

Analitical results:

Coaxial setup with differents materials

Introduction

In order to analyze the variation of the permittivity of a coaxial cell culture inside when applied to a microwave beam must first determine if our network analyzer have sufficient sensitivity. To obtain the sensitivity to be measured, the S parameters of the coaxial have been analyzed when the interior has different medium. The mediums that will be analyzed are the following:

- Vacuum
- Distilled water
- Sea water
- Cultivation water
- Cell culture (P = 0.1)

Experiment

//Cal definir els parametres de matlab

Expressions

Expressions only valid for $\epsilon_r'' \ll \epsilon_r'$

$$\epsilon_r'' = \frac{\sigma}{\omega \epsilon_0}$$

$$\alpha = 60\pi \frac{\sigma}{\sqrt{\epsilon_r'}}$$

$$\beta = \frac{2\pi\sqrt{\epsilon_r'}}{\lambda_0}$$

$$|S_{21}| = e^{-j\alpha\Delta z}$$

$$\phi_{S_{21}} = -\beta\Delta z$$

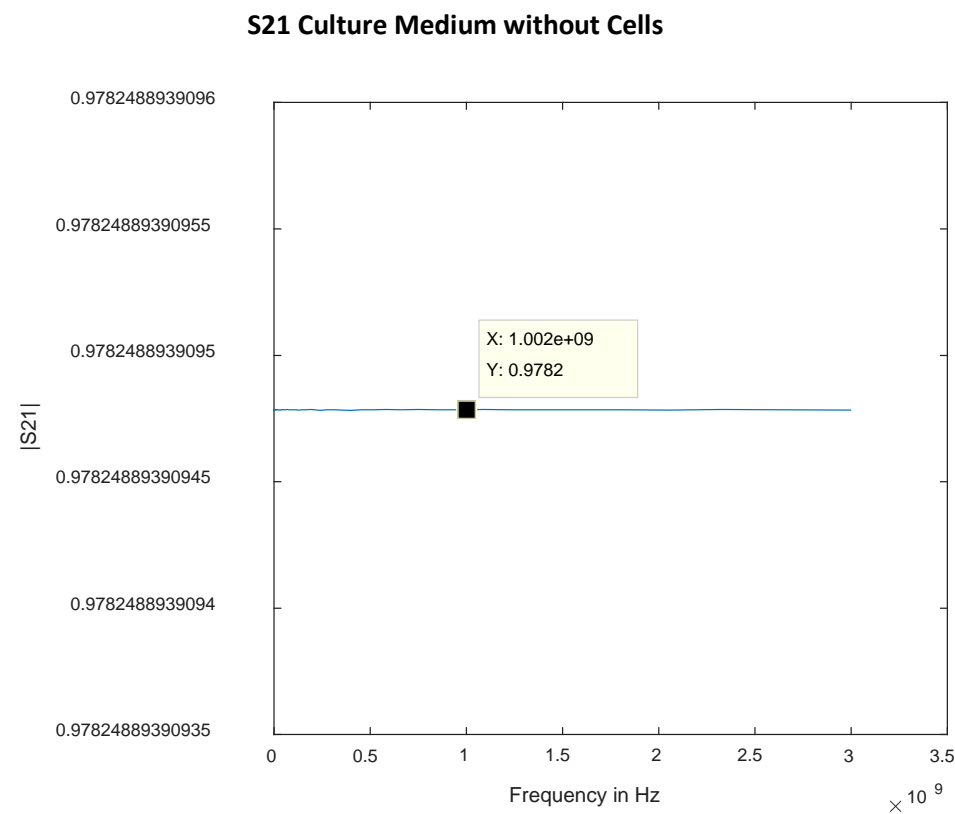
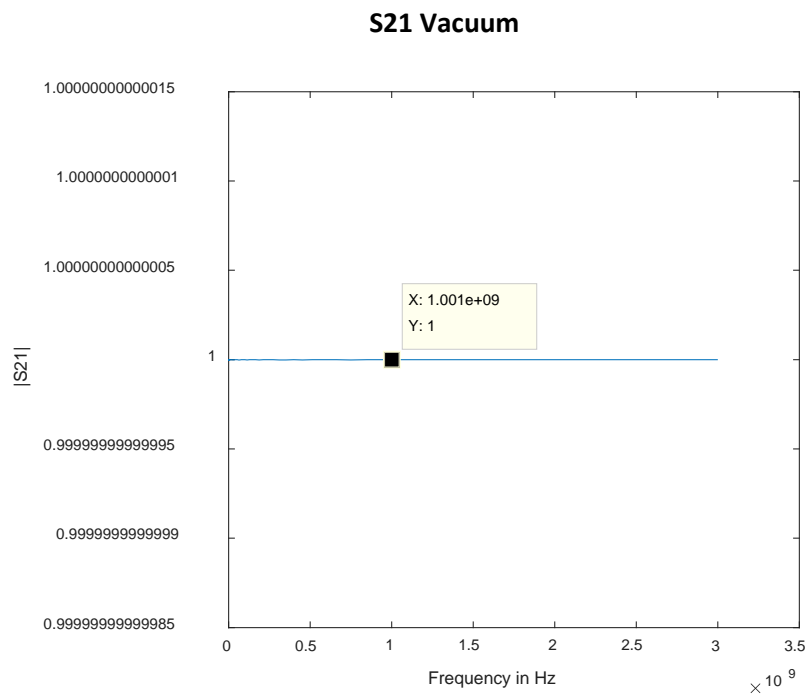
$$\epsilon_0 = 8.854 \cdot 10^{-12}$$

