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# Numerical Simulations for Different Log Periodic Lenses

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Abstract

The numerical simulations that can be used to determine the radius of different $\varepsilon_r$ lenses with constant wavelength to cross section ratio are discussed.

## 1 Introduction

Numerical simulations of different size log periodic lenses concentrating the field on a target are discussed. Addition of a lens before the second focus of a prolate-spheriodal IRA is discussed in detail in [1].This paper deals with a half sphere lens design with subsequent layers. The focal point of the prolate-spheroidal IRA is $z_0 = 37.5$ cm and the other parameters are defined in [2,3]. The IRA and lens geometry is illustrated in figure 1. The analytical calculations for a log periodic lens are presented in [4].

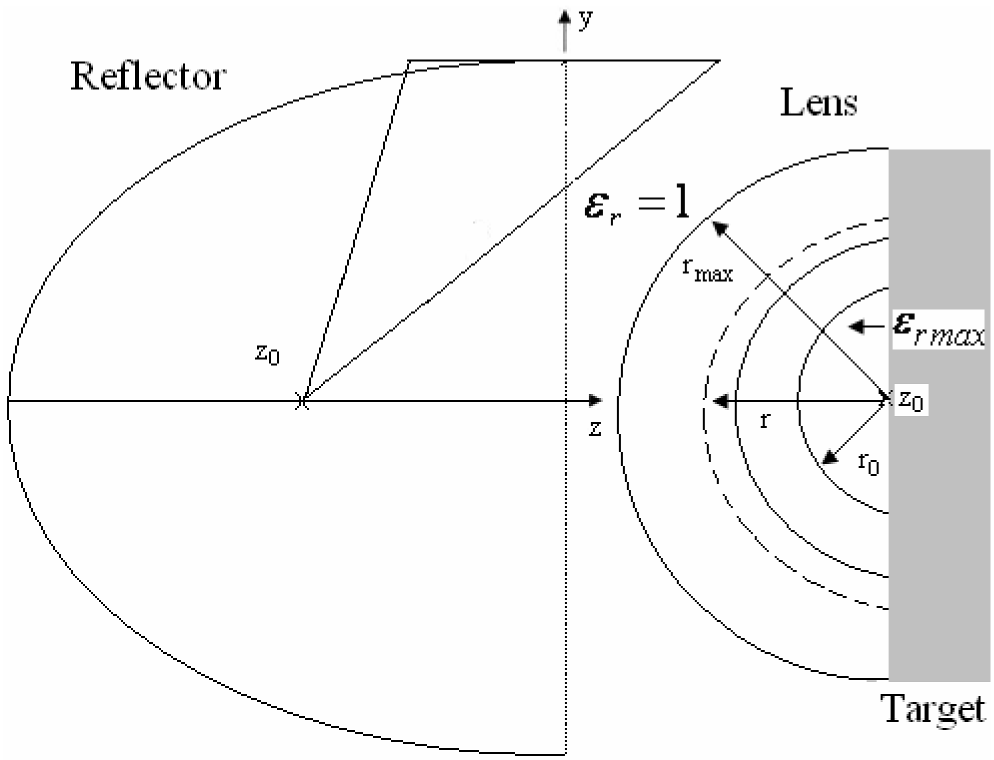


Figure 1 IRA and Lens Geometry

## 2. Design Considerations

Log periodic lenses with different dimensions are designed. The parameters that can be used for analytical calculations are presented in [4].

$$\frac{r}{r_0} = \varepsilon_r^{1/2}(r), \quad r_0 = \frac{\nu c \Delta t}{\varepsilon_{r\,max}^{1/2}}. \tag{1}$$

where r is the radius of the lens, $r_0$ is a constant for each layers that gives a relation between r and $\varepsilon_r(\mathrm{r})$, c is the speed of light, $\Delta t$ is the pulse width and $\nu$ is a scaling parameter that can be used to determine the radius of the lens.

**3. Numerical simulations**

We have a ramp rising step with $\Delta t = 100\,\mathrm{ps}$ pulse width and 1V (peak to peak) amplitude. The dielectric constant of the last layer is $\varepsilon_{r\max} = 9$ and we have 5 layers which have a constant ratio of dielectric constant as in [4,5] . The focal waveforms of different log periodic lenses for different $\nu$ values are presented in Figures 2a, 2b, 2c, 2d and 2e.

