BROADBAND MICROWAVE AMPLIFIER FOR TRANSCEIVERS APPLICATIONS TO IMAGENOLOGY SYSTEMS

High Frequencies
Research Center CICESE

By: Ing. Jorge Rodrigo Ortega Solís

Co-autors:
Dr. Ricardo A. Chavez Perez
Dr. José Luis Olvera Cervantes (INAOE)
Dr. José Luis Medina Monroy

INTRODUCTION

This work presents the systematic methodology for the design and construction of microwave amplifiers wideband using the balanced amplifiers configuration in the frequency range of **Ultra Wideband** (UWB) for **imagenology applications**. A balanced amplifier is constituted of a **power divider / combiner** in quadrature to the input and output respectively and two intermediate **stages of amplification.** The system is considered **balanced** when the **two amplifiers are identical**.

Imagenology system of the type[1]:

- **Step-Frequency Radar ,**
- **Synthetic Aperture Radar**
- **Ground Penetrating Radar**

It's used **with great success**, for:

- **Imaging in human tissue,**
- **Fracture detection structures,**
- **View through the walls and subsurface images.**

BALANCED AMPLIFIER

The balanced amplifier architecture employs a combiner / divider (Wilkinson, Hybrid couplers and Lange couplers) of 3 dB with 90° of difference phase and intermediate stage of amplification. The Balanced Amplifier schematic shown in Figure 1.

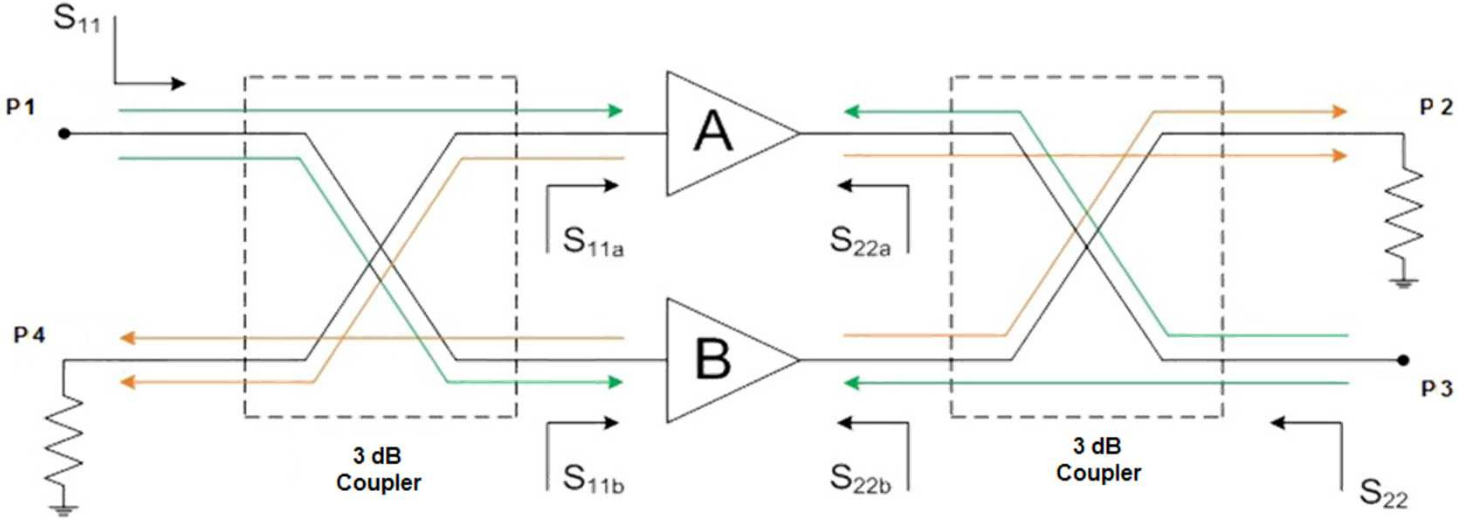


Figure 1. Balanced amplifier schematic.