In general

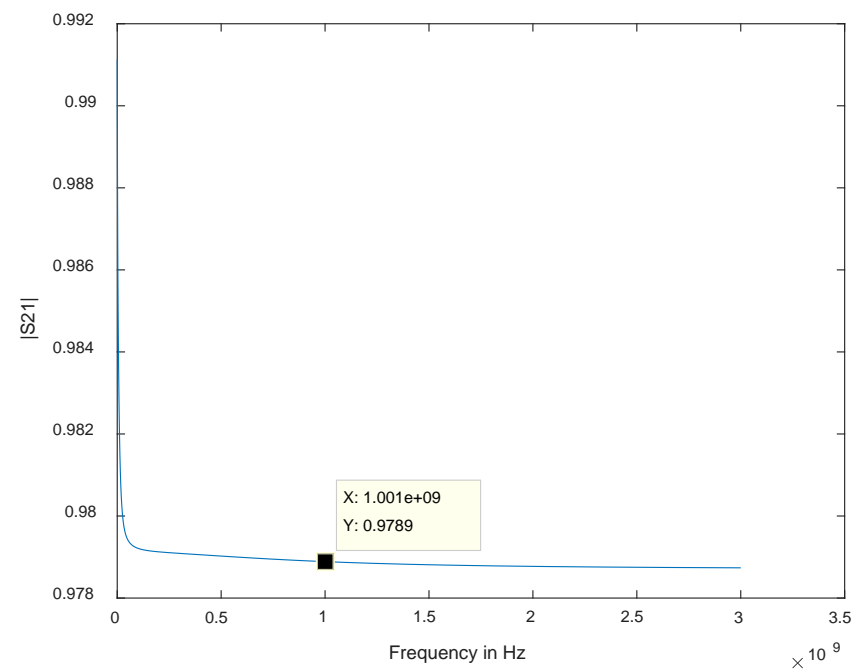
$$\alpha = \frac{2\pi}{\lambda_0} \left[\frac{1}{2} \epsilon' \left(\sqrt{1 + \left(\frac{\epsilon''}{\epsilon'} \right)^2} - 1 \right) \right]^{1/2}$$

