Implementation of a Doppler Radar on PCB

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***Abstract*—This paper demonstrates design and implementation of a Doppler radar. This paper contains schematic and layout designs on Advanced Design System (ADS). Moreover, simulation results are included. The design section of this paper continues with implementation of designed hardware on printed circuit board (PCB). Final section of this paper contains measurements of transmitter part of implemented hardware.**

***Keywords*—Doppler radar, PCB, receiver design, transmitter design, microwave, radio frequency design**

I. INTRODUCTION

Doppler radar is a type of radar that is used to detect velocity of a moving object. Doppler radar sends a continuous-wave signal at a certain frequency to a target. The signal bounces back from the target with a frequency shift due to the phenomenon called Doppler effect (Doppler shift). Frequency shift of the returning signal is used to calculate velocity of the target. Equation (2) is used to calculate velocity of target (v) from the frequency shift. Where f_T is the frequency of the transmitted signal, f_R is the frequency of the received signal, f_d is the frequency shift calculated by (1), c is the speed of light.

$$f_d = | f_T - f_R | \quad (1)$$

$$v \approx c\ (f_d / f_T) / 2 \quad (2)$$

Assuming

$$v << c \quad (3)$$

Fig. 1 provides an illustration of Doppler effect.

Figure. 1: Illustration of Doppler effect

II. DESIGN

A. Structure and Components

Fig. 2 provides structure of the design of the Doppler radar. This design uses two different antennas for transmitting a continuous signal *(f_T)* and receiving the return signal *(f_R)*, named Tx and Rx respectively. A power amplifier (PA) placed before the Tx to increase the range of the system. GALI-24+ is used as a PA in this design. 1214 Mhz (at 25ºC) contunious signal provided to the system by a Local oscillator (LO). POS-1400+ is used as the LO of this design. Frequency of the transmitted signal was selected according to output power of the LO, which provides the highest power output, 13.14 dBm, at 1214 Mhz (at 25ºC). To divide the power of the LO to the PA and mixer (Mix) a directional coupler is used. Isolated port of the coupler is connected to a 50Ω resistor. Coupler designed to provide the highest possible signal power while providing enough signal power (7 dBm) to the mixer. In this design, a passive mixer, LRMS-30J+ is used. Received return signal from Rx is amplified by a low noise amplifier (LNA), RAMP-33LN+. Amplified return signal and output signal of coupler is appled to the mixer. Mixer generates f_d signal with harmonics. To remove these harmonics, a low pass filter (LPF) is used after mixer output (IF signal). LFCN-400+ is used as the LPF.

