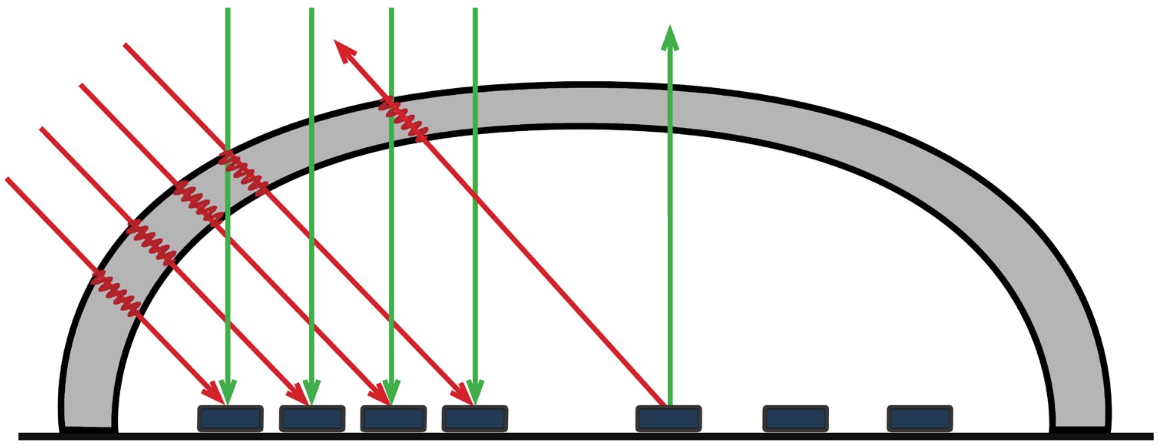
Radome wall thickness and antenna distance



If the goal is to minimize reflection of the incident wave, introducing a surface at the lowest wave amplitude it ideal. This occurs at the half-wavelength point and this logic applies to the radome. Assuming the material selected is proper for the application, the radome thickness and the distance to the antenna should be in multiples of half-wavelengths.

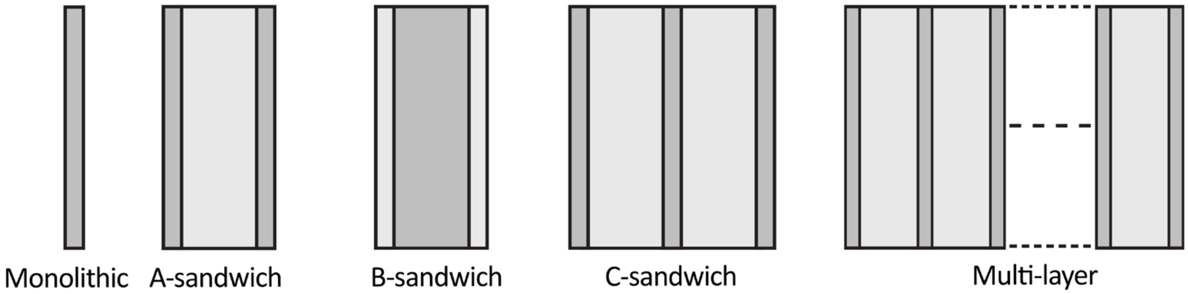
Since the medium between the antenna and radome surface is air, the optimal distance is dependent only on the frequency. If the radome material shared the same Dk as air, the radome thickness could be the same as the distance from the antenna surface, however this is not the case. Because waves "slow-down" as they enter the radome material from signal loss, understanding how much loss occurs in the radome material is necessary. Once this value is understood, the wavelength and therefore optimal thickness can be calculated.

Radome Angle Dependence



Given all the properties are known, designing the radome can appear to be relatively straightforward. In theory, understanding the dielectric properties of the material and the antenna frequency would be sufficient to create the optimal design, however, this does not consider the direction of the wave. If the wave enters perpendicular to the radome (bore-sight), reflections of the wave are minimal if the thickness is correct. If the angle of arrival is different, the wave will incur some degree of increased reflection as the amount of radome material to pass has increased. The magnitude of reflection is increased as the angle of arrival increases. It is recommended to shape the radome to lower this angle. This may increase the distance between the antenna and radome surface so a middle ground must be found.

3. Use the correct configuration



Understanding materials suitable for the application and designing the radome so it optimizes those materials is key, but radome configuration is just as important.

Frequency is a fundamental component when calculating radome geometry. When the frequency is known, designing a radome is rather straightforward, but most antennas do not operate at one frequency. The Bandwidth of an antenna, or the range of frequencies in each band, can make a chosen geometry both optimal and poor. Choosing the right configuration can minimize losses at larger bandwidths and/or reduce reflectivity.

Radomes generally come in monolithic, sandwich, and multi-layer designs.

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Monolithic

The simplest radome is a single-wall structure, which is a homogeneous half-wavelength thick dielectric material, such as a glass thermoset. Electromagnetic waves typically experience less reflection when contacting the dielectric substrate in the bore-sight direction. However, reflection gets worse as the incident angle increases.

Sandwich

Another radome configuration used to minimize RF reflections is the sandwich radome, which consists of dielectric skins separated by a core material. The reflection can be lowered by the mutual cancellation of the reflections between the skins. This type of radome has a high strength-to-weight ratio comparing to a single wall structure. The bandwidth of this type of radomes can be further enhanced by increasing the core thickness by its integral multiples. Cores and skins can be added to further increase the bandwidth without increasing the thickness.

Multi-Layer

Multi-layer structures may have any number of layers required to achieve desired properties such as low transmission loss over a wide frequency band or to incorporate desired environmental and structural features. Often this is measured in multiples of A-sandwich radomes attached together.

Conclusion

Although the process can seem daunting, following these tips will help you organize your selection process. The Gund Company offers material specifically designed for radome application such as ProDome®, a low dielectric skin and monolithic radome material. We also offer foams and adhesives to support the entire project.

The Gund Company maintains state of the art manufacturing equipment to support radome production of even the most complex design. Let us help you create the perfect radome for you application today!

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