Results

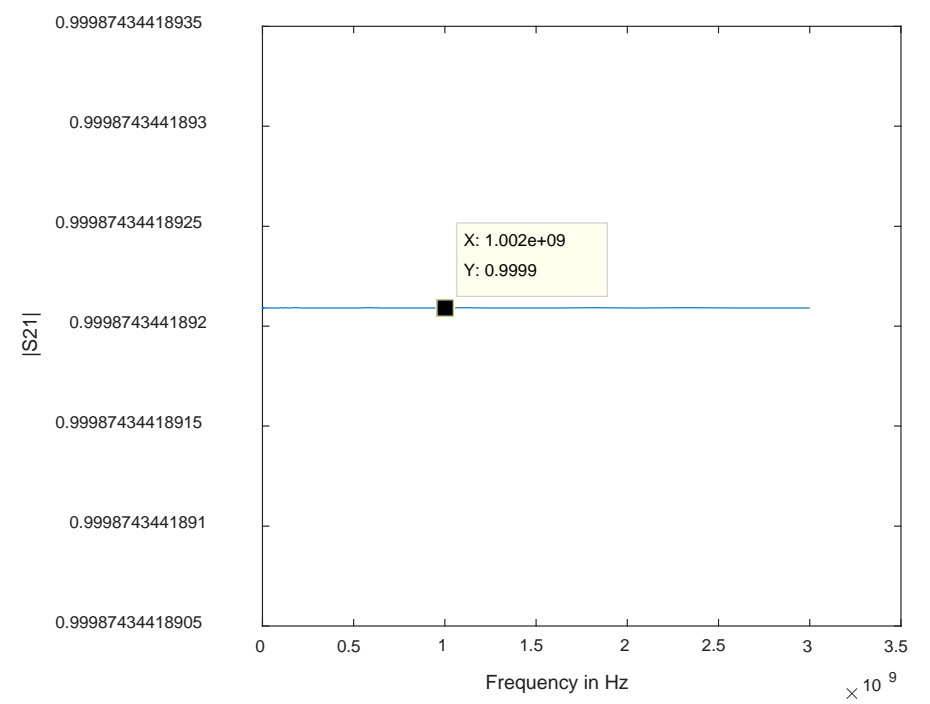
Scattering parameters for differents mediums



