DOPPLER SIMULATOR FOR 10 GHz RADAR PROJECT

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Outline

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1. Motivation

- To design Phase Shifter.
- To design bias circuit for the Phase Shifter.
- Realization and test of both circuits (Doppler Simulator) with Doppler Radar.

2. Phase Shifters & their types

Phase shifter is a two port device which by virtue of its design provides change in the phase of RF signal.

- The phase of a signal of wavelength λ passing through a line of length l at a velocity of v is as follows

$$\varphi = \frac{2\pi l}{\lambda} = \frac{2\pi f l}{v} = 2\pi f l\sqrt{\mu\epsilon}$$

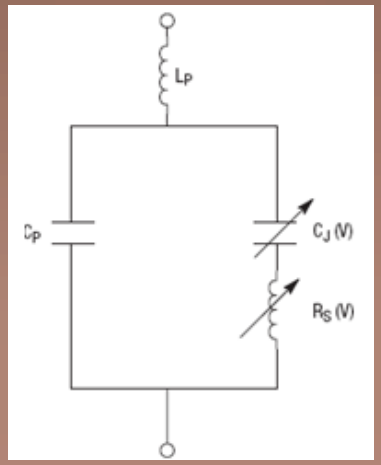
- Parameters like frequency, length, permeability, permittivity, and velocity are considered in the design of any particular type of phase shifter.
- Depending on whether the phase shift is obtained by mechanical or electronic tuning, the phase shifter can be electronic or mechanical.

2. Phase Shifters & their types

- Based on the way of operation, they can be grouped as analog or digital.
- Another way of classifying the phase shifter is by considering the type of transmission media (e.g. waveguide, planar transmission line etc.) used in designing the phase shifter.
- The technology for fabrication (planar hybrid, or monolithic) is another way of classifying the phase shifter.

3. Varactor Diodes and Operational Amplifiers

Varactor Diode is a semiconductor diode which is voltage dependent variable capacitor also known as varicap or voltacap, or voltage-variable capacitor diode.



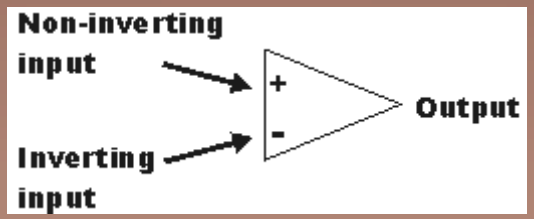
3. Varactor Diodes and Operational Amplifiers

- It is a reverse-biased junction diode whose mode of operation depends on its junction capacitance.
- The size of depletion layer is in direct proportion to the applied reverse bias. Therefore, the capacitance of the varactor diode is changed with the changes in reverse bias.
- It may be of abrupt and hyper-abrupt types.
- If the doping concentration is constant in the active region then the varactor is abrupt varactor diode
- Otherwise it is hyperabrupt varactor diode.

3. Varactor Diodes and Operational Amplifiers

Operational amplifiers can be considered as ideal amplifiers having following properties. Following is shown a differential amplifier.

a. Very high input impedance
b. Very low output impedance
c. Very high gain



3. Varactor Diodes and Operational Amplifiers

- The non-inverting input appears on the output without any phase shift whereas as the other input appear on the output side with a phase difference of 180^{0} .
- A large number of circuits can be employed by using the operational amplifier. E.g. amplifiers, integrators, comparators, oscillators, timers etc.

