CIRCUIT SIMULATION AND ETCHING OF DISTRIBUTED PHASE SHIFTER MMIC USING LUMPED ELEMENT COUPLER

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ABSTRACT

This paper describes circuit simulation, Printed Circuit Board (PCB) etching and analysis of analogue phase shifter based on distributed Coplanar Waveguide (CPW) transmission lines loaded by a lumped element. The simulation was carried out on ADS2009simulator and layout was generated using TinyCad, electronic circuit PCB system which was etched on a PCB board using iron on PCB method of etching. The simulated results were obtained from ADS2009. Comparing the published measurements of the studied distributed phase shift and the simulated parameters, obtained there was a perfect relation between them which made a good agreement and confirmed the results obtained in this work.

INTRODUCTION

Over the last decades, several advances have been made in analogue and digital. These devices are used to change the insertion phase of transmitted signal. The main and interesting phase shifters are those providing low insertion, return loss, and equal amplitude in all phase states. These criteria are becoming very important for several wireless communications. Most of phase shifters are reciprocal networks, meaning that they work effectively on signals passing in either direction. Phase shifters can be controlled electrically, magnetically or mechanically (Nagra and York, 1999). The main important application is within a phased array antenna system in which the phase of a large number of radiating elements can be controlled to force the electromagnetic signal to add up at a particular angle to the array (Klymyshyn and Kumar, 1999).

In this paper, distributed phase shifter consists of a high impedance line 180Ω capacitive loaded by the lumped element. By applying a single bias voltage on the line, the distributed capacitance can be changed, which in turn changes the velocity of the line and creates a phase shift, the phase shift can be varied in a large variation range depending on the bias voltage and the length of the distributed line.

Design

The circuit topology of the designed Distributed Phase Shift (DTPS) consisting of a 3-dB 90 degree coupler and the distributed loads is shown in Figure.1, input and output are symmetrically matched to 50Ω.The phase of the circuit can be adjusted by the control voltage. Control which is fed through the connected drains and sources of the filter.

Distributed Phase Shifter

The distributed analogue phase shifter is attractive for its simple fabrication and wide bandwidth. The device is realized by periodically loading a high impedance line with variable shunt capacitance. This results in a transmission line with a tunable electrical length. There has been great interest in the design recently, because of its compatibility with ferroelectric and MEMS varactor technologies. Devices operating around 10 GHz usually have lengths measured in centimeter. The long length makes semiconductor or ferroelectric based designs (Hardin *et.al,* 1960). The lower fabrication cost of the alternative technologies make the distributed phase shifter design more practical for low cost applications, but reductions in length can be obtained.

