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A 3D Printed Dish Antenna With Integrated Feeding Structure

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***Abstract*—This paper describes the design and fabrication of a fully 3D printed dish antenna with integrated feeding. As opposed to traditional dish antennas where the dish, feeding antenna, and cables are separate components, a fully 3D printed dish antenna incorporates all these elements in one integrated structure. The designed 3D printed dish antenna operates at 28 GHz with 28.5 dBi of gain and features a integrated horn antenna feed, which is built directly onto the surface of the dish, and an integrated waveguide connector for connections for external RF connections. The introduction of 3D printable dish antenna structures with integrated feeding and connectors, grants users an extremely low cost and simple to manufacture antenna for applications which requires high gain and ease of deployment.**

***Index Terms*—3D printing, Dish Antenna, Parabolic , Reflector**

I. Introduction

Dish antennas are widely utilized in applications requiring high gain for long range communications. They are also low loss and easily scalable compared to other types of antennas, such as microstrip antennas, since the aperture can be constructed to be wider without having to add additional array elements and feeding networks. However, they are generally rely on multiple parts, specifically the parabolic reflector, feeding antenna, and structural supports for mechanical stability. These need to be assembled which is time consuming and costly, since these parts need to be machined out of metal and individually pieced together. Therefore it is beneficial to introduce an easy method of integrating the parabolic dish with its various peripherals to make an integrated dish antenna that is easy to fabricate and to use.

3D printing is a powerful tool which is revolutionizing various manufacturing processes. This novel manufacturing technique builds structures layer by layer additively, where traditional methods are subtractive. With 3D printing, complex antennas have been created which is not possible to fabricate with traditional CNC machining or lithography techniques [1]. Utilizing 3D printing to fabricate dish antennas allows for an inexpensive integrated structure that doesn't need to be assembled but offers the same high gain like that of a traditionally machined and assembled dish antenna.

II. Antenna Design

The antenna is 3D printed using Sterolithography Apperatus (SLA) printing using a Formlabs Form 2 printer. SLA printing uses light to polymerize resins and is a superior method for antenna fabrication as compared to Fused Deposition Modeling (FDM) printing due to its smaller surface roughness and print resolution [2]. The printing material utilized was the Formlabs Clear photoresin, which acted as the base structural material. A coating of metallic material needs to be deposited onto the base material for it to operate as an antenna [3].

The critical feature of the 3D printed dish antenna is that it is one contiguous structure. The antenna designed follows a traditional parabolic dish shape with a horn antenna feeding. A gooseneck waveguide structure extends from the apex of

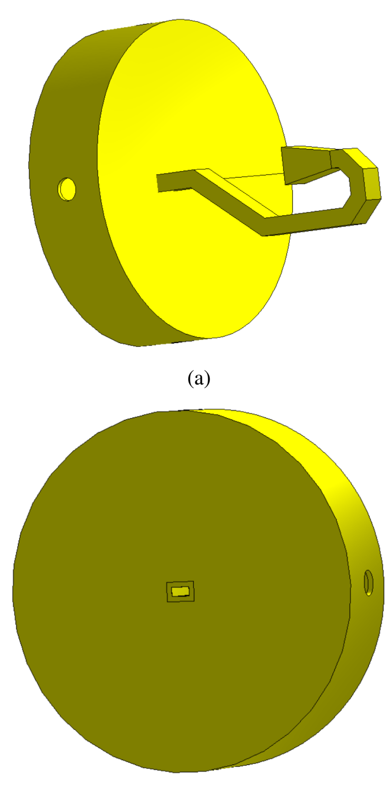

Fig. 1. (a) Front side of the dish antenna featuring a gooseneck style horn antenna feed. (b) Backside of the dish antenna with a waveguide port for connecting RF transitions.

the parabolic dish which terminates into a horn antenna at the focal point of the parabolic dish and is used as the antenna feed. The waveguide extends down below the parabolic dish and terminates into a waveguide opening, used to connect to external waveguide transition pieces for measurement or transceiver circuitry. The antenna can be seen in Fig. 1 (a) and the bottom waveguide transition portion in Fig. 1 (b). A standard WR28 waveguide size was chosen for the feeding, allowing for standard waveguide transitions to be mounted for measurements.