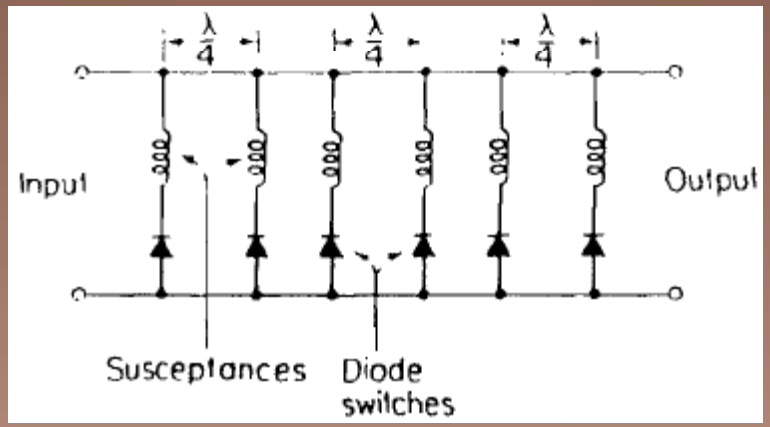
4. Realization of Phase Shifter

- Diode phase shifter which employ varactors have been used for the realization of the Phase Shifter in this master thesis.
- Diode phase shifter posses following characteristics.

a. They are almost immune to the normal temperature changes.
b. Their switching is very rapid.
c. They are very small sized.
d. They can be used in microwave integrated circuit and can be used for the whole range of frequencies of interest of radar.
e. They can be built using all types of transmission lines.
f. Their loss increases and power handling decreases at higher microwave frequencies.

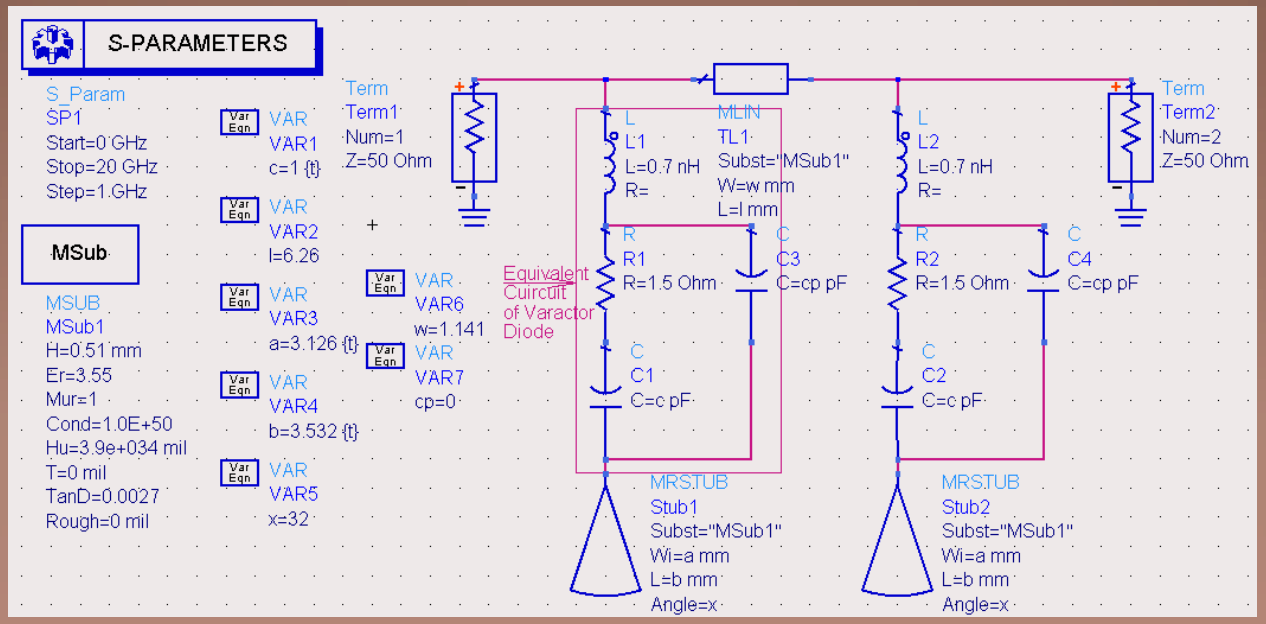
4. Realization of Phase Shifter

- Phase Shifter Design here is based on loaded line topology.
- In loaded line topolgy, transmission line is periodically loaded with switched impedances.