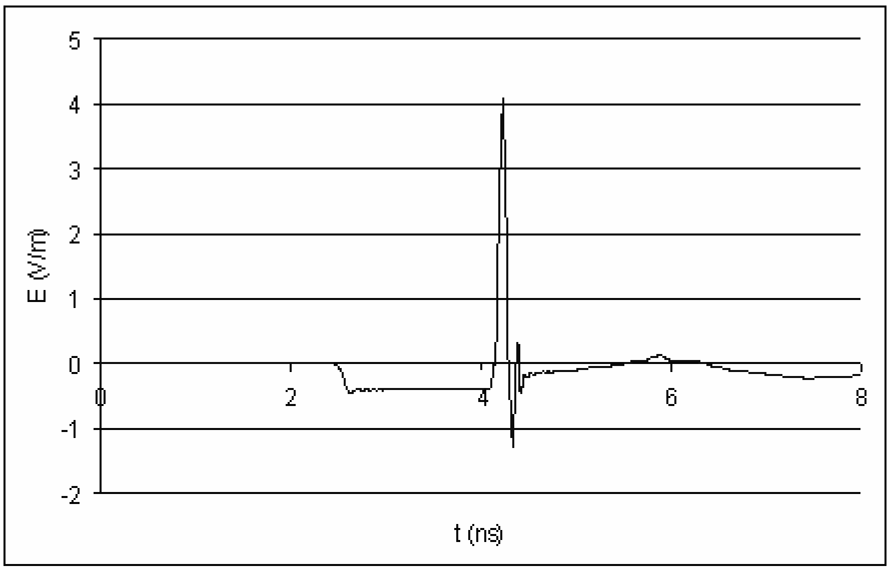


Figure 2a Numerical focal waveform without lens $\nu = 0$ .

