BOR-SPR Antenna with a Stop Band

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1. Introduction

The input impedance of a conducting body of revolution (BOR) above a ground plane has a wideband frequency response. The lower edge of the operating frequency band of the BOR depends on the height of the BOR. Recently, we added a parasitic ring [1] to a BOR, whose height is extremely small (0.07 wavelength at lower band edge [2]), and found that this antenna, designated as the BOR-SPR (abbreviation for BOR with a shorted parasitic ring), has a 148% bandwidth for a VSWR = 2 criterion.

This paper is a sequel to the research on the BOR-SPR found in [2] and presents a technique for generating a stop band in the frequency response of the VSWR [3]. Such a stop band is effective in reducing interference with nearby devices, or enhancing the isolation of transmitted signals from received signals [4].

The stop band in this paper is generated by adding a conducting line to each of the four pins that connect the parasitic ring to the ground plane. This conducting line (of length l_L) is located parallel to the pin, with spacing s_L. The analysis of this BOR-SPR is performed using the finite-difference time-domain method (FDTDM) [5]. The effects of the length l_L and spacing s_L on the stop band are analyzed and the center frequency and width of the stop band are discussed. Note that the radiation pattern is also analyzed and discussed.

2. Configuration

Fig. 1 (a) shows the configuration of a conventional BOR-SPR antenna [2]. The antenna is composed of a conducting body of revolution, a parasitic ring, and a ground plane. The parasitic ring is shorted to the ground plane using four pins. The generating line of the BOR is specified with points $P(x_P, 0, z_P)$ and $Q(0, 0, z_Q)$. The parasitic ring, for which the inner and outer diameters are $D_{in, ring}$ and $D_{out, ring}$, respectively, is located at height z_P. The ground plane has a diameter of D_{GP}. Fig. 1(b) shows a modified BOR-SPR, where a conducting L-line is added to each of the four pins. The L-line is specified by length l_L and spacing s_L.

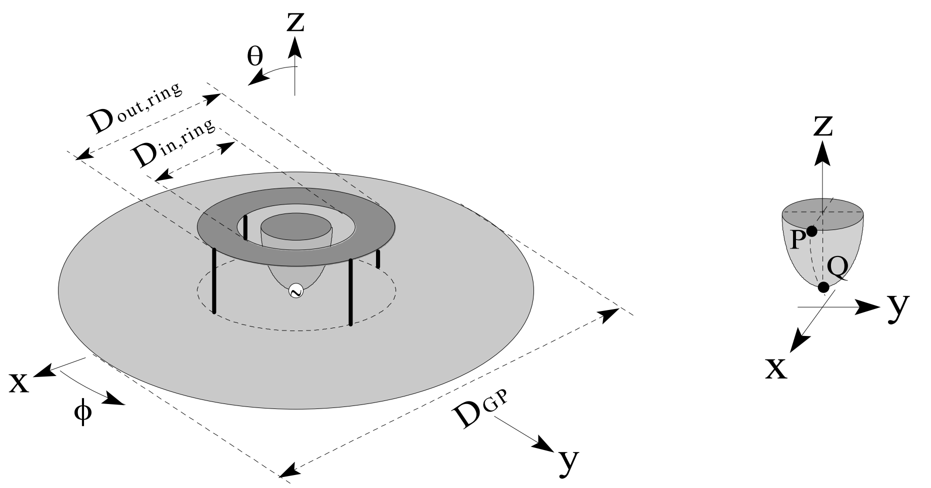
3. Analysis and discussion

The antenna characteristics are calculated using the electric and magnetic fields (**E** and **H**) obtained using the FDTDM. The field components at symmetric points with respect to the x-z plane in Fig. 1 have the following relationships: $E_x(x, y, z) = E_x(x, -y, z)$, $E_y(x, y, z) = -E_y(x, -y, z)$, $E_z(x, y, z) = E_z(x, -y, z)$, $H_x(x, y, z) = -H_x(x, -y, z)$, $H_y(x, y, z) = H_y(x, -y, z)$, $H_z(x, y, z) = -H_z(x, -y, z)$. This means that the x-z plane acts as a magnetic wall. Note that the y-z plane also acts as a magnetic wall and hence the practical analysis space of the FDTDM can be reduced to one-fourth of the total analysis space.