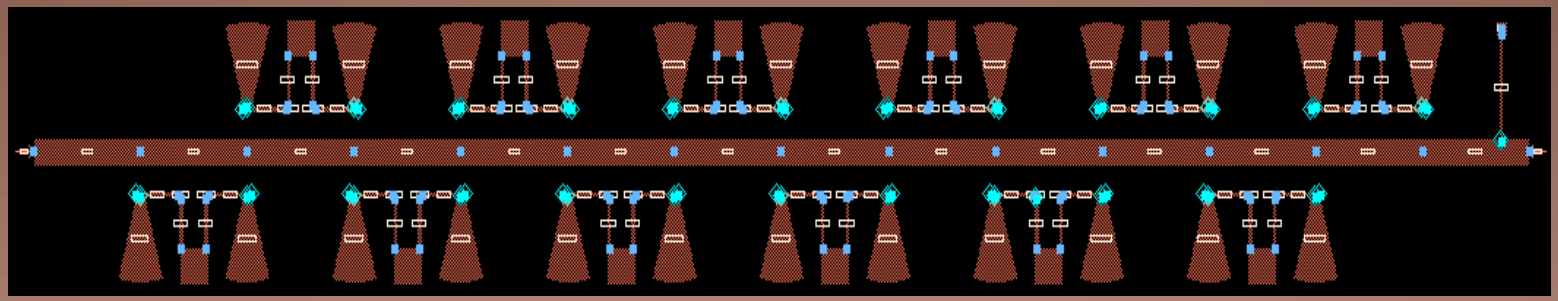
4. Realization of Phase Shifter

- The spacing between the diodes is ¼ wavelengths at the operating frequency
- Each pair produces just an increment of the whole phase shift required.
- Following figure shows the basic circuit used to design the phase shifter.

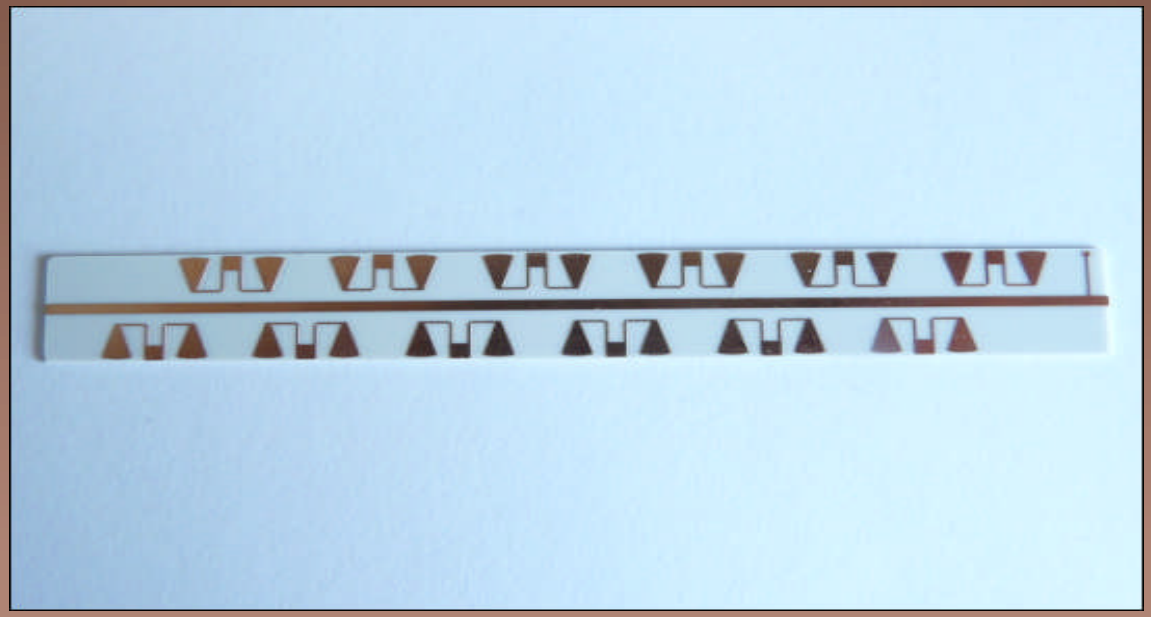


4. Realization of Phase Shifter

- Length and width of microstripline along with the capacitance is tuned to get the desired phase shift with appropriate match.
- SMV1232-079LF varactor diodes have been used.
- Following are the PCB‘s layout, PCB of Phase shifter.

