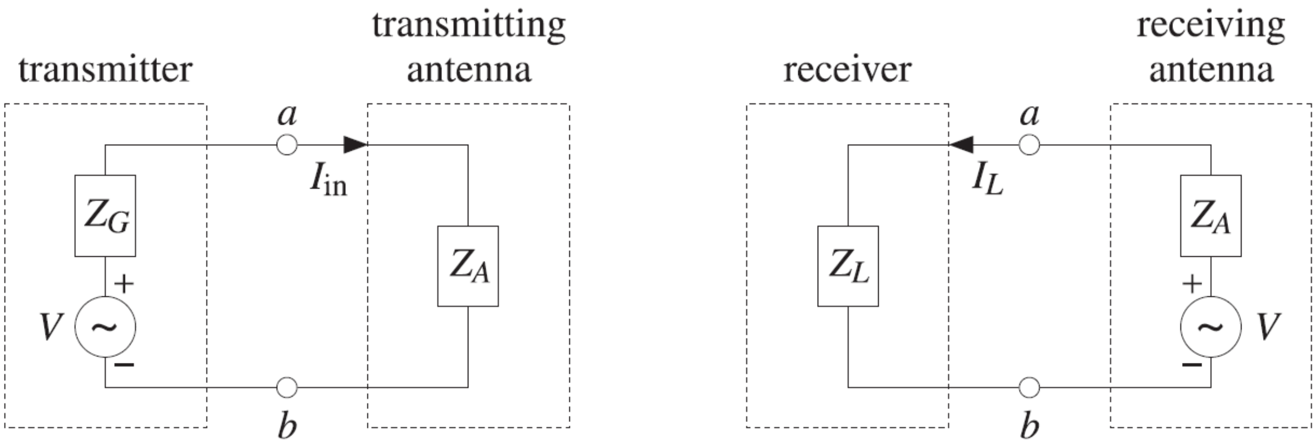
Antennas: Parameters

Impedance

- In Tx and Rx the antenna equivalent circuit of the antenna connected to the transmitter or receiver are:

Kontuz! Antena hartzailea eskuinean dago!!



- In Rx, V is the open circuit voltage of the receiving antenna (V_{CA} circuito abierto in Spanish), as it is the voltage in the antenna terminals when no load is connected.
- V will depend on the E field or power density at the antenna location and on the antenna characteristics.
- If $Z_A \neq Z_L^*$ then some mismatch losses reduce the power at Z_L .

Antennas: Parameters

Impedance

- The antenna impedance is one of the most important parameters. It indicates if a device can be used as an antenna or not.
- To measure the impedance normally the network analyzer is used. The impedance can be obtained from the reflection coefficient as follows:

$$\rho = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

Modulia erabiliko dugu gehienetan (edo guztietan).

- Usually network analyzers provide Z_{in} measurement directly.
- Other measurements related with ρ and consequently with Z_{in} are:
  - Return losses: $-20\log|\rho|$
  - Voltage Standing Wave Ratio (VSWR) *Relación o Coeficiente de Onda Estacionaria (ROE/COE):* $VSWR = \frac{1+|\rho|}{1-|\rho|}$
  - Mismatch Loss: $-10\log\left[1-|\rho|^2\right]$
- In transmission, a mismatch between the transmitter and the antenna can cause important damage in the equipment due to the reflected power. So good matching is a critical factor.

Ejemplos/adibideak- Transmitting antenna 1

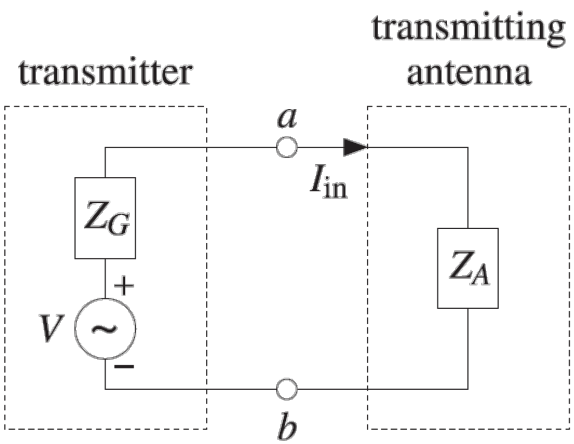
Generator Vg=30 V, Zg=50 Ω

a) Power radiated by an antenna with Za=50 Ω

b) Power radiated by an antenna with Za=75 Ω

b.1) Mismatch losses (linear units and logarithmic units)

b.2) Reflection coefficient. Mismatch losses (linear and logarithmic)



a) $P_{rad}|_{Za=50} = 4.5$ W

b) $P_{rad}|_{Za=75} = 4.32$ W

b.1) Mismatch losses= $P_{rad}|_{Za=75} / P_{rad}|_{Za=50} = 0.96$

Mismatch losses= $10\log10[P_{rad}|_{Za=75} / P_{rad}|_{Za=50}] = -0.177$ dB

b.2) $\rho=0.2$

$$\left[1-|\rho|^2\right] = \left[1-0.2^2\right] = 0.96$$

$$10\log\left[1-|\rho|^2\right] = 10\log\left[1-0.2^2\right] = -0.177\ \text{dB}$$

The generator can provide 4.5 W to a matched antenna. Due to mismatch, the 75 Ω antenna gets 4.32 W. This suppose -0.177 dB mismatch losses. Mismatch losses can also be calculated from the reflection coefficient.