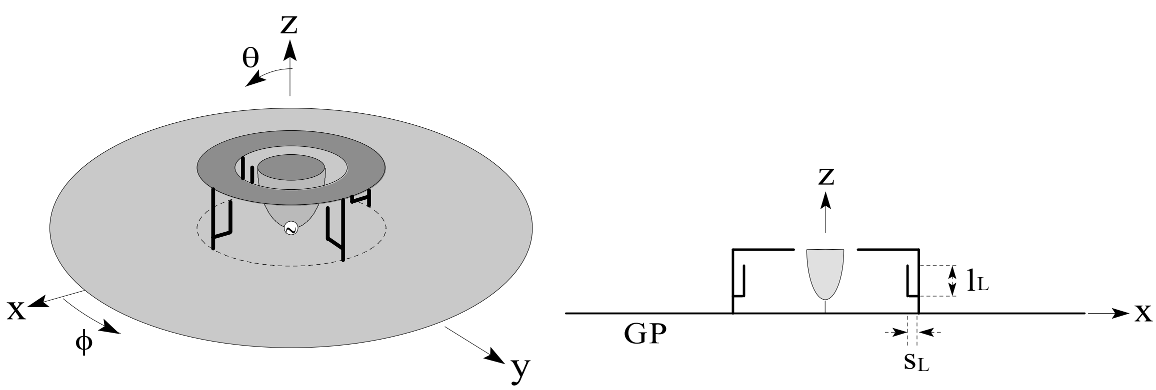
Fig. 2 shows the VSWR frequency response for a spacing of $s_L = 2\Delta$ with length l_L as a parameter, where $\Delta = \lambda_{7.2}/100$ with $\lambda_{7.2}$ being the wavelength at a frequency of 7.2 GHz. The configuration parameters are chosen to be $P(x_P, 0, z_P) = P(8\Delta, 0, 36\Delta)$ and $Q(0, 0, z_Q) = Q(0, 0, 2\Delta)$ for the BOR, $(D_{in,ring}, D_{out,ring}, z_P) = (24\Delta, 96\Delta, 36\Delta)$ for the parasitic ring, and $D_{GP} = 328\Delta$ for the ground plane. It is found that the L-line BOR-SPR has a stop band in the VSWR frequency response. The center frequency of the stop band is closely related to the length l_L; the center frequency corresponds to the frequency at which the L-line length is approximately one-quarter wavelength. Note that the conventional BOR-SPR without L-lines shows a wideband frequency response without a stop band, with the lower band edge at 1.8 GHz.

Next, we investigate the effect of the L-line spacing s_L on the VSWR. Fig. 3 shows the frequency response of the VSWR with spacing s_L as a parameter, where the L-line length l_L is fixed ($l_L = 32\Delta$). It is found that as the L-line spacing is decreased, the bandwidth for a VSWR = 20 criterion decreases: 9.7% for $s_L = 4\Delta$, 7.3% for $s_L = 3\Delta$, and 4.8% for $s_L = 2\Delta$. It is also noted that the L-line spacing slightly affects the stop band center frequency.

So far, we have discussed the effects of the L-lines on the bandwidth and center frequency of the stop band. Finally, we investigate the radiation fields at frequencies outside the stop band. Fig. 4 shows the radiation patterns at 3.1 GHz and 10.6 GHz, where the L-line has parameters of (l_L , s_L) = (32Δ, 2Δ). For comparison, the radiation patterns when no L-lines are present are also shown in Fig. 4. It is found that the L-lines do not noticeably affect the radiation pattern at frequencies outside the stop band. The maximum radiation is not in the horizontal direction (see the radiation pattern in the x-z plane); the beam is tilted upward above the ground plane due to the finite-sized ground plane. The radiation in the x-y plane is found to be almost omni-directional.



(a)



(b)

Fig. 1. BOR-SPR antenna. (a) Conventional BOR-SPR. (b) BOR-SPR with L-lines.

4. Conclusions

A BOR-SPR antenna is investigated for generating a stop band in the VSWR frequency response, where four conducting L-lines, each specified by length l_L and spacing s_L, are added to the outer pins. The center frequency and width of the stop band are investigated. It is found that the length l_L controls the center frequency and the spacing s_L can be used to control the stop-band width. It is also revealed that the radiation pattern at frequencies outside the stop band is very similar to that for the antenna structure where no L-lines are present, showing almost omni-directional radiation about the antenna axis.

Acknowledgements

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References

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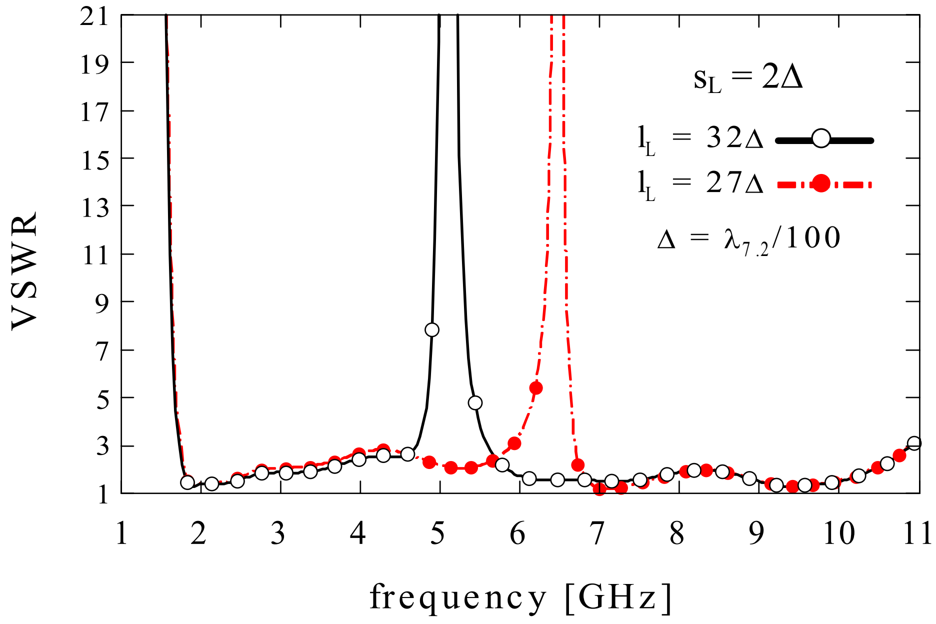

Fig. 2. VSWR of a BOR-SPR with L-lines, with length l_L as a parameter and $s_L = 2\Delta$.