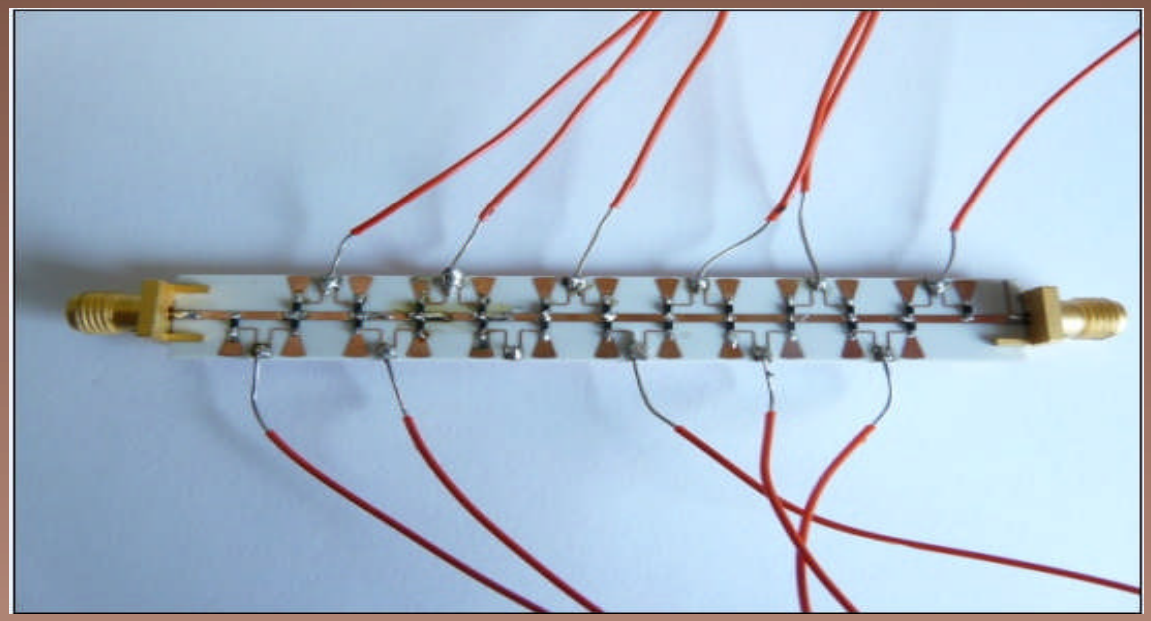


4. Realization of Phase Shifter



4. Realization of Phase Shifter

- Phase Shifter

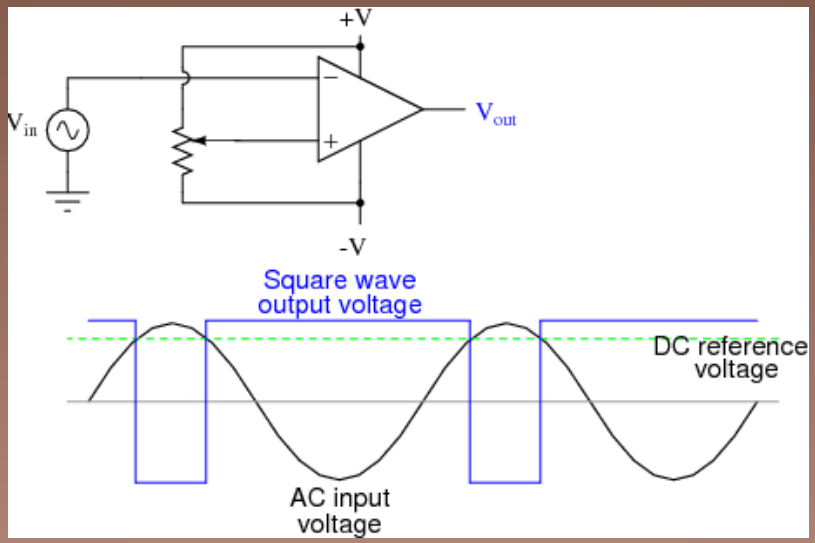


5. Realization of Bias Circuit

- Schmitt trigger was preferred over comparator circuit in the realization of bias circuit.
- ***Comparator*** takes two inputs, compares them and produces the output of two states.
- This type of circuit has bistable output.
- The main problem of comparator circuit is that even small amount of noise will cause the output to switch back and forth.
