Wireless Video System Using Dualfunction Omnidirectional Glass Dielectric Resonator Antenna

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***Abstract*—A table lamp using a dualfunction omnidirectional glass dielectric resonator antenna (DRA) was made and successfully applied to a 2.4-GHz wireless video system. Super-bright light emitting diodes (LEDs) are placed inside the hollow region of the glass DRA to serve as the light source. On one hand the glass DRA functions as a light cover and on the other hand, it radiates like an electric monopole. It is shown that practically the lighting and antenna parts do not interfere with each other.**

***Index Terms*—Dielectric resonator antenna (DRA), glass antenna, transparent antenna, dualfunction antenna.**

I. Introduction

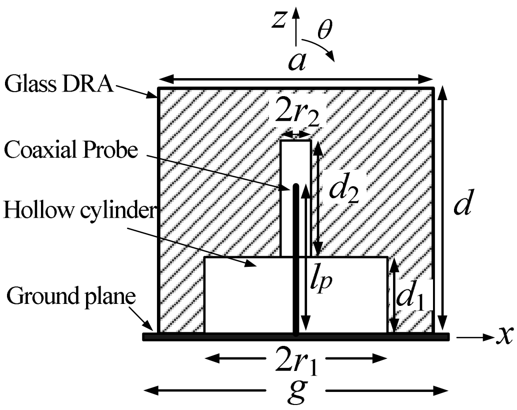
Due to a number of attractive features such as its small size, low loss, wide bandwidth, and ease of excitation, the dielectric resonator antenna (DRA) has been studied extensively in the past two decades [1], [2]. Various antenna geometries, excitation schemes, and bandwidth enhancement techniques have been developed for DRA designs. Today, dual- or multi-function designs [3] have received much attention because they can reduce the system size and cut the system cost. For example, it has been reported that dualfunction DRAs can additionally provide functions of packaging cover [4], oscillator load [5], filter [6]–[8], or even decoration artwork [9]. The transparent DRA [10] that simultaneously functions as a radiating element and optical focusing lens is another example of dualfunctional DRA. It can also serve as a protective cover for its underlaid solar cell. Since transparent glass DRAs do not need any conducting part to resonate, their antenna gains can be much higher than those of the traditional transparent antennas [11]–[16]. Recently, a hollow rectangular glass DRA used as a light cover has been investigated in [17]. In [17], four light emitting diodes (LEDs) are placed inside the hollow region of the glass DRA to serve as the light source. The hollow glass DRA is centrally fed by a coaxial probe, exciting its fundamental TM mode and generating linearly polarized (LP) omnidirectional fields. Apart from providing the function of light cover, the design can be used to hide the antenna to avoid the concern of radiation. In this paper, the rectangular glass DRA is applied to a table lamp for the first time to demonstrate the practicality of the light-cover idea. The table lamp has been successfully used as the transmitter of a 2.4-GHz wireless video system. It can, of course, be used as the receiver of the wireless video system.

II. Glass DRA and Wireless Video System

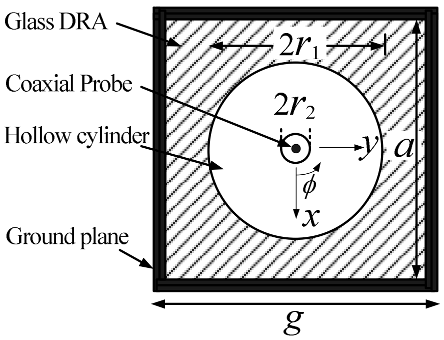
Fig. 1 shows the configuration of the omnidirectional glass DRA which has been recently studied in [17]. The omnidirectional glass DRA was designed at 2.4GHz using ANSYS HFSS. The rectangular DRA was made of K9 frosted glass, with a square cross section of side length a = 62 mm, height d = 43 mm, and a dielectric constant of ε_r = 6.85. Since the DRA is simultaneously used as a light cover, a cylindrical hollow region of radius r_1 = 18 mm and height d_1 = 14 mm is made at the bottom of the DR to accommodate the LEDs. On top of the hollow region is a second hollow region for the accommodation of the feeding probe. This hollow region is a slender air cylinder of radius r_2 = 3 mm and height d_2 = 19 mm. The probe has a length of l_p = 24 mm and a radius of r_p = 0.63 mm, penetrating into the second hollow region of the DRA. A square ground plane with a side length of g = 62 mm is used for the antenna.

