Antenna Impedance Phase Measurement System

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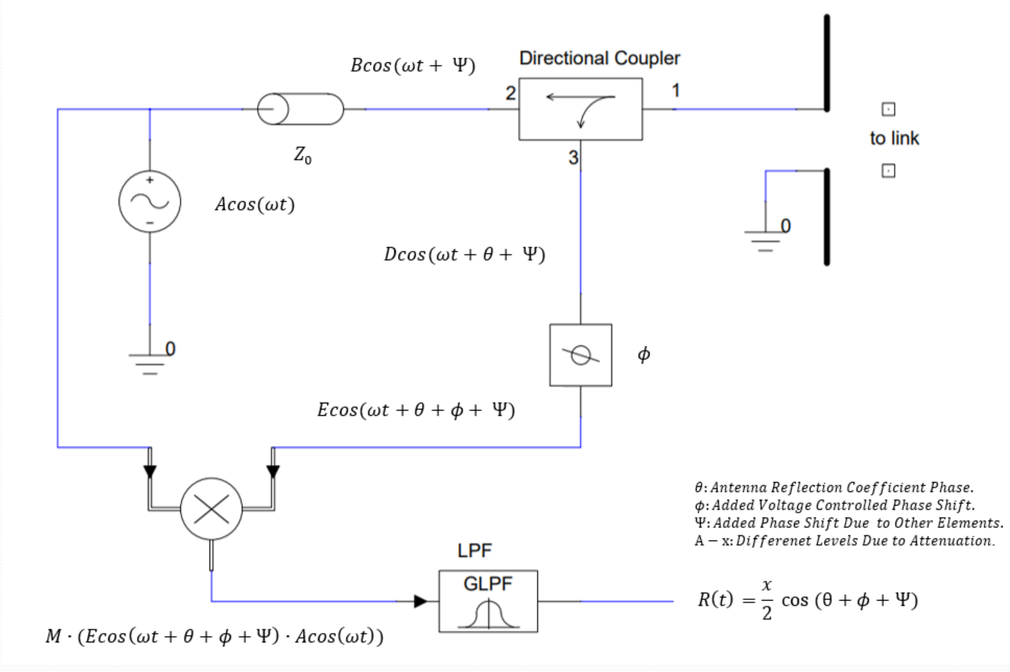
1 INTRODUCTION

A wideband antenna measurement system will be implemented using RFIC custom PCB design. The objective of the project is to develop an antenna measurement system suitable for use in an undergraduate antenna laboratory. In 2021, half of the system was designed and implemented by Efe KİRAZ and Faruk ASLAN HATIK as their final project[1], enabling antenna characterization through a turntable approach. However, the system lacks the ability to measure the phase of the antenna's impedance, which is an essential parameter. The system components will be realized within a budget of $1000 using “off-the-shelf” components and specially designed RF circuits.

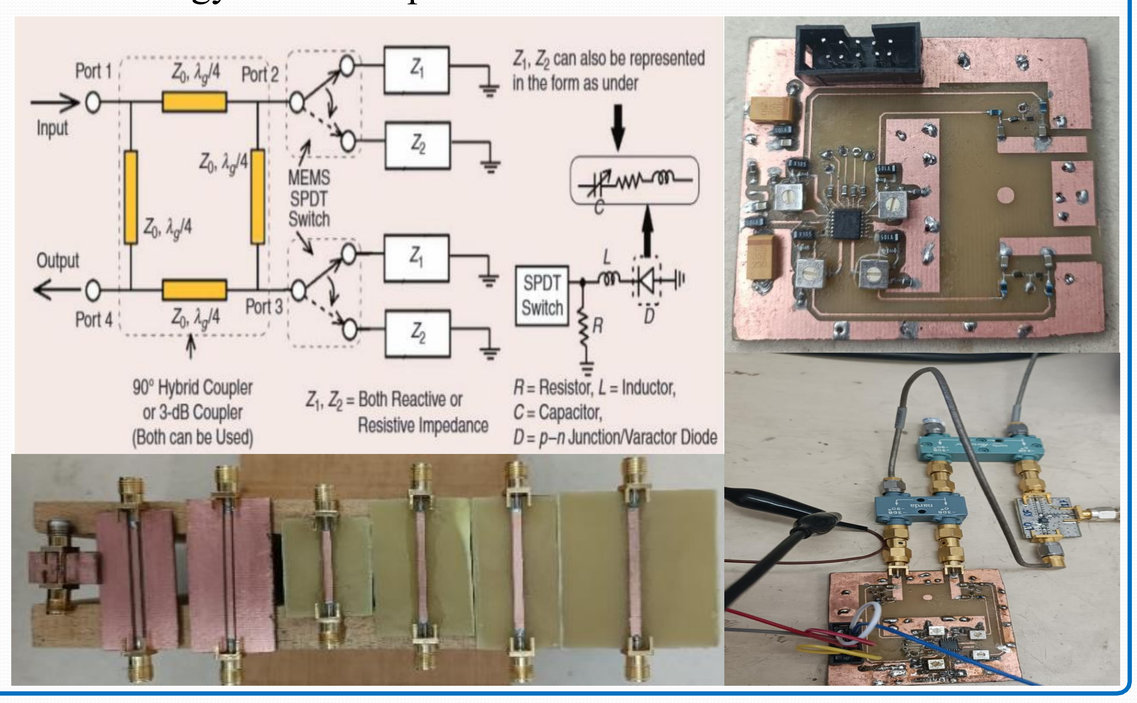
2 METHOD

The phase of the reflection coefficient of the antenna will be measured directly by phase shifting the reflected wave from the antenna and mixing it with the reference signal until a phase lock is detected at which the phase of the reflected wave will be equal to the added phase shift by the phase shifter after performing proper calibration to remove the effect of different phase shifts coming from each component by exploiting their measured S parameters and performing the necessary calculations.