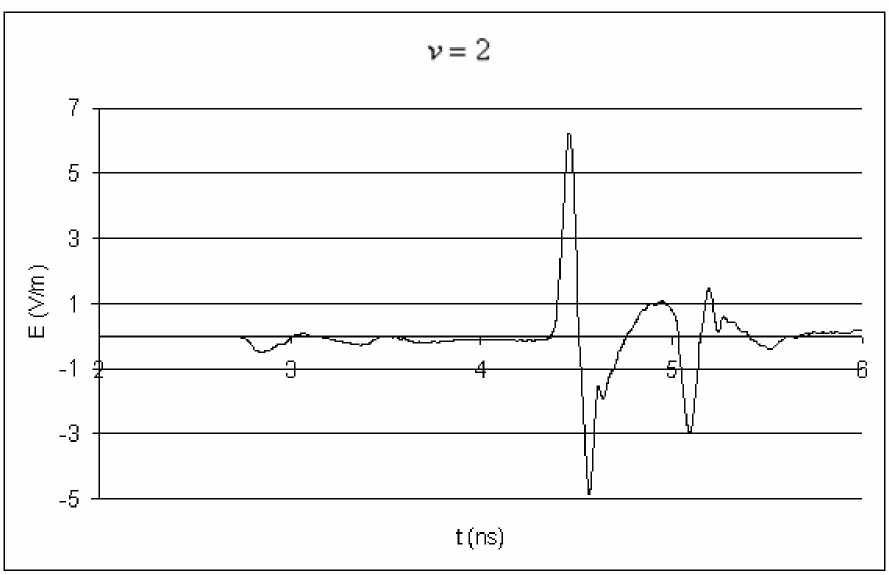


Figure 2 b)Focal waveform of a log periodic lens which has $\nu = 2$

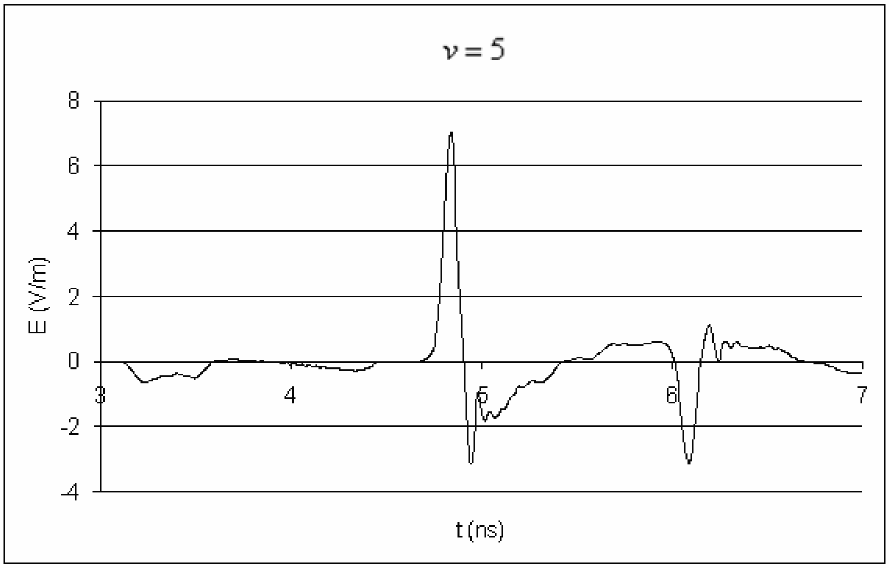


Figure 2 c)Focal waveform of a log periodic lens which has $\nu = 5$

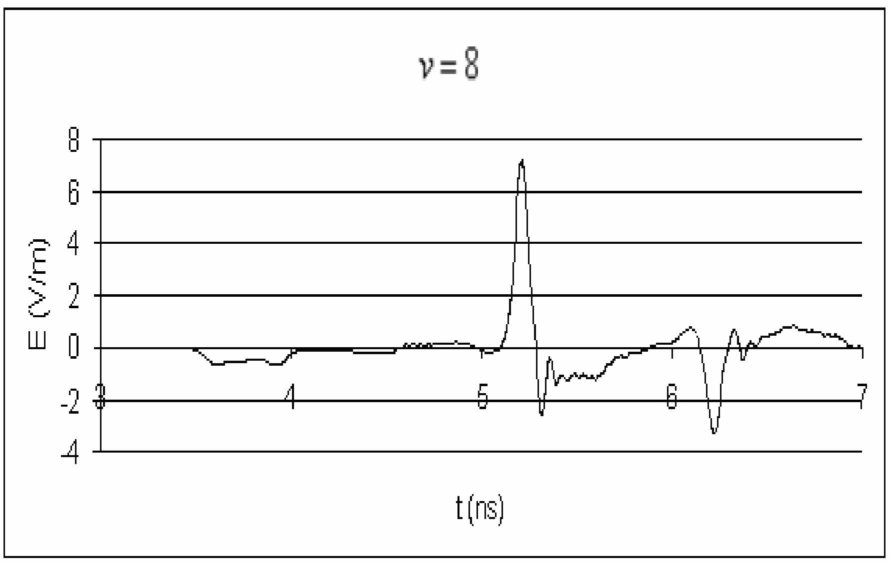


Figure 2 d)Focal waveform of a log periodic lens which has $\nu = 8$

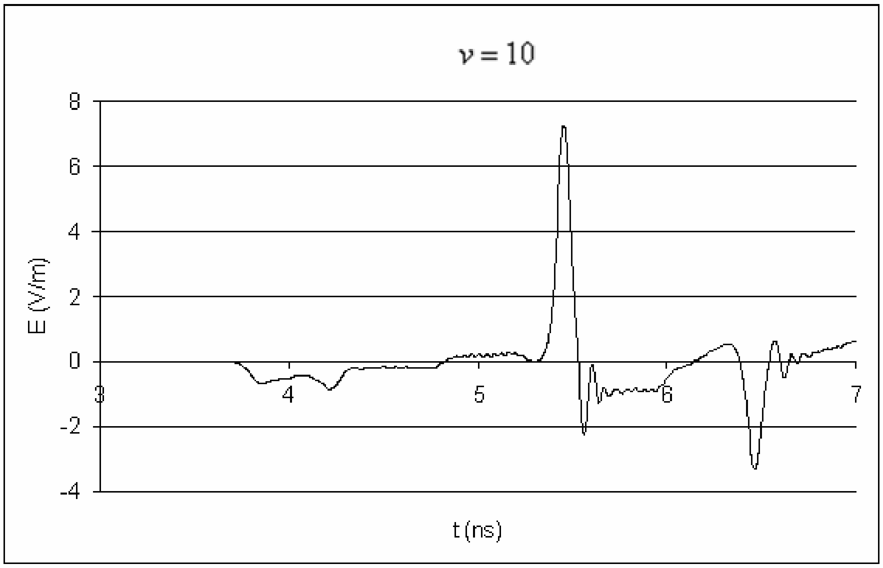


Figure 2 e)Focal waveform of a log periodic lens which has $\nu = 10$

We should determine the radius of the lens. There are two things that one should consider: the larger lens has the higher impulse amplitude. However the larger lens has lower impulse amplitude due to loss and dispersion. The detailed calculations will be discussed later. We will also use numerical simulations and experiments to obtain more information about loss and dispersion.

Figure 3 shows the geometry of the log periodic lens for $\varepsilon_{\mathrm{r\,max}} = 9$ and 5 layers.