Two photos of the prototype are given in Fig. 2. They show the top and bottom faces of the rectangular glass DRA. The measured and simulated 10-dB impedance bandwidths ($|S_{11}| < -10$ dB) are given by 28.8% (1.99–2.66 GHz) and 28.0% (2.03–2.69 GHz), respectively. A measured antenna gain of ~1.8 dBi and efficiency of ~0.95 are found at 2.4 GHz. The antenna presents a good omnidirectional radiation pattern. For each plane, the co-polarized field is generally stronger than the cross-polarized counterpart by more than 20 dB.

Fig. 3(a) and (b) shows the DRA-integrated table lamp. Here, three super-bright SMD LEDs are used as the light source, as shown in Fig. 3(c). The feeding probe is also shown in Fig. 3(c). The table-lamp antenna is used as a transmitter of a 2.4-GHz wireless video system. Fig. 3(d) shows a photo of the base of the table-lamp, which houses the modulator and biasing circuit of the system. The modulator modulates the video and audio signals at 2.4 GHz. Fig. 3(e) shows the overall wireless video system consisting of the transmitter and receiver parts. The operation of the system is described as follows. Video and audio signals from the output of the DVD player are fed into the modulator that was placed inside the base of the table lamp. The modulated signal is passed to the glass DRA through a coaxial cable embedded along the trunk of the table lamp. The modulated signal is transmitted by the glass DRA and received by the monopole antenna of the

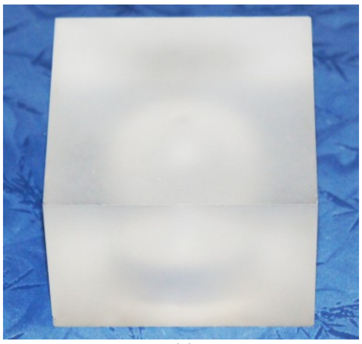


(a)

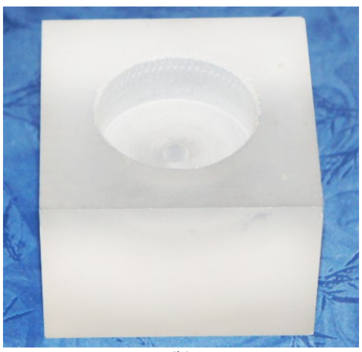


(b)

Fig. 1. Configuration of the proposed omnidirectional probe-fed glass DRA (a) Front view. (b) Top view.



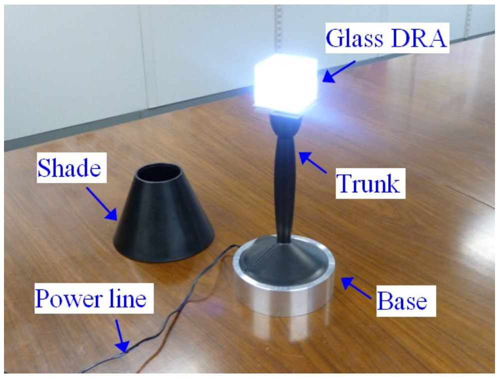
(a)



(b)

Fig. 2. Photos of the omnidirectional glass DRA. (a) Perspective view showing the top face. (b) Perspective view showing the bottom face.