BALANCED AMPLIFIER

The Balanced Amplifier is important in many high frequency systems because:

- **It exhibits high bandwidth (For this work should be >90% Fractional Bandwidth).**
- **Flat gain.**
- **Good standing wave ratio at the input and at the output.**

TYPES OF DIVIDERS / COMBINERS

- ***Power Divider*[3]**

A power divider is a network of three or more ports for dividing the signal power incident on one of the ports between the other two along a given proportion to each amplifier stage. [4]

- ***Power Combiner*[3]**

Since it is a reciprocal lattice, in reverse to combine the power incident on two or more of the ports of each stage. [4]

TYPES OF DIVIDERS / COMBINERS

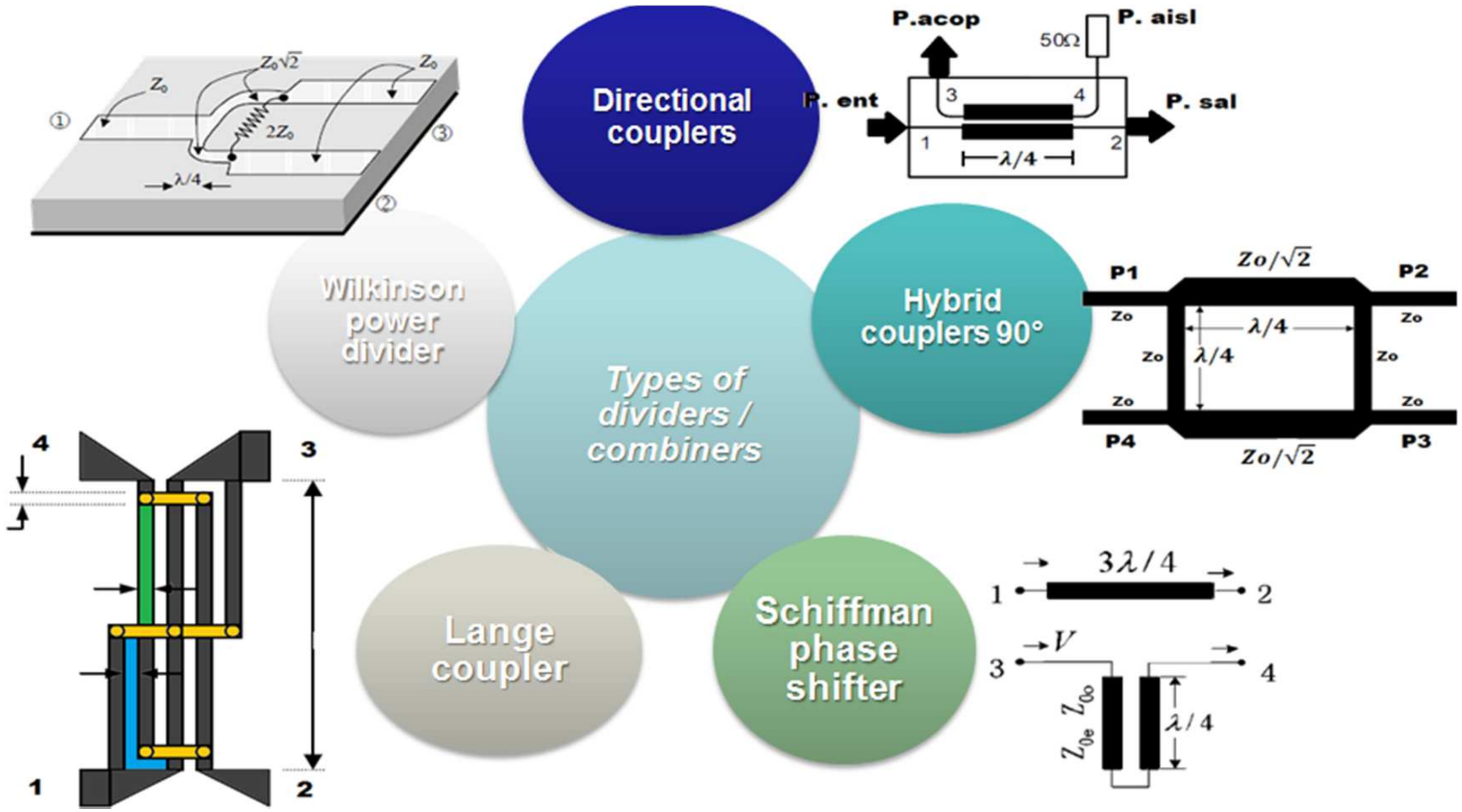


Figure 2. Types of divider / combiners

DESIGN AND CONSTRUCTION OF THE BA WITH ELEMENTS METAMATERIALS

The design of the balanced amplifier to the center frequency of 2 GHz, comprises the following microwave devices:

- Dual-stage Wilkinson divider.
- Metamaterial quadrature phase shifter (important complement to the Wilkinson divider)
- Low noise transistors ATF-36077
- Bias Tee (Element works to feed the transistors)