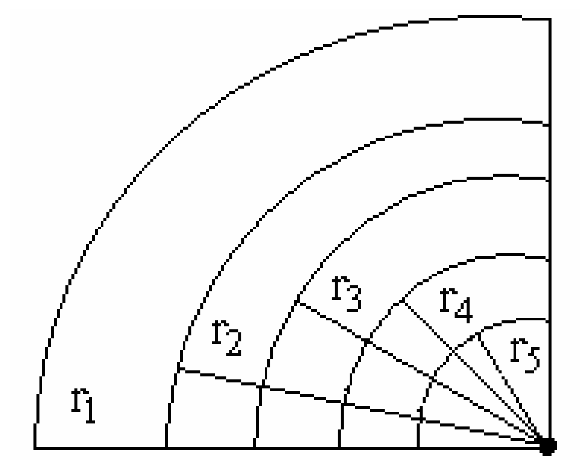


Figure 3 Log Periodic lens for $\varepsilon_{\mathrm{r\,max}} = 9$ and 5 layers

The numerical simulation results for the focal impulse amplitude for different $\nu$ values are presented in Figure 4.

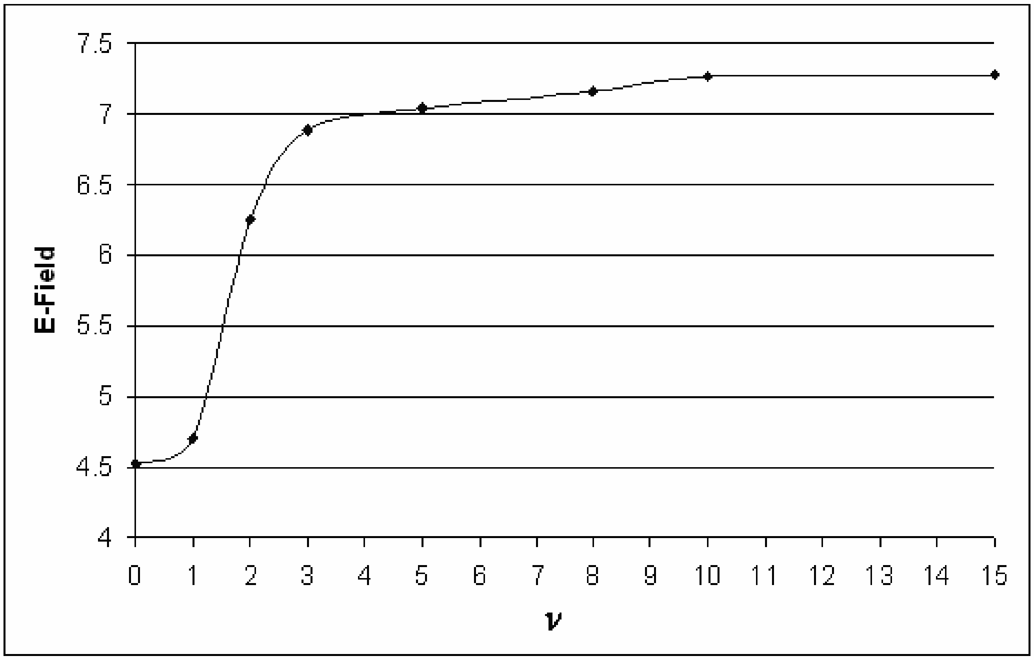


Figure 4 Focal impulse amplitude values for different $v$ values

If we have a continuously increasing dielectric lens we have a total transmission improvement as defined in (5.2) in [1] as

$$\varepsilon_{r\max}^{1/4} = 9^{1/4} = 1.732 \tag{2}$$

However in our case we have 5 layers and the total transmission coefficient was calculated in [6] as

$$T_{total} = \left( \frac{2\left(\varepsilon_{r\max}^{1/N}\right)^{-1/2}}{1+\left(\varepsilon_{r\max}^{1/N}\right)^{-1/2}} \right)^{N} \tag{3}$$

The net transmission improvement can be defined as in (5.2) in [1]

$$\varepsilon_{rmax}^{1/2}\, T_{total} = 1.68 \tag{4}$$

We normalize focal impulse amplitude values for different $v$ values by dividing each value in Figure 4 by the amplitude of the step from prepulse value to peak shown in Figure 2a (0.4 V/m + 4.1 V/m= 4.5 V/m). Then we compare these results with the net transmission improvement.

The normalized focal impulse amplitudes, the amplification factor $A_e$, are shown in Figure 5.