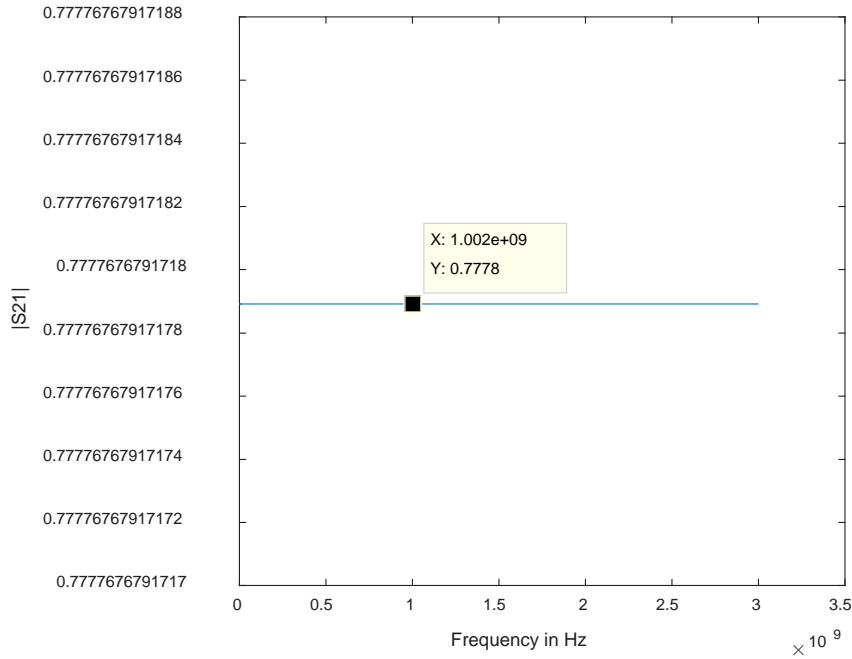
S21 Culture Medium with 0.1% Cells



S21 Distilled Water



S21 Sea Water

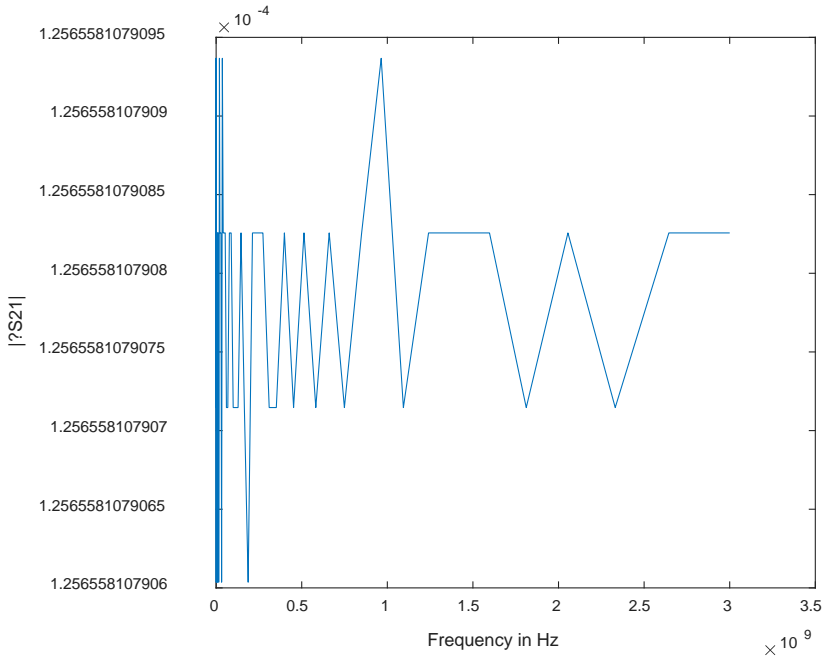


Material (1GHz, $\Delta z=3\text{mm}$)	ϵ'_r	σ	ϵ''_r	α	β	$ S_{21} $	$\angle S_{21}$
Distilled Water	81	0.0002	0.023	0.0042	188.5	0.99998740 -0.00011 dB	- 32.401°
Fresh Water	81	0.0325	3.671	0.6807	188.5	0.99795998 -0.0177	- 32.401°
Sea Water	81	4.0	451.77	83.78 (287.9218 exact)	188.5	0.77775789 -2.1831 dB -7.5025 dB	- 32.401°
Culture Liquid	81	0.35	39.53	7.33	188.5	0.97825002 -0.1910 dB	- 32.401°

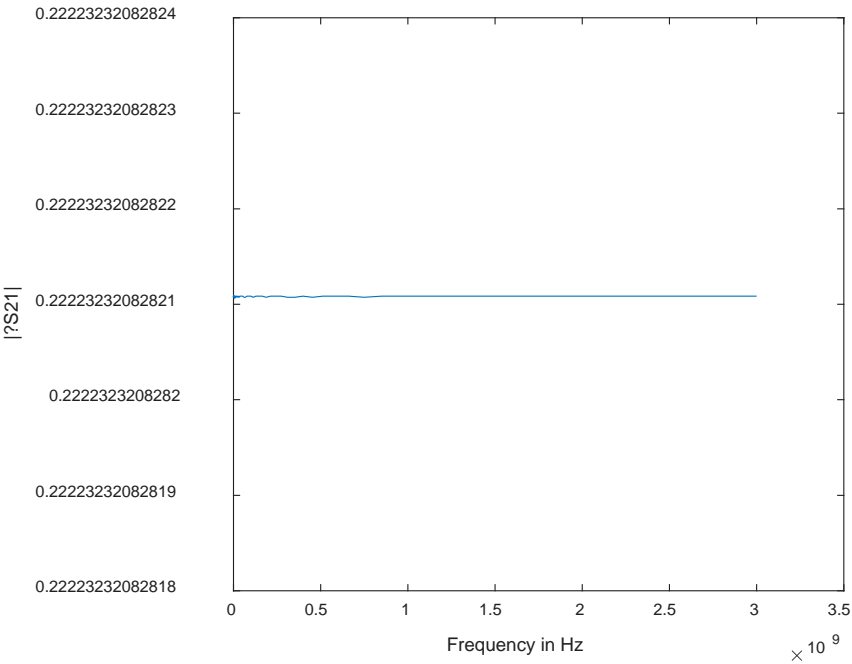
As you can see, the analog results and those of matalab at the 1GHz frequency are the same