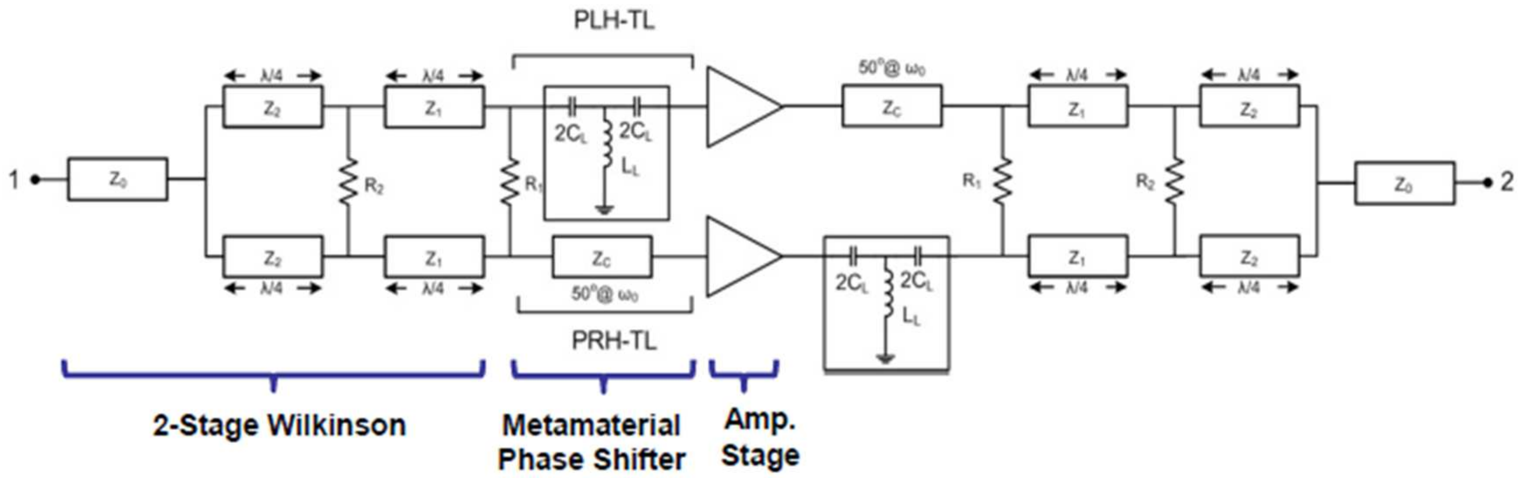


Figure 3. Architecture BA

Dual-stage Wilkinson

The **Wilkinson divider** is divider with the following **method:**

1. From values: $\boldsymbol{W_p = 1.2}$ **and** $\boldsymbol{R = 2}$, reported by Matthaei in Table 6.04-1[4],are the values of $\boldsymbol{Z_1}$ **and** $\boldsymbol{Z_2 = R/Z_1}$ (which are impedance normalized lines).
2. From the line impedance gets the value of the resistances of stage of the divider.

$$\boldsymbol{r_2} = \frac{2z_1z_2}{\sqrt{(z_1+z_2)(z_2 - z_1 cot^2\phi_3)}} \quad (1)$$

$$\boldsymbol{r_1} = \frac{2r_2(z_1 + z_2)}{r_2(z_1+z_2) - 2z_2} \quad (2)$$

Denormalized:

$$\boldsymbol{R_1} = r_1(50\Omega) \quad (3)$$

$$\boldsymbol{R_2} = r_2(50\Omega) \quad (4)$$

Where $\boldsymbol{\phi_3}$:

$$\boldsymbol{\phi_3} = 90^o\left[1 - \frac{1}{\sqrt{2}}\left(\frac{f_2/f_1 - 1}{f_2/f_1 + 1}\right)\right] \quad (5)$$

$$f_2 \big/ f_1 = \frac{-\left(\frac{ABF}{2} + 1\right)}{\frac{ABF}{2} - 1} \quad (6)$$

FBW=1.2

Whose values Z_1, Z_2, R_1 y R_2 are:

$\boldsymbol{Z_1 = 87.78\ \Omega}$

$\boldsymbol{Z_2 = 65\ \Omega}$

$\boldsymbol{R_1 \approx 100\ \Omega}$

$\boldsymbol{R_2 \approx 100\ \Omega}$

DESIGN AND CONSTRUCTION OF THE BA WITH ELEMENTS METAMATERIALS

Metamaterial phase shifter

From the analysis of the metamaterial technology[5][6] , was obtained phase shifter works perfectly Wilkinson divider coupled to the output of each port is obtained at phase difference of $90^0 \pm 10^0$. In the figure shows the composite metamaterial line.