- Following figures show the behaviour of comparator to noisy and nois free signals.

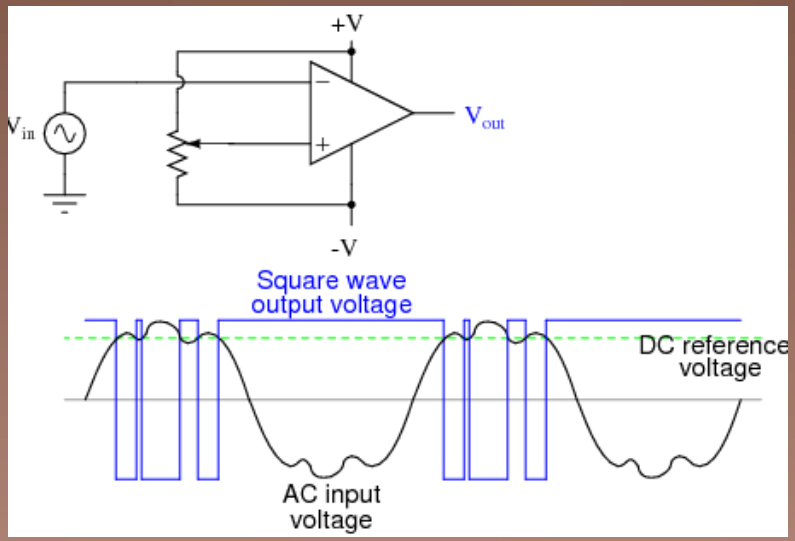
5. Realization of Bias Circuit

- Response to noise free signal.



5. Realization of Bias Circuit

- Response to noisy signal.

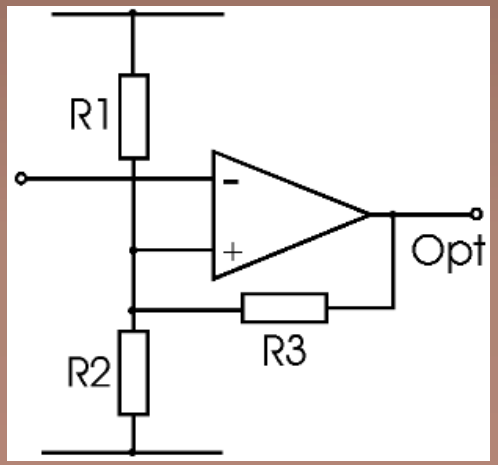


5. Realization of Bias Circuit

- Solution to the above problem is Schmitt trigger.
- A feedback is introduced from the output to the non-inverting input.
- This feedback:

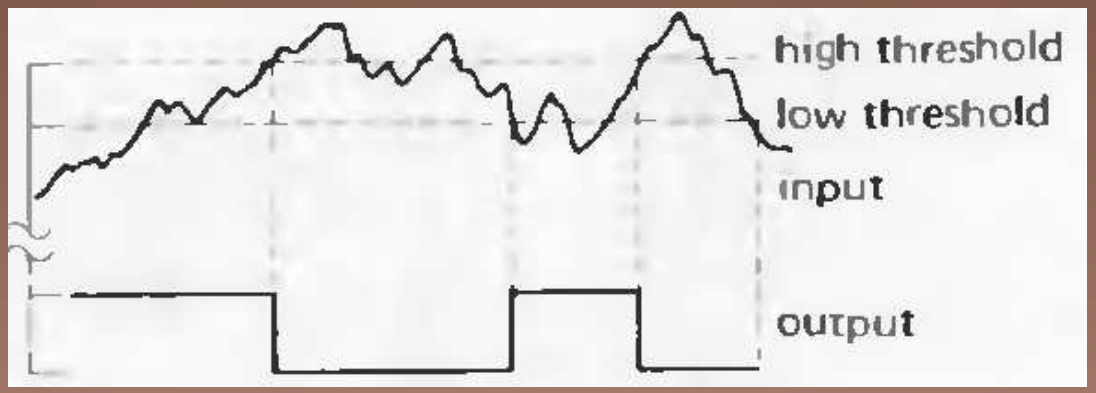
a. Handles Noisy Signal (with two threshold levels).

b. Results in fast output swing with slowly varying input.



5. Realization of Bias Circuit

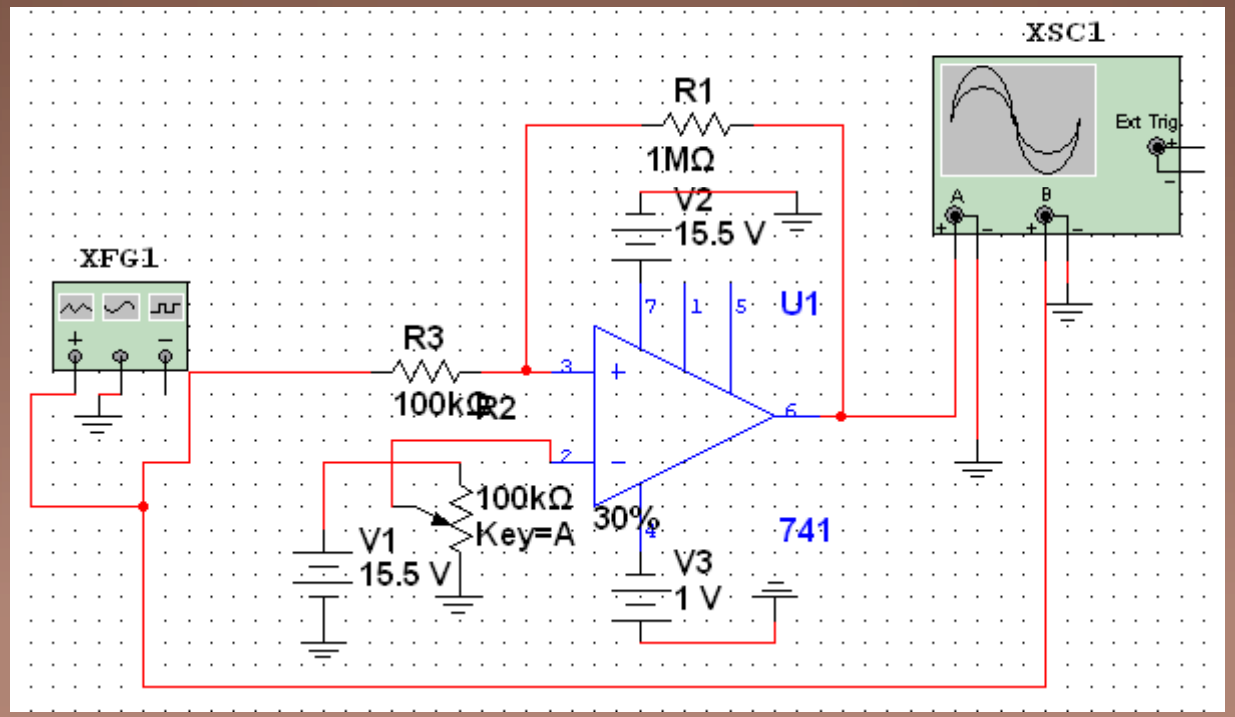
- Response of Schmitt Trigger to the noisy signal.