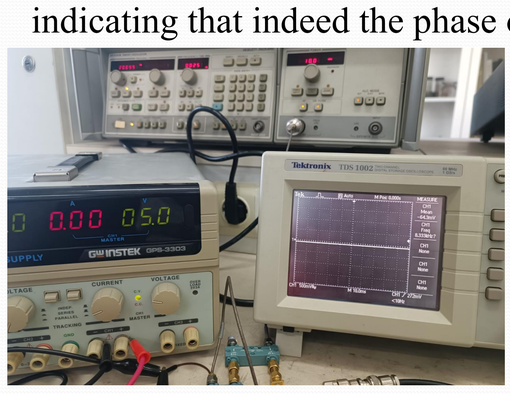
3 EXPERIMENT / SIMULATION

- Before starting the design process the relative permittivity of FR-4 plate was measured by manufacturing different transmission lines, embedding them in HFSS, sweeping material ϵ_r and then choosing the closest S parameters traces to the measured traces with VNA.
- All circuit elements were researched and suitable RFIC were found but no wide band phase shifter was found hence it was designed by implementing varactor diodes and reflection type phase shifter methodology after its capabilities were checked in HFSS.

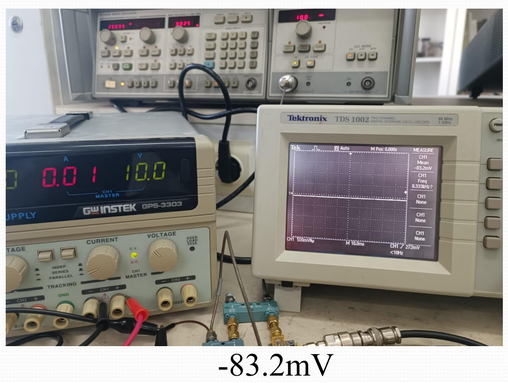


4 RESULTS

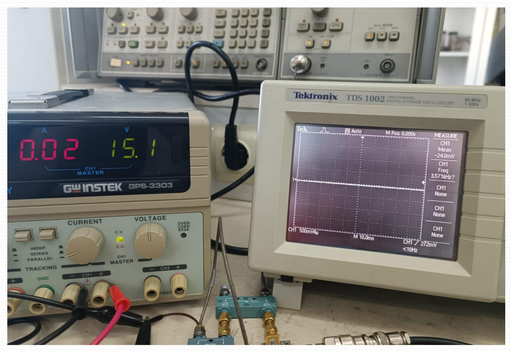
- It was verified that the plate at obtained is indeed FR-4 and its ϵ_r changes between 4 and 4.4 for frequency range 500MHz to 4GHz.
- Constructing the circuit in and controlling the phase shifter with different voltage levels the mixed low pass filtered dc voltage changed accordingly indicating that indeed the phase of the wave is being shifted.



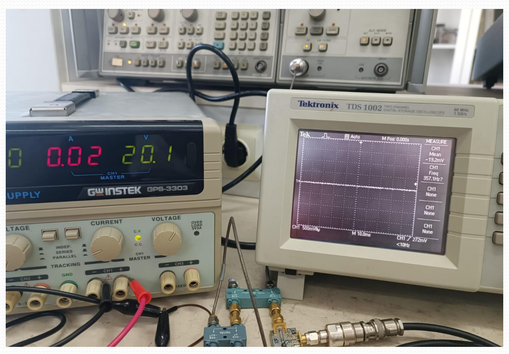
-64.3mV



-83.2mV



-24.0mV



-19.2mV

5 COST ANALYSIS

•Budget Analysis

Component	Unit Price (TL)	Quantity	Total (TL
SMA Connectors	13.5	x20	270
FR-4 Copper Plates	250	x2	500
OPA4172IPWR (OPAMP)	164	x5	794
SMV1281-079LF (Varicap 1-13pF)	41.86	x20	945
SMV1408-040LF (Varicap 1-3 pF)	32.81	x20	779
LQW18ANR27G80D (RF choke)	7.72	x30	187
C0805C104K5RACTU (DC block)	4.53	x30	60.65
4.7kOhm resistor 0603	0.05	x100	5
1kOhm resistor 0603	0.05	x100	5
Kemet, 1uF Tantalum Capacitor 35V	4.55	x70	318.5
Kemet, 10uF Tantalum Capacitor 35V	27.9	x20	557.86
10kOhm SMD Pot	33.61	x20	672.28
Mini Drill Vertical Stand	394.5	x1	394.5
Mini Drill 6-18V (PCB Drilling)	424	x1	424
Raspberry Pi Official Adaptor	355	x1	355
Total	6267.79 TL		

• Environmental Impacts
• PCB&Chemical substances usage & disposal, HF radiation.

• Economical and Social Impacts
• Cost reduction, Commercialization potential, Education and research quality enhancement.

6 CONCLUSION

A wide band HF voltage controlled phase shifter has been designed, implemented and tested which alongside the RFIC components at hand finalizes the phase detection system from the hardware point of view. By mapping each measured voltage level to a specific relative phase shift and performing the necessary calibration the antenna impedance phase measurement system can be finalized and a final PCB will be produced and integrated with the radiation pattern measurement system developed by Efe KİRAZ and Furkan HATIK creating a cost effective solution for antenna measurement and characterization procedure.

7 REFERENCES

[1] KIRAZ, E., HATIK, F. A., and GÜNEL, S., "Standalone Antenna Measurement System," 2022 International Conference on Applied Electronics (AE), Pilsen, Czech Republic, 2022, pp. 1-5.

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