The capacitor and inductor values calculated are the following:

- ***CL = 2.84964pF***
- ***LL = 7.124nH***

And for the transmition line has:

- ***A line of 50 Ω and an electric length Θ=50º***

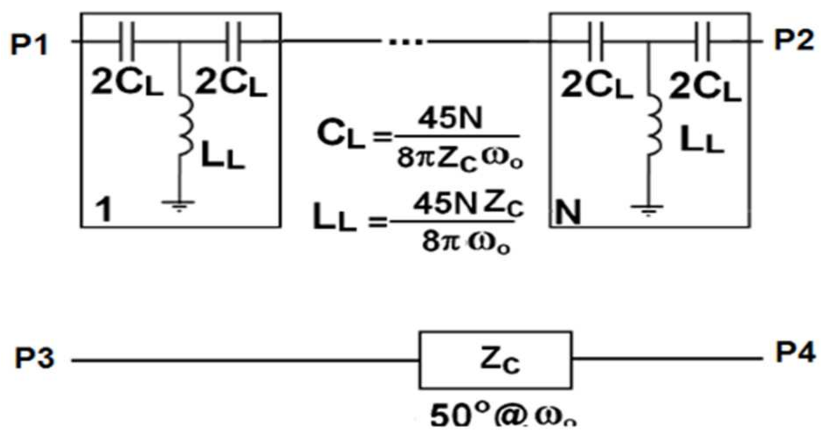
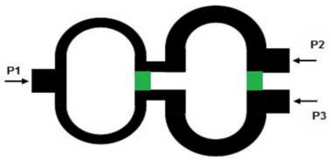
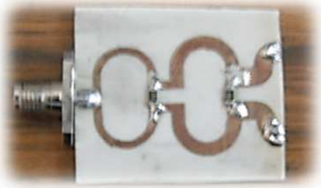


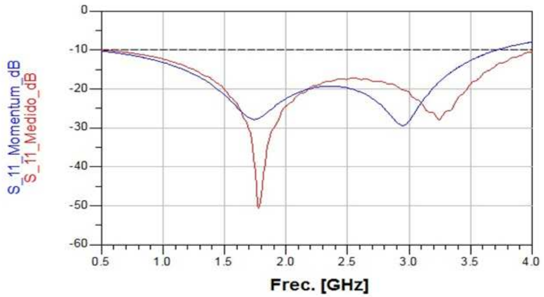
Figure 4. Metamaterial phase shifter

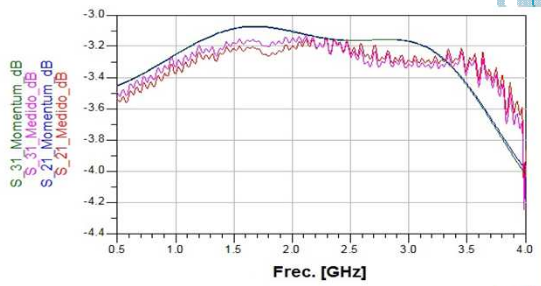
RESULTS (STRUCTURES AND PARAMETERS MEASURED)

a. Dual-stage wilkinson divider

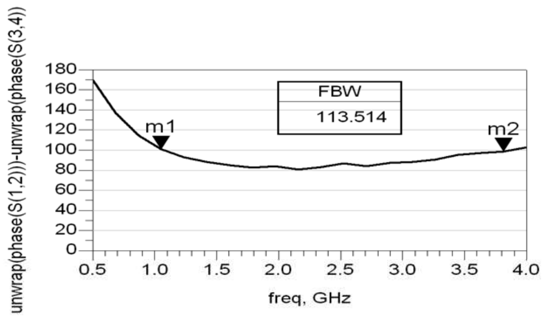




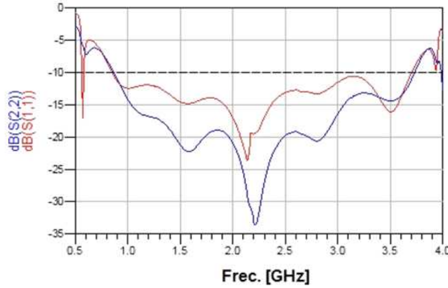


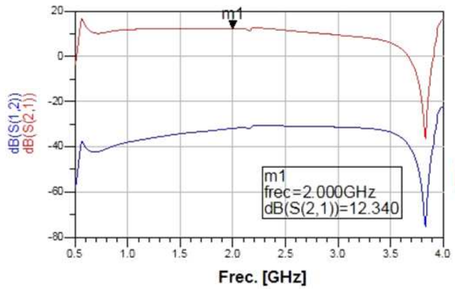


b. Metamaterial phase shifter



c. Balanced Amplifier





Thank you!!!

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