- UA741 OP AMP is used to realize schmitt trigger.
- In the following are diagram of schmitt trigger and image of bias circuit.

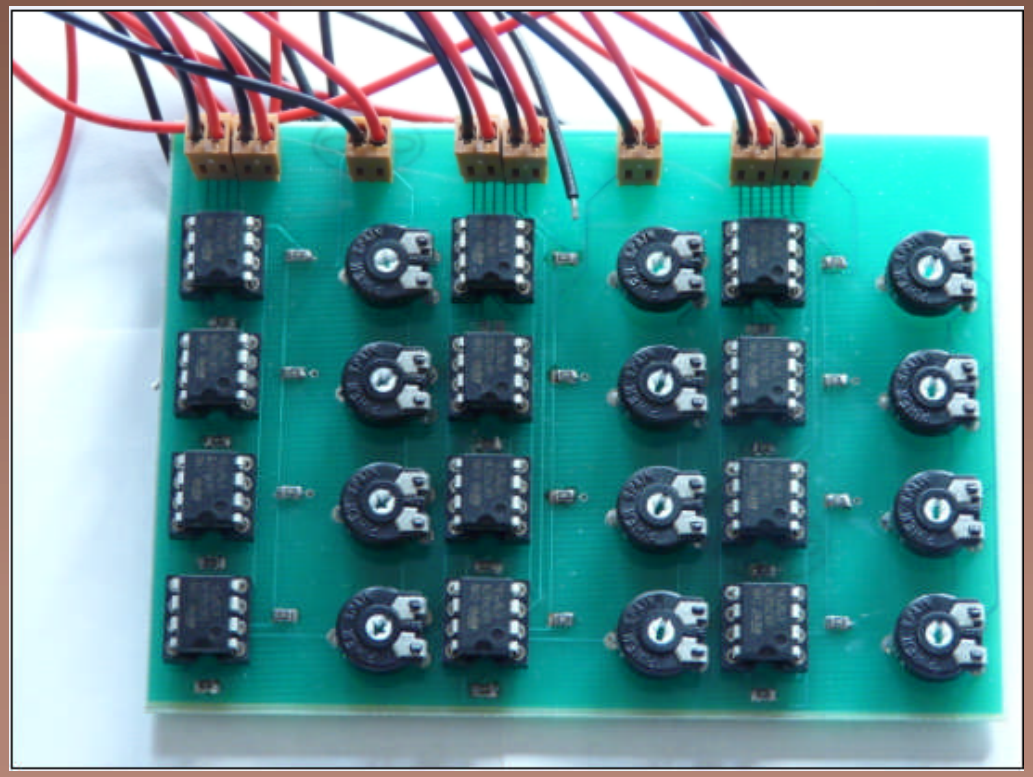
5. Realization of Bias Circuit

- Schmitt Trigger for bias circuit