Generator nominal power: the power dissipated by a load which impedance is equal to the generator impedance.

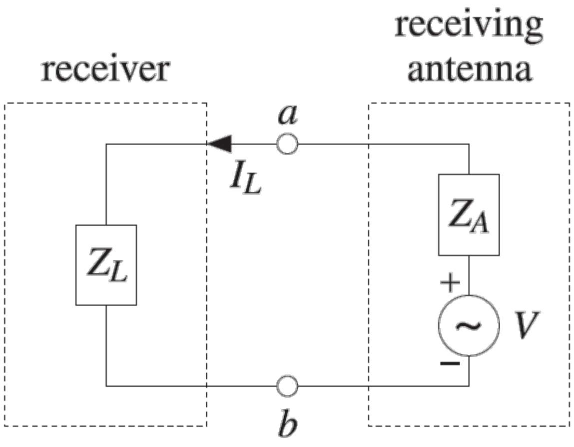
Ejemplos/adibideak- Receiving antenna 1

Receiving antenna Za=50 Ω. Receiver with Z_L=75 Ω

a) Reflection coefficient. Mismatch losses (linear and logarithmic)

b) Ratio between power received by the receiver with Z_L=75 Ω and power received by the antenna (Za=50 Ω).

c) If the antenna takes 1 mW, how much does the receiver take?



a) ρ=(75-50)/(75+50)=0.2

$$\left[1-|\rho|^2\right]=\left[1-0.2^2\right]=0.96$$

$$10\log\left[1-|\rho|^2\right]=10\log\left[1-0.2^2\right]=-0.177\ \mathrm{dB}$$

b) $P_{receiver}$/ $P_{antenna}$ = mismatch losses = 0.96

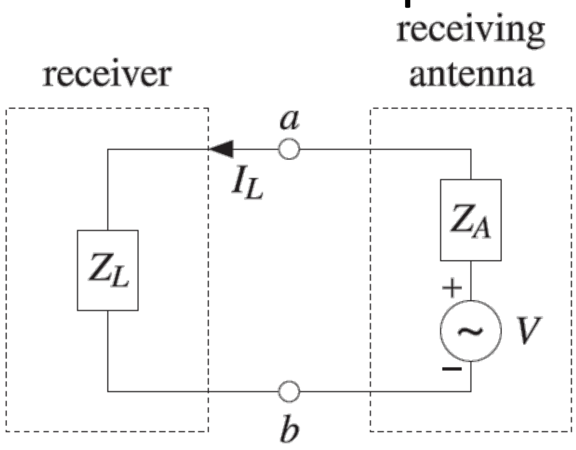
c) $P_{receiver}$=$P_{antenna}$·mismatch losses=1·0.96 = 0.96 mW

$P_{receiver}$(dBm)=$P_{antenna}$(dBm) - mismatch losses(dB)=
=10*log(1) – 0.177= -0.177 dBm

The antenna takes 1 mW. Due to impedance mismatch, the 75 Ω receiver gets 0.96 mW. This suppose -0.177 dB mismatch losses.

Ejemplos/adibideak- Receiving antenna 2

Receiving antenna Z_A=50 Ω taking 1 mW power. How much power would a receiver with Z_L=100 Ω take?



Solution:

Reflection coefficient ρ=(100-50)/(100+50)=1/3

$$1-|\rho|^2 = 1-(1/3)^2 = 0.889$$

$$10\log\left[1-|\rho|^2\right] = 10\log\left[1-(1/3)^2\right] = -0.51\,\mathrm{dB}$$

$P_{receiver}$=$P_{antenna}$·mismatch losses=1·0.889 = 0.889 mW

$P_{receiver}$(dBm)=$P_{antenna}$(dBm) - mismatch losses(dB)=10*log(1) – 0.51= -0.51 dBm

Matched impedances Z_L=Z_A=50 Ω, power in Z_L=1 mW, we can calculate V

$$P_{Z_L=50\Omega} = \left|\frac{V}{Z_A+Z_L}\right|^2 \cdot Z_L \Rightarrow V = \sqrt{\frac{P_{Z_L}}{Z_L}} \cdot (Z_A+Z_L) = \sqrt{\frac{10^{-3}}{50}} \cdot (50+50) = 0.4472\ \mathrm{V}$$

Mismatched impedances Z_L=100 Ω, Z_A=50 Ω

$$P_{Z_L=100\Omega} = \left|\frac{V}{Z_A+Z_L}\right|^2 \cdot Z_L = \left|\frac{0.4472}{50+100}\right|^2 \cdot 100 = 0.889\,\mathrm{mW}$$