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Lens Design for Incoming Spherical Wave for Different Biological Dielectric Tissues

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Abstract

In this paper different biological dielectric tissues are used as different target dielectrics and we try to obtain better focusing for a prolate-spheroidal IRA for an incoming spherical wave from the reflector for these tissues.
1 Introduction

This paper is an extension of [1,2] and the lens design considerations are based on [3]. We use 5 different target dielectric tissues and these are water, muscle, tumor, skin and fat that can be used for some biological applications [4]. Ten layers of an increasing dielectric lens, which have the same ratio of dielectric constants between adjacent layers, are considered for a prolate-spheroidal IRA [2].

2 Design Considerations

Ten layers of increasing-dielectric-constant lens are used based on the calculations in [1]. We use the same ratio of dielectric constant between subsequent layers for \( \varepsilon \frac{1}{N} \)

\[
\varepsilon_{\text{ratio}} = \varepsilon_{\text{rmax}}
\]

(2.1)

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Layer} & h_n / h & \Delta z_n / h & z_n / h & \theta_{1\text{max}} & \theta_{2\text{max}} \\
\hline
1 & 1.0 & 0.096 & 0.000 & 0.992 & 0.927 \\
2 & 0.9 & 0.079 & 0.096 & 1.056 & 0.992 \\
3 & 0.8 & 0.066 & 0.175 & 1.120 & 1.056 \\
4 & 0.7 & 0.054 & 0.241 & 1.185 & 1.120 \\
5 & 0.6 & 0.044 & 0.295 & 1.249 & 1.185 \\
6 & 0.5 & 0.036 & 0.339 & 1.313 & 1.249 \\
7 & 0.4 & 0.027 & 0.374 & 1.379 & 1.313 \\
8 & 0.3 & 0.020 & 0.401 & 1.442 & 1.379 \\
9 & 0.2 & 0.013 & 0.421 & 1.506 & 1.442 \\
10 & 0.1 & 0.006 & 0.434 & 1.571 & 1.506 \\
\hline
\end{array}
\]

Table 2.2 \( h_n / h, \Delta z_n / h, z_n / h, \theta_{1\text{max}}, \theta_{2\text{max}} \) values for \( \theta_{1\text{max}0} = \pi / 2 \) [2]

\( h_n / h, \Delta z_n / h, z_n / h, \theta_{1\text{max}}, \theta_{2\text{max}} \) are defined in [2].

A new coordinate system can be defined as centered at \( z = z_0 \). We will call this system \( z' \) and it can be defined as

\[
z' / h = -(z - z_0) / h
\]

(2.2)
A lens is designed for incoming spherical waves to obtain better focusing for a prolate-spheroidal IRA for different dielectric human tissues. We obtain better focusing for higher dielectric lens.

$\Psi / h$ vs $z'/h$ values for $\theta_{1\max 10} = \pi / 2$ and $85^0$ for different $e_{r\max}$ are presented in Fig. 3.1 and Fig. 3.2. One can see from Fig. 3.1 and Fig. 3.2 for smaller $e_{r\max}$, the first shell moves left. This is because we have fixed the vertical ($\Psi / h$) axis values to increment by a uniform 0.1, leaving some variation (small) in the location along the horizontal coordinate.
Figure 3.1 $\Psi/h$ vs $z'/h$ for $\theta_{1\text{max}} = \pi/2$ and different $\varepsilon_{r\text{max}}$
Figure 3.2 $\Psi / h$ vs $z / h$ for $\theta_{1\text{max}10} = 85^0$ and different $\varepsilon_{r \text{max}}$:

- a) $\varepsilon_{r \text{max}} = 81$
- b) $\varepsilon_{r \text{max}} = 70$
- c) $\varepsilon_{r \text{max}} = 50.74$
- d) $\varepsilon_{r \text{max}} = 34.7$
- e) $\varepsilon_{r \text{max}} = 9.8$
References