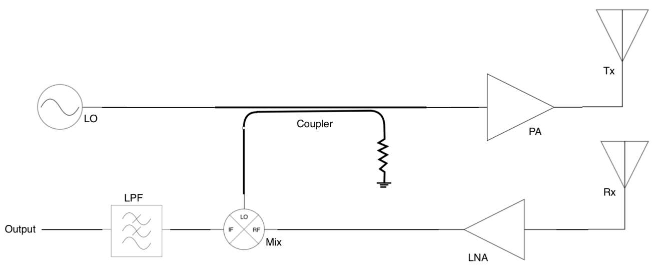

Figure 2: Doppler Radar Schematic

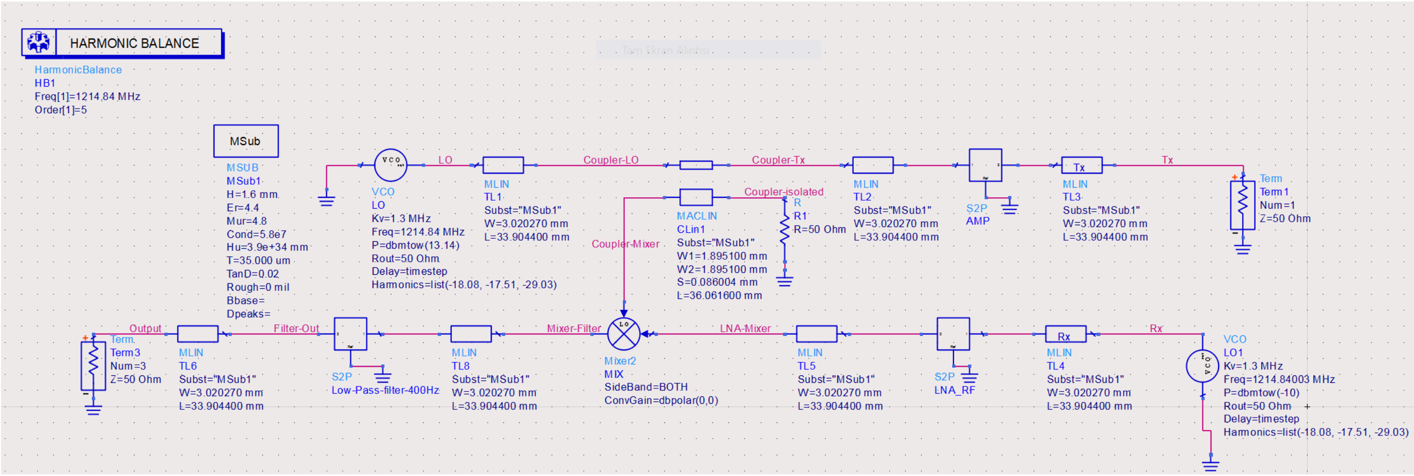

Figure 3: Schematic and simulation parameters at ADS

B. Schematic on ADS

Keysight's Advance Design System (ADS) is used to simulate designed Doppler radar. Fig. 3 provides the view of schematic on ADS with harminic balance simulation settings. As substrate FR-4 will be used thus its properties added as MSUB. Demensions of coupler and transmission lines are calculated using LineCalc tool of ADS. To model the amplifers and the filter s-parameter files provided by manufacturer's website (minicircuits.com) is used. For local oscillator a VCO model is used. Properties of the VCO model is entered from the data sheet of the POS-1400+. Tx and output ports ended with a term (50 Ω resistor) and Rx port is connected to another VCO with the same properties, except power and frequency. Power of second VCO is reduced and frequency of second VCO is increased to model loss at the path and Doppler effect of return signal. Between all components, transmission lines placed. Simulation results can be found at fig. 4. Signal names at fig. 4 can be seen at fig. 3.

C. Layout

Again ADS is used to layout design and convert designed layout to gerber file so that it can be printed. Pads for the companents are drawed from data sheets. Transmission lines and the coupler is automatically generated by ADS. Two huge ground