Sensitivity

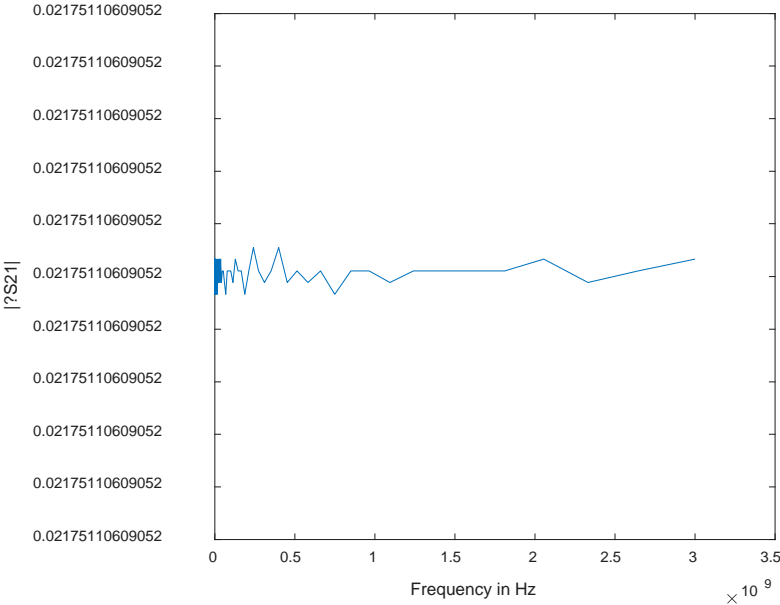
Vacuum – Distilled Water



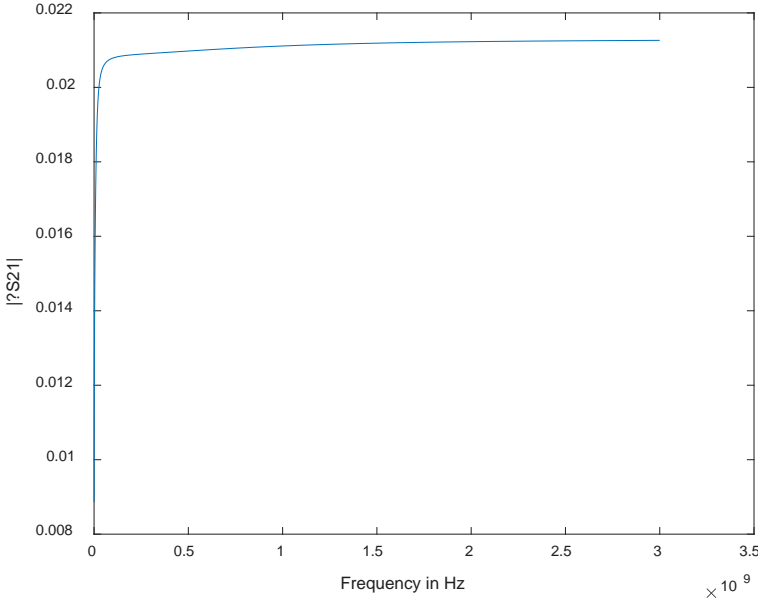
Vacuum – Sea Water