(a)



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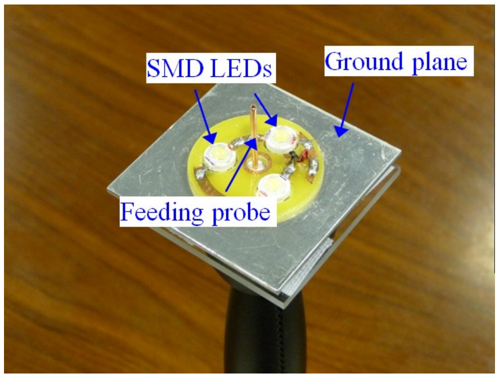
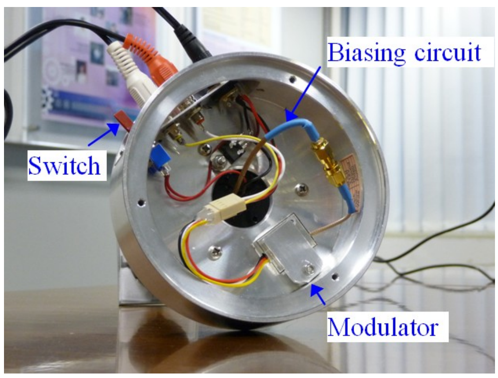
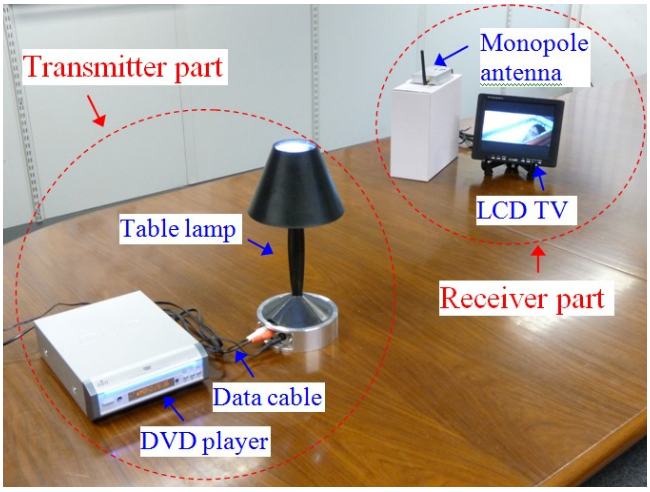


(c)



(d)



(e)

Fig. 3. Photos of a 2.4-GHz wireless video system deploying the omnidirectional LP glass DRA. (a) Table lamp integrated with glass DRA. (b) Table-lamp antenna with the light shade off. (c) Three super-bright SMD LEDs used as the light source of the table lamp. (d) Bottom of table lamp showing the modulator and biasing circuit. (d) Overall wireless video system with both transmitter and receiver. Demodulated video signal is shown on the LCD TV.

demodulator. Finally, the demodulated signal is fed into the LCD TV to reproduce the pictures and sound. A demonstration of this wireless video system can be found on the web [18]. It can be seen on the web that the DVD video is playing well when the system is ready. But when the glass antenna is removed, the video signal is lost. The video signal resumes when the glass antenna is put back, verifying that the glass works as an effective antenna. Also, it was found that switching the LEDs on or off does not affect the antenna characteristics at all. These results are very favorable, as it shows that using the DRA as a light cover does not sacrifice its antenna performance.

III. Conclusion

The omnidirectional probe-fed rectangular glass DRA has been integrated with a table lamp. It serves as the cover of the light source. Three super-bright SMD LEDs have been placed inside the hollow region of the glass DRA. For demonstration, the table lamp has been used as a transmitter for a 2.4-GHz wireless video system. It has been experimentally found that the LEDs have no practical effects on the antenna performance. Therefore, it is not required to take them into account when designing the light-cover DRA. This greatly facilitates the design process. Also, it can save the footprint when both the antenna and table lamp are needed. Finally, it should be mentioned that the proposed configuration can be used as an excellent hidden antenna to avoid possible concerns of radiation.

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