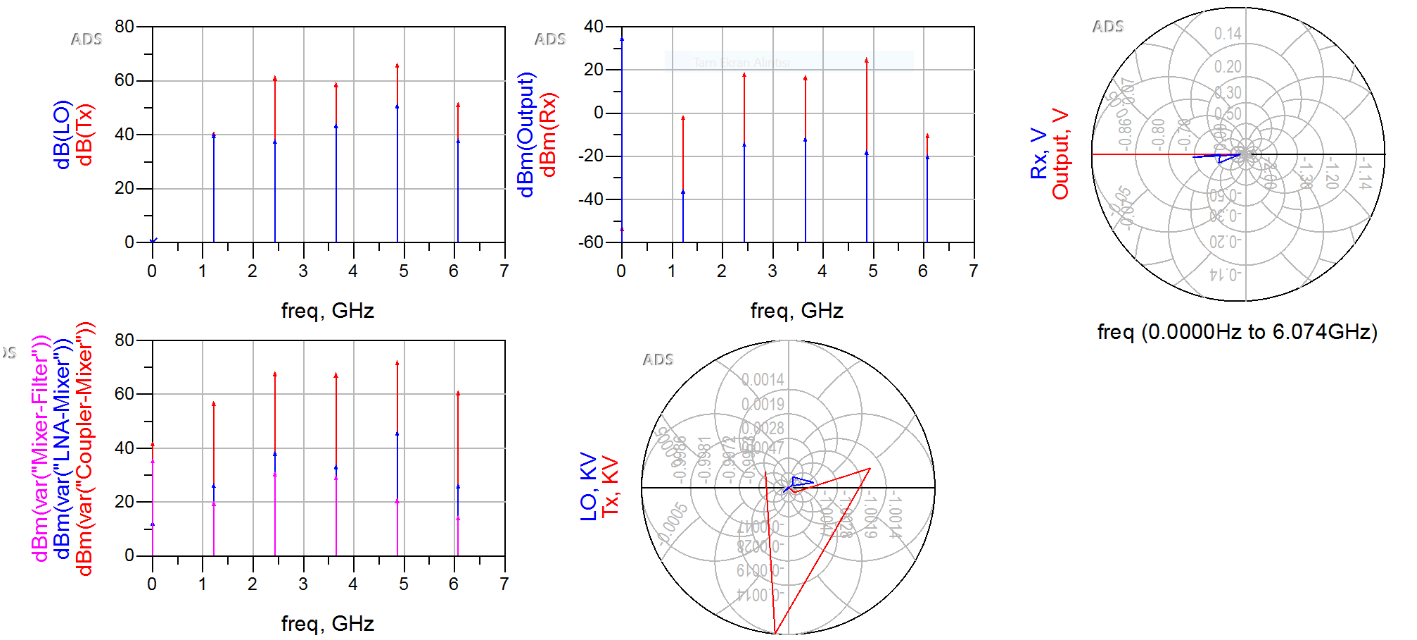

Figure 4: Schematic simulation results

plates were added to obtain better ground and increase accessibility of the ground for discrete components. All ground plates were connected each other. DC bias ports of the components were connected to edge of board like Tx, Rx and output ports. Fig. 5 provides the layout design. RF simulation results were similar to fig. 4.

III. IMPLEMENTATION

After designed circuit had been printed, PCB was modified a little. Bias circuitry and DC block capacitors for GALI-24+ were added. Two big ground plates connected with the bottom of PCB via wires and top (and bottom) of these wires soldered. Little holes created to place pins of POS-1400+ on PCB, and these pins were soldered. Connectors (for output, Tx and Rx) and wires (for DC bias) soldered to use radar. Remaining companents were soldered using liquid solder, however liquid solder caused many problems thus it was removed. These components soldered again using classical solder. Two more wires were added to measure signals before output.

Fig. 6 provides a final view of PCB. Components and connections at fig. 6 were numbered as follows:

1. Local oscillator (POS-1400+)
2. Directional coupler
3. Power amplifier (GALI-24)
4. Low pass filter (LFCN-400+)
5. Low noise amplifier (RAMP-33LN+)
6. Ground plates

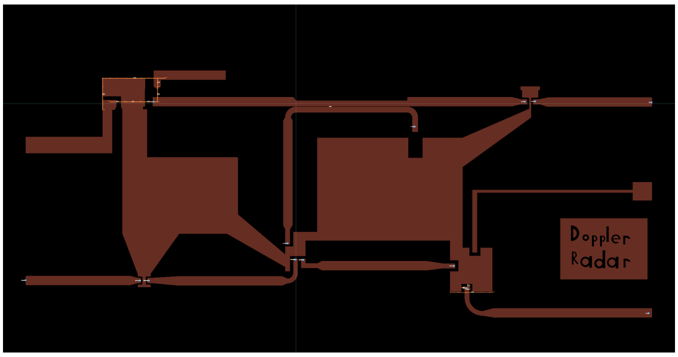

Figure 5: Layout

7. DC bias wires
8. Tx connector
9. Rx connector
10. Output connector
11. Wires to measure signal at corresponding line
12. Label (has no other functionality)
13. Mixer (LRMS-30J+)

Transmisson circutry was measured and results can be found at fig. 7. However due to the soldering problem measurements for Rx were not done.

IV. CONCULUTION

Step by step explanation of design and implementation of Doppler radar on PCB has been presented. Also basic information about working principle of Doppler radar provided.