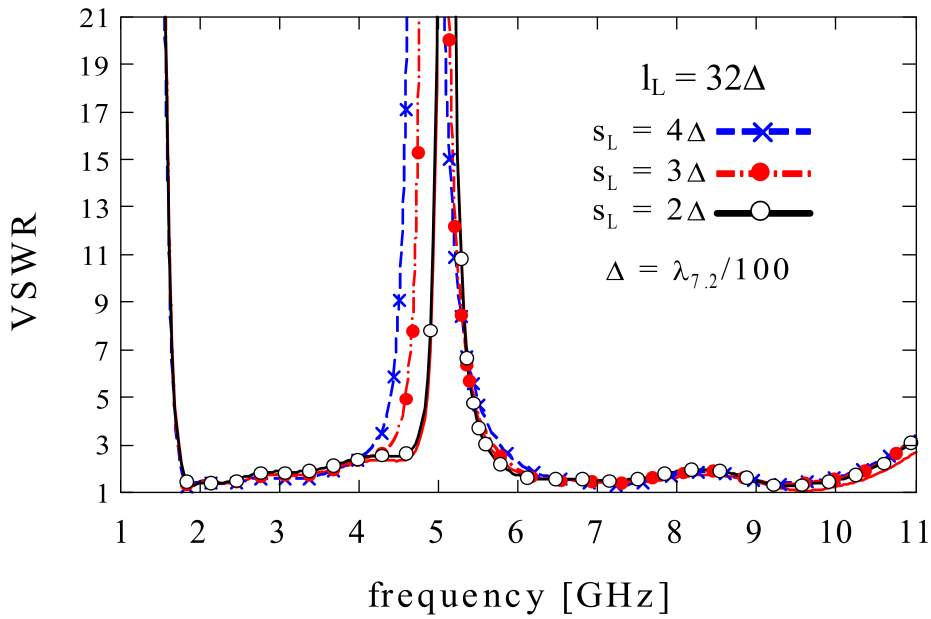

Fig. 3. VSWR of a BOR-SPR with L-lines, with spacing s_L as a parameter and $l_L = 32\Delta$.

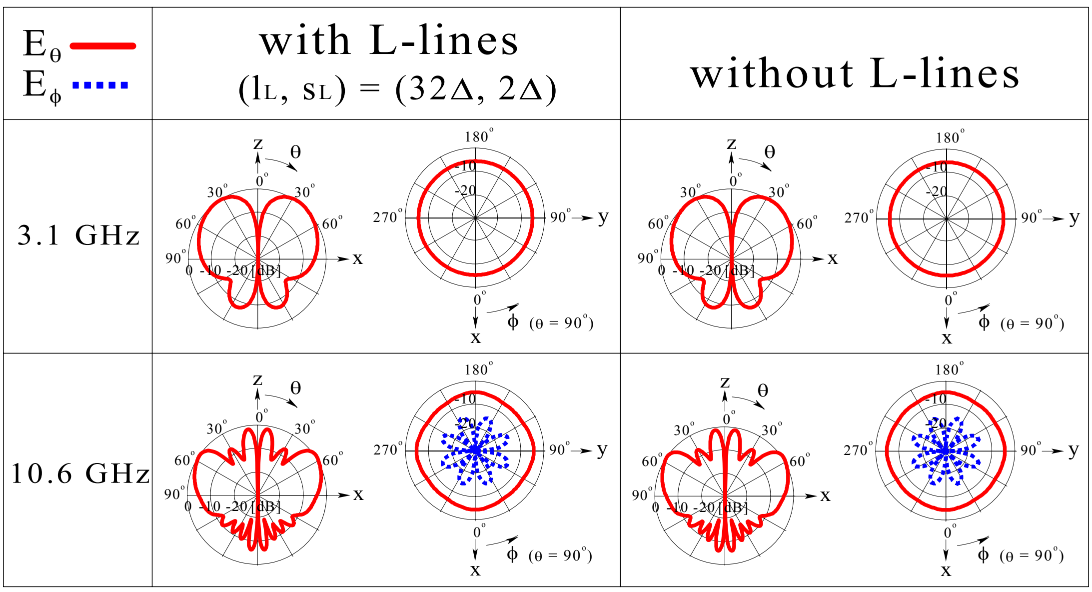

Fig. 4. Radiation patterns.