M1-IRELE

**ELEC-H415 Communication Channels**

# V2V communication project


*Authors :*

Colot Emmeran

*Professor :*

Horlin François


**Academic year :**

2024 - 2025

# Contents

# 1

# Introduction

# 2 Theoretical answers

## 2.1 Step 1

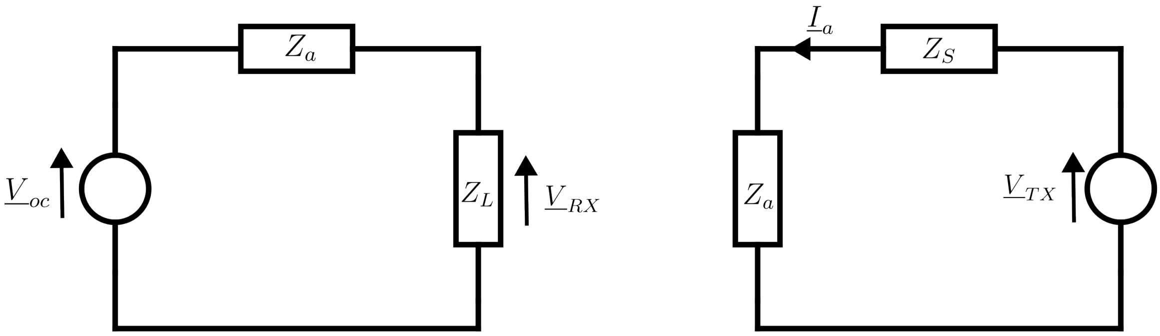


Figure 2.1: Equivalent electric circuit of an antenna in RX (left) and TX (right)

Fig 2.1 shows the equivalent electrical circuit at RX and TX where $\underline{V}_{oc}$ is the induced voltage, $\underline{V}_{RX}$ the voltage at the output of the RX antenna, $\underline{V}_{TX}$ at the input of the TX antenna and $\underline{I}_a$ the current entering the TX antenna.

As both transmitting and receiving antenna are vertical $\lambda/2$ dipoles, their equivalent heights can be analytically computed:

$$\vec{h}_e(\theta,\phi) = \frac{\lambda}{\pi}\frac{\cos(\frac{1}{2}\cos\theta)}{\sin^2\theta}\vec{1}_z$$
$$\vec{h}_{e\perp}(\theta,\phi) = -\frac{\lambda}{\pi}\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\vec{1}_\theta$$

The transverse part of the equivalent height allows to give an expression for the emitted electric field.

$$\underline{\vec{E}} = j\frac{Z_0 \underline{I}_a}{2\pi}\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\frac{e^{-j\beta r}}{r}\vec{1}_\theta$$

To make the transmission parameters appear in the electric field expression, $\beta$ and $\underline{I}_a$ must be replaced using:

$$\beta = \frac{2\pi f_c}{c}$$
$$\underline{V}_{TX} = (Z_a + Z_S)\underline{I}_a$$

Wich yields

$$\underline{\vec{E}} = j\frac{Z_0 \underline{V}_{TX}}{2\pi(Z_a + Z_S)}\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\frac{e^{-j\frac{2\pi f_c r}{c}}}{r}\vec{1}_\theta$$
$$\underline{\vec{E}}\Big|_{\theta=\pi/2} = -j\frac{Z_0 \underline{V}_{TX}}{2\pi(Z_a + Z_S)}\frac{e^{-j\frac{2\pi f_c r}{c}}}{r}\vec{1}_z$$

Where $\theta$ has been chosen equal to $\pi/2$ in order to study only the electric filed in the horizontal place. At the receiving side, the incoming electric filed $\underline{\vec{E}}_i$ is simply equal to the transmitted electric field after it traveled over a distance $r = c\tau$ where $\tau$ is the propagation delay. This is of course in the case of line of sight (LOS) communication with no interfering object (IO) between TX and RX.

$$\underline{\vec{E}}_i = -j\frac{Z_0 c \underline{V}_{TX}}{2\pi(Z_a + Z_S)}\frac{e^{-j2\pi f_c \tau}}{\tau}\vec{1}_z$$

The voltage at the output of the antenna $\underline{V}_{RX}$ can then be deduced using:

$$\underline{V}_{RX} = \frac{Z_L}{Z_a + Z_L}\underline{V}_{oc}$$
$$\underline{V}_{oc} = -\vec{h}_{e\perp}(\theta,\phi)\Big|_{\theta=\pi/2}\cdot\underline{\vec{E}}_i$$

Resulting in:

$$
\begin{aligned}
\underline{V}_{oc} &= \frac{\lambda}{\pi} \cdot \underline{E}_i \\
&= -j \frac{Z_0 c \lambda \underline{V}_{TX}}{2\pi^2 (Z_a + Z_S)} \frac{e^{-j2\pi f_c \tau}}{\tau} \\
\underline{V}_{RX} &= -j \frac{Z_0 Z_L c \lambda \underline{V}_{TX}}{2\pi^2 (Z_a + Z_S)(Z_a + Z_S)} \frac{e^{-j2\pi f_c \tau}}{\tau}
\end{aligned}
$$

# Is the actual formula correct?