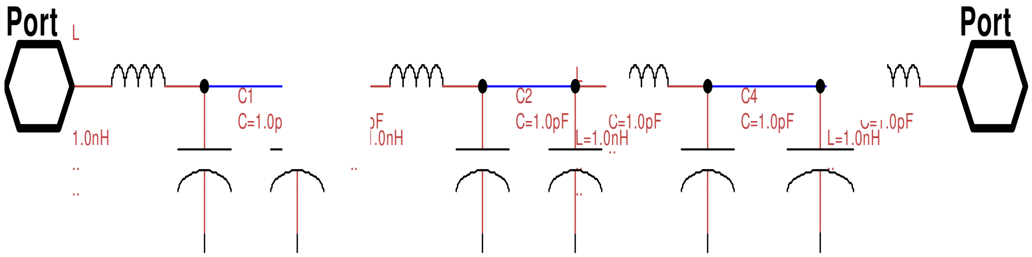


Figure 1. Distributed Phase Shifter Circuit

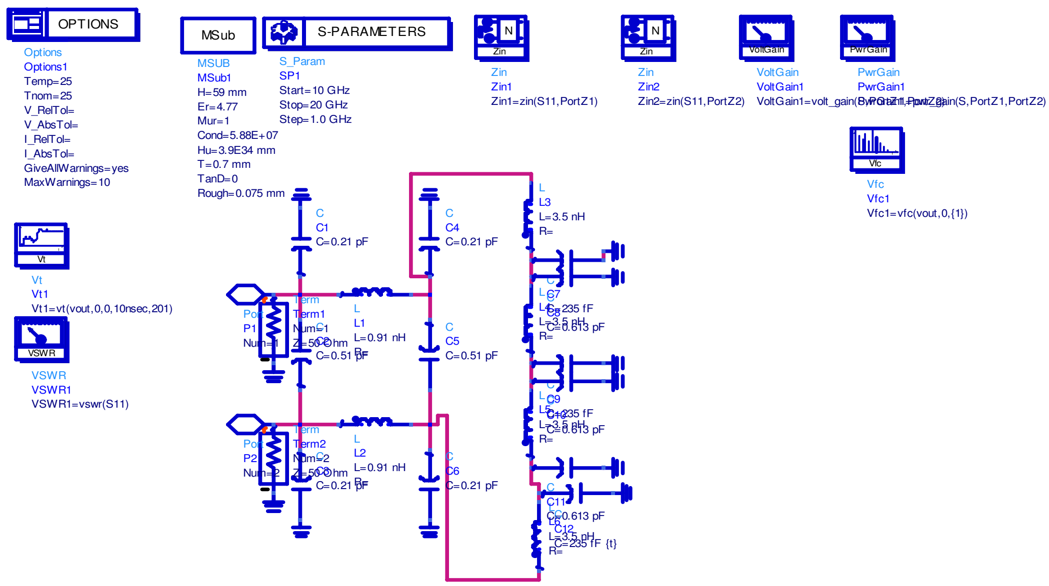


Figure 2.Circuit topology of the DTPS using Lumped Elements

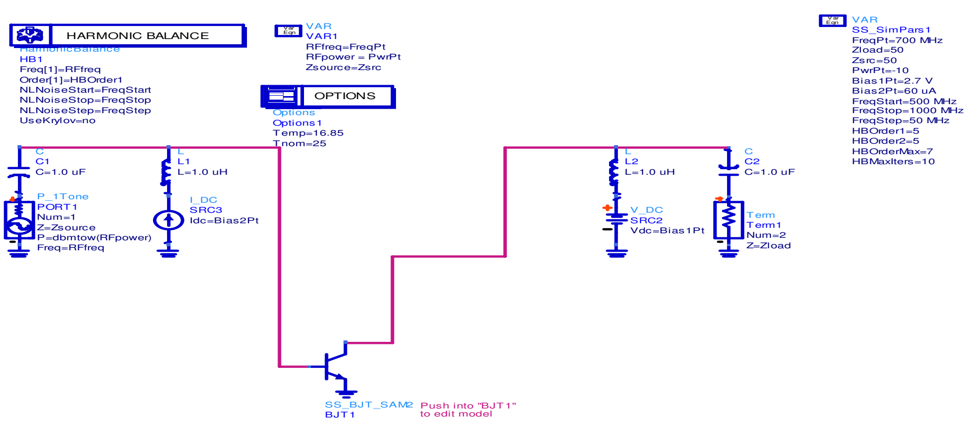


Fig 3: The NPN resolved Circuit

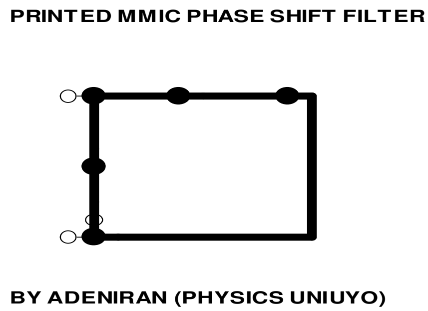


Figure 4: Layout picture of the Simulated MMIC Phase Shifter

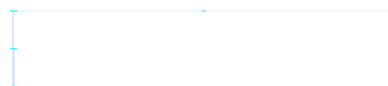


Figure 5: The Graphic Layout for the Printed Filter

PCB printing

A simple circuit model is shown in Figure 1.The distributed inductance and capacitances per unit length of the transmission line are represented as L_o and C_o respectively. These values are derived from the intrinsic characteristic impedance Z_o and phase velocity V_{ph} of the unloaded transmission line. The tunable shunt capacitance per unit length is represented by C_{var} (Nagra and York, 1999).

$$Z_o = \sqrt{\frac{L_o}{C_o}} \quad 1$$

$$Z_o = \sqrt{\frac{L_o}{C_o + C_{var}}} \quad 2$$

$$v_{ph} = \frac{1}{\sqrt{L_o C_o}}$$

$$v_{ph} = \frac{1}{\sqrt{L_o (C_o + C_{var})}} \quad 3$$

3-dB 90-degree Coupler (Lumped Element)

Instead of microstrip lines, the 3-dB 90-degree coupler is realized with lumped elements, which can be calculated as follows (4), (5).

$$c_i = \frac{1}{\omega_o Z_o} \quad 4$$

$$L_h = \frac{Z_o}{\omega_o \sqrt{2}}$$

$$c_2 = \frac{1}{\omega^2 L_h} - c_1 \quad 5$$

The port impedance Z_o=50Ω and angular frequency .Figure 1 shown the simulated losses and phases of the coupler within the bandwidth of 100MHz.