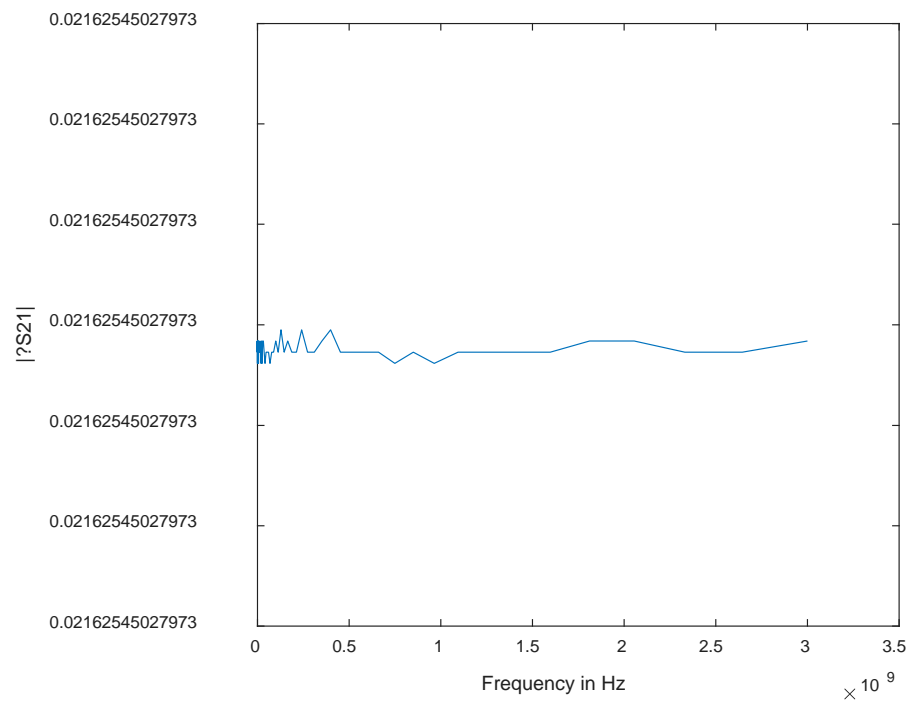
Vacuum – Culture Medium Without Cells



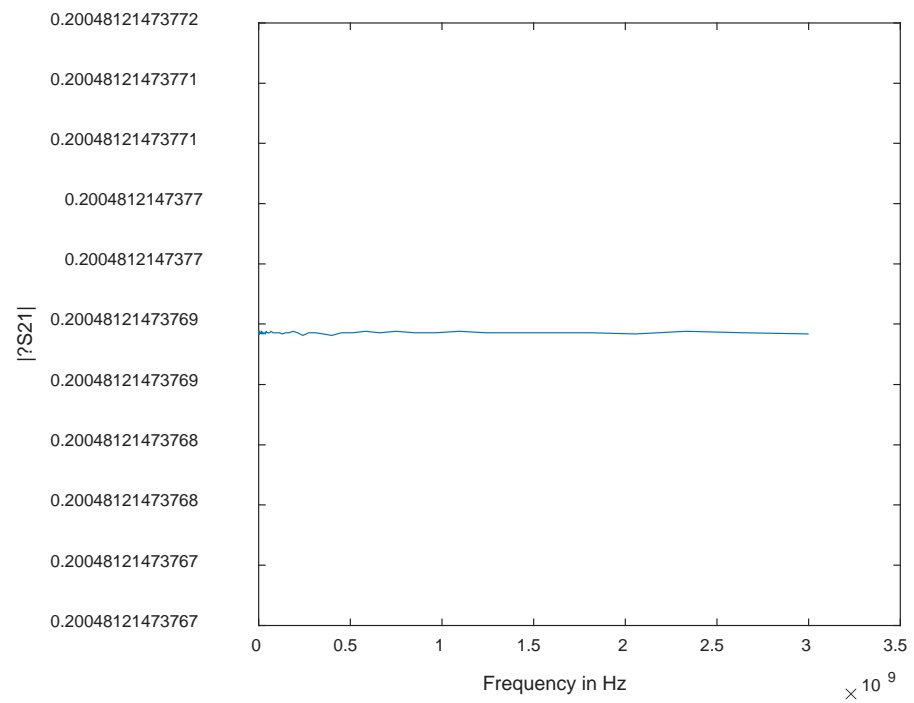
Vacuum – Culture Medium (P=0.1)