Certain design considerations must be taken into account when 3D printing the antenna. For example, the gooseneck feeding shape must be printed with supporting structures which when removed, can leave small imperfections on the dish surface. This can decrease the aperture efficiency, which is why the feeding must be printed with minimum amounts of supporting material. Additionally, typical waveguide connectors are flat, which means that the backside of the dish needs to be flat to accommodate. To save weight and material, the bottom of the dish can be hollowed out. A fabricated model is shown in Fig. 2

The simulation results demonstrates a high (28.5 dBi) gain on the main lobe and consequently a narrow beam width. Due to the horn feeding, the antenna also has a wide impedance bandwidth. These results are summarized in Fig. 3 (a) and (b). The antenna was simulated with a ABS plastic dielectric and 10 µm of copper coating. The underlying choice of dielectric has little effect on the simulation results as long as there is a metallic coating on the outside. The coating is typically deposited utilizing electroplating [3].

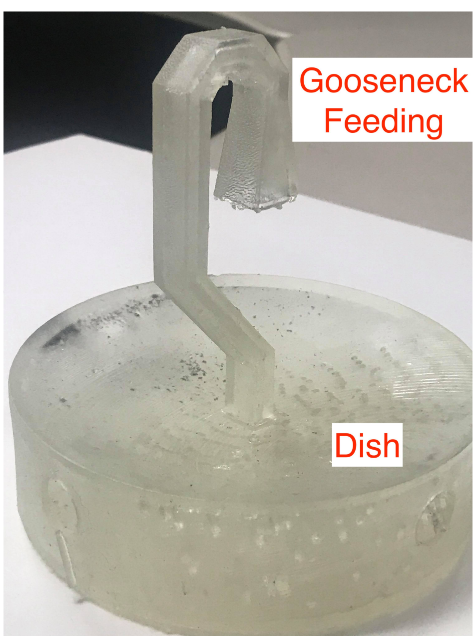

Fig. 2. Bare 3D printed dish antenna without the outer metallic coating. Some ”spots” are seen on the dish portion and the horn antenna portion, due to the supports.

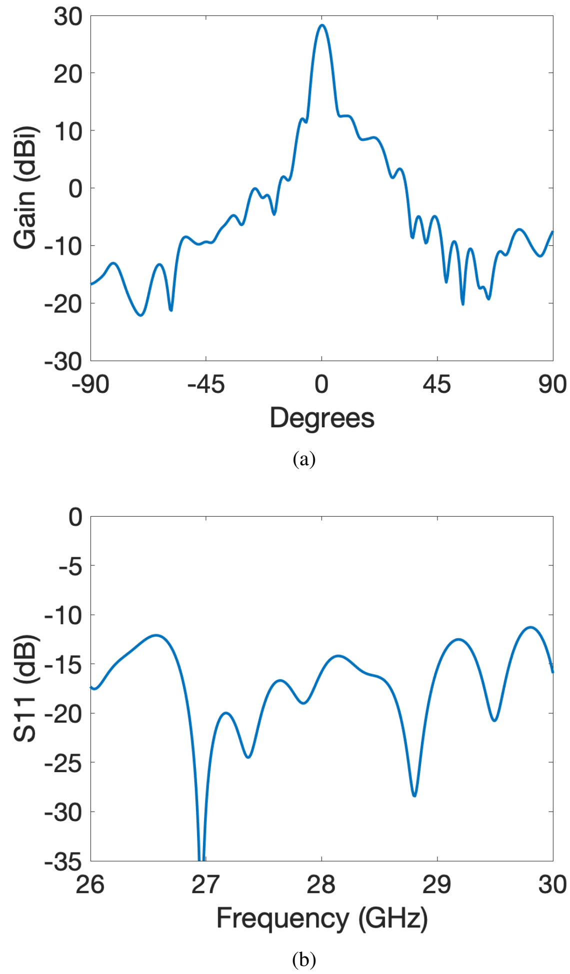

Fig. 3. (a) Gain pattern of the 3D printed dish antenna. The antenna achieves 28.5 dBi of simulated gain along constant ϕ. (b) S11 of the dish antenna. Since this utilizes a horn feed antenna, the dish antenna has a wide impedance bandwidth.

III. Conclusion

This paper summarizes a 3D printed dish antenna with integrated feeding. Utilizing 3D printing manufacturing allows for an inexpensive high gain antenna to be easily fabricated. It is important to note that this structure is impossible to be fabricated using traditional subtractive methods which demonstrates the great advantages of 3D printing.

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