RESULT AND DISCUSSION

The distributed Phase shift (DTPS) MMIC has been designed, simulated and constructed /etched on Printed circuit board (PCB) using iron on board method, the simulation was done using ADS2009 and the circuits were drawn and analyzed as shown in Figure 1-12, where the topography of the circuits were shown and the S-parameter analysis results were obtained as shown in Table 1 below. Table 1 shows the gain, max power gain, radiated power, return loss, Stability B1, Radio Frequency chart and the impedance factor for the circuit shows a perfect correlation to the existing results.

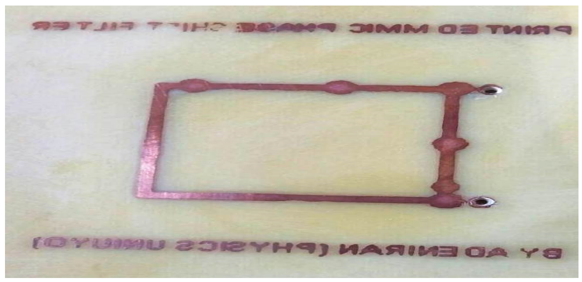
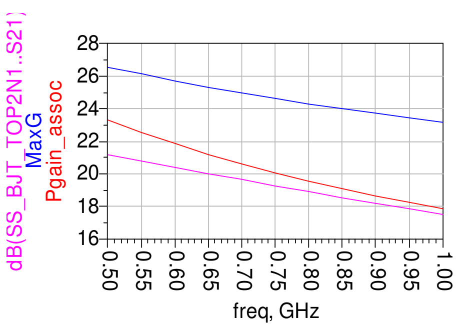


Figure 6: Etched Distributed Phase Shifter MMIC



Figures 7: The graphs for Power Gain in dB

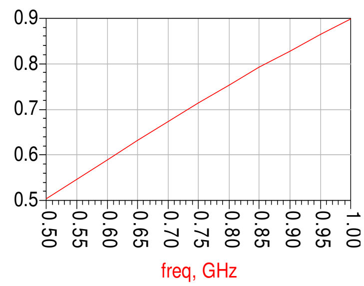


Figure 8: Max. Power Gain against the Frequency

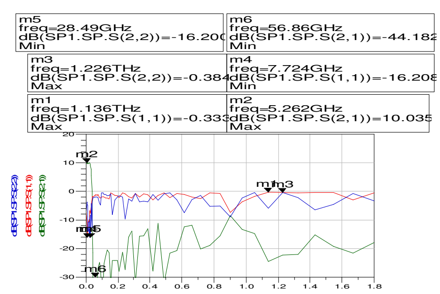


Figure 9: Gain and Return Loss at diff Frequencies

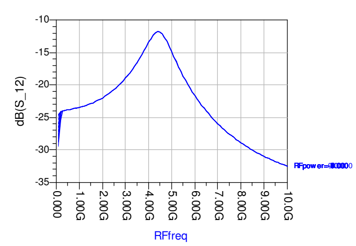


Figure 10: Radiated Power against the frequency

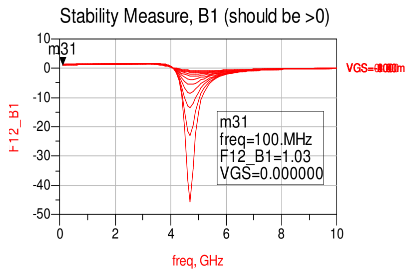


Figure 11: Simulated Stability B1

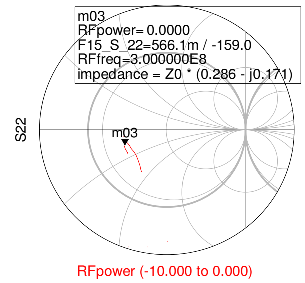


Figure 12: Smith Chart for Radio Freq. Power and the Impedance factor

Table 1: S –Parameters for the MMIC Simulated

S-Parameters	Values
S11 max	-6.88dB
S12	-28.9dB
S21	17.857
S22	-2.967
Power gain	23.421dB
Z source	50.00
NF min	2.785

CONCLUSION

In this research the step by step design, simulation and etching of distributed phase shifter MMIC was done and the performance analysis of the circuits was obtained using ADS2009. The performance analysis shows a perfect correlation in values for the input and output reflection loss, Power gain, Reflection coefficient and the stability factor which are in accordance with the existing works by other authors which made the shifter to be employed in electronics gadget.

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