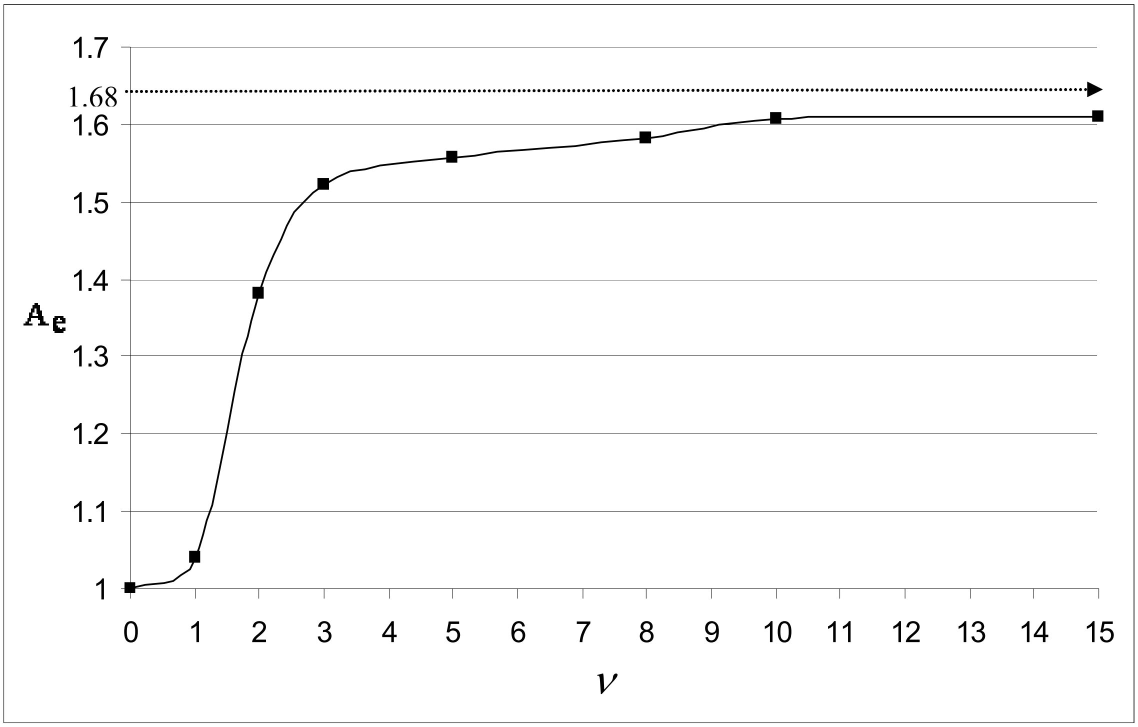


Figure 5 Amplification factors for different $\nu$ values

**4. Conclusion**

The numerical simulations are used to determine the radius of different $\varepsilon_r$ spherical lens with constant wavelength to cross section ratio. Figure 5 shows that

1. $\nu$ values should be bigger than 3 to obtain the exponential increase in the amplification factors $A_e$.
2. After $\nu > 10$ we do not obtain that much amplification and the dimensions are not appropriate for our case [2].
3. $\nu$ values should be $5 < \nu < 8$ based on the present calculation.
4. Loss and dispersion will influence our choice of the radius of the log periodic lens. The detailed calculations will be discussed later. Also our experiments and numerical simulations will give us information concerning the loss and dispersion.

## References


1. C. E. Baum, "Addition of a Lens Before the Second focus of a Prolate-Spheroidal IRA " Sensor and Simulation Note 512, April 2006.
2. Baum, C.E. (2007), Focal Waveform of a Prolate-Spheroidal Impulse-Radiating Antenna (IRA), Radio Sci. , Vol. 42, RS6S27, doi:1029/2006RS003556.
3. S. Altunc and C. E. Baum, "Extension of the Analytic Results for the Focal Waveform of a Two-Arm Prolate-Spheroidal Impulse-Radiating Antenna (IRA)", Sensor and Simulation Note 518, Nov 2006.
4. Serhat Altunc, Carl E. Baum, Christos G. Christodoulou and Edl Schamiloglu ,"Lens Design with Constant Wavelength to Cross Section Ratio as $\varepsilon_r$ Varies: a Log Periodic Lens", EM Implosion Memos Memo 19, Feb 2008.
5. S. Altunc and C. E. Baum, "Lens Design for a Prolate Spheroidal IRA", Sensor and Simulation Note 525, Oct 2007.
6. S. Altunc and C. E. Baum, "Calculating the Optimum Number of Layers for a Lens", EM Implosion Memos Memo 13, Feb 2007