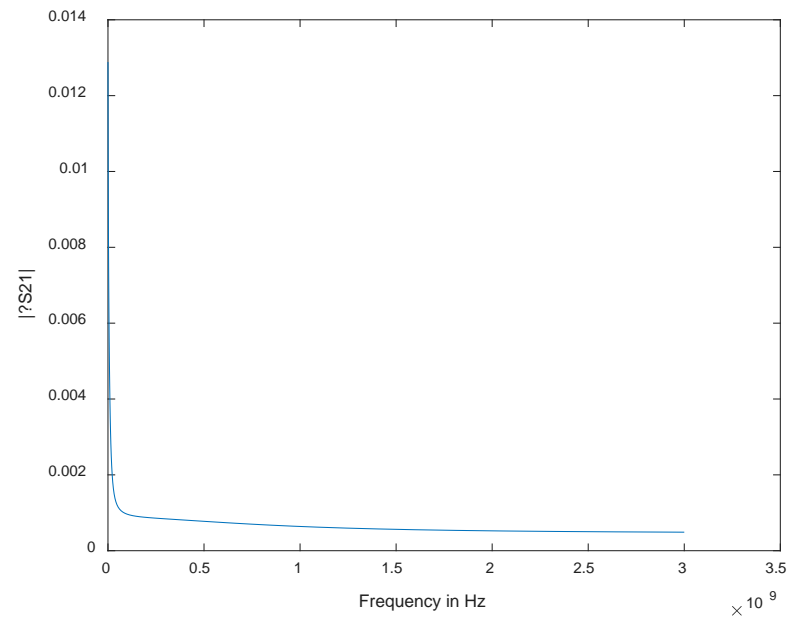
Culture Medium without cells – Distilled Water



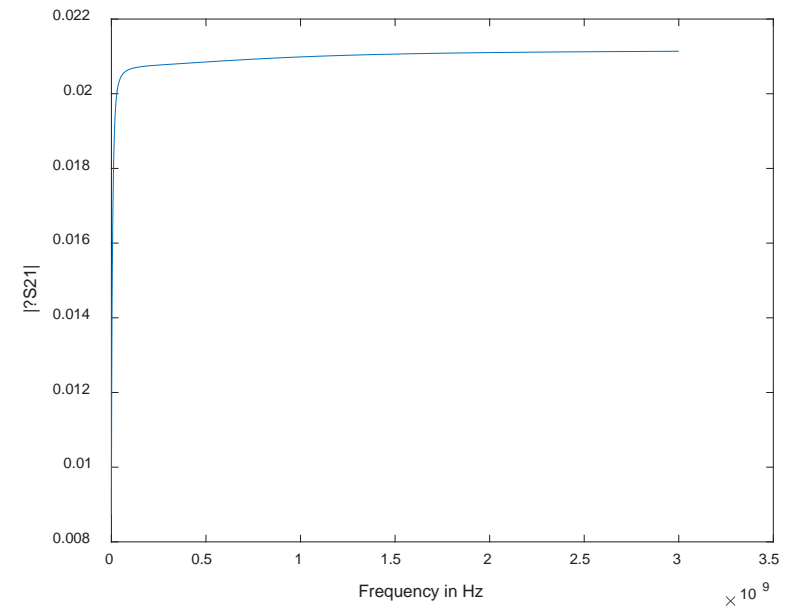
Culture Medium without cells – Sea Water



Culture Medium without cells - Culture Medium (P=0.1)



Culture Medium (P=0.1) – Distilled Water



Culture Medium (P=0.1) – Sea Water