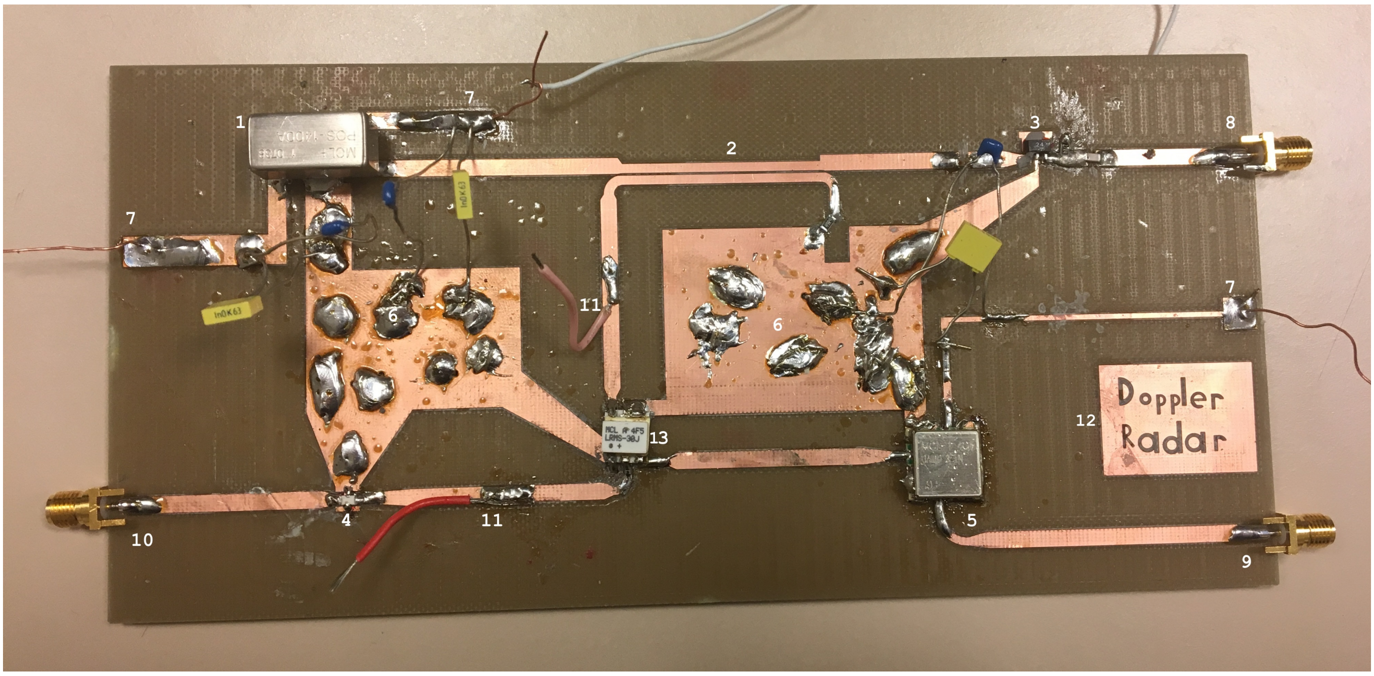

Figure 6: Final stage of designed PCB

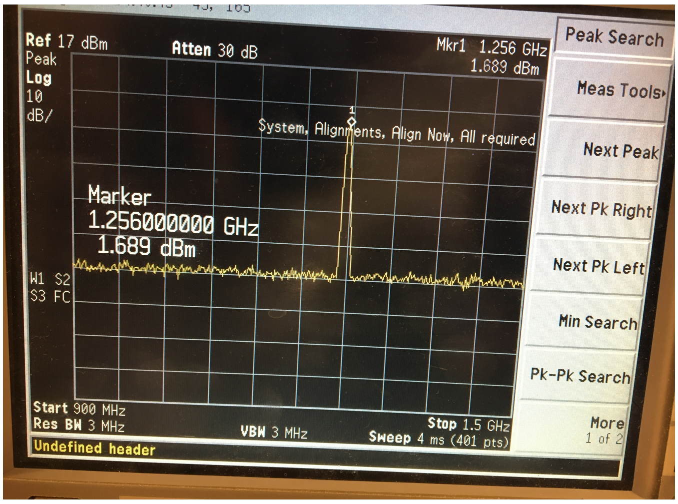

Figure 7: Tx measurement

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