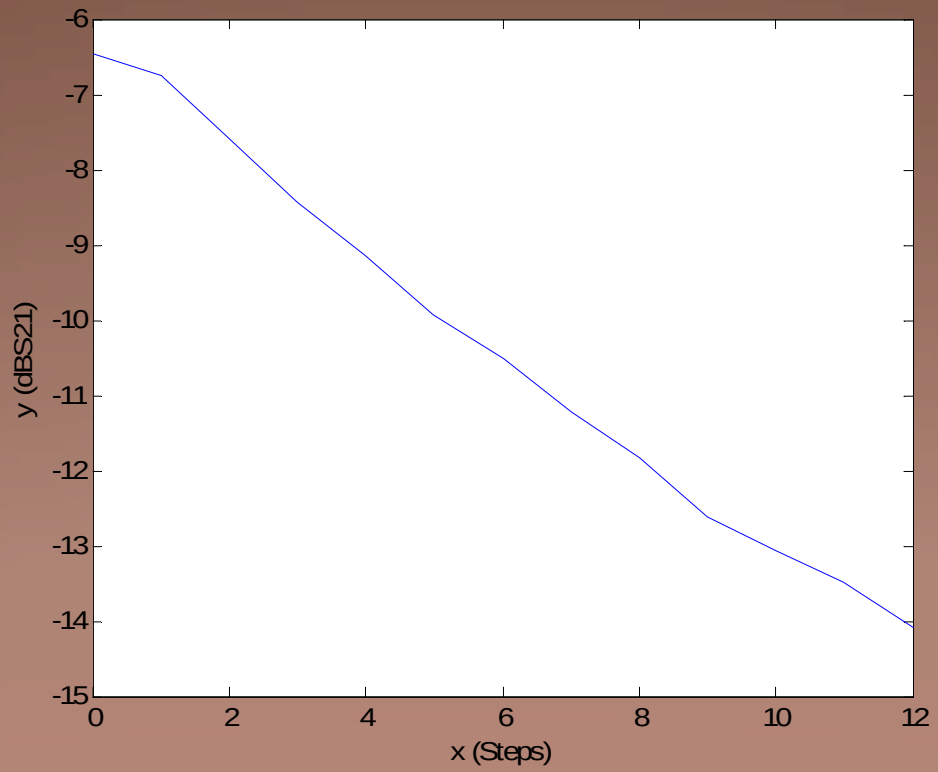
5. Realization of Bias Circuit

Bias Circuit



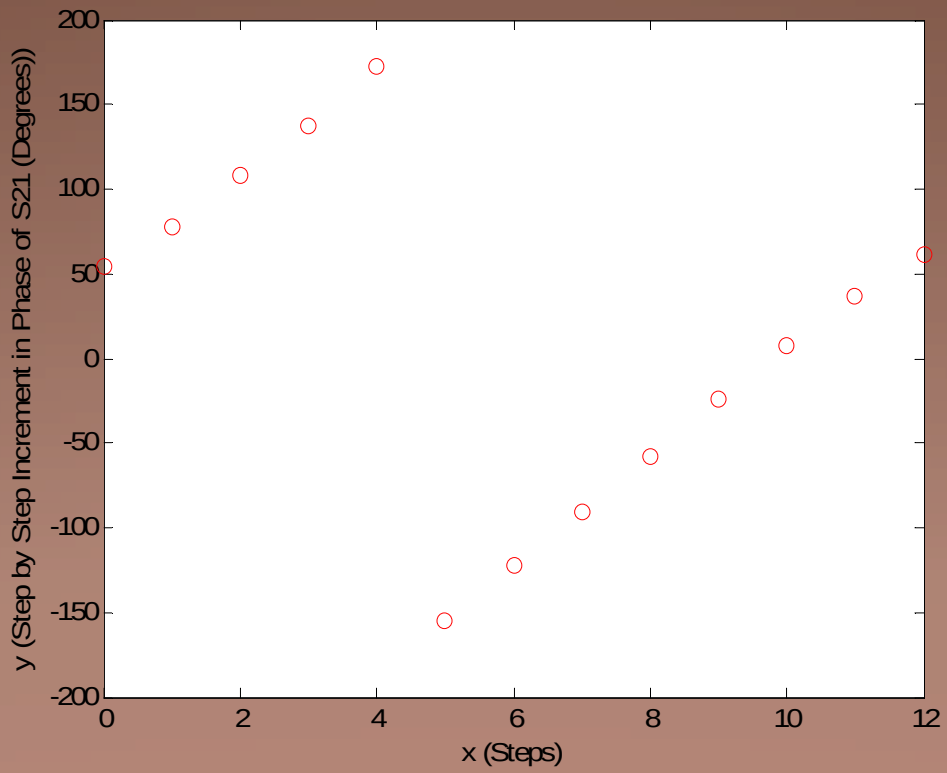
6. Measurement Results

Performance of Phase Shifter together with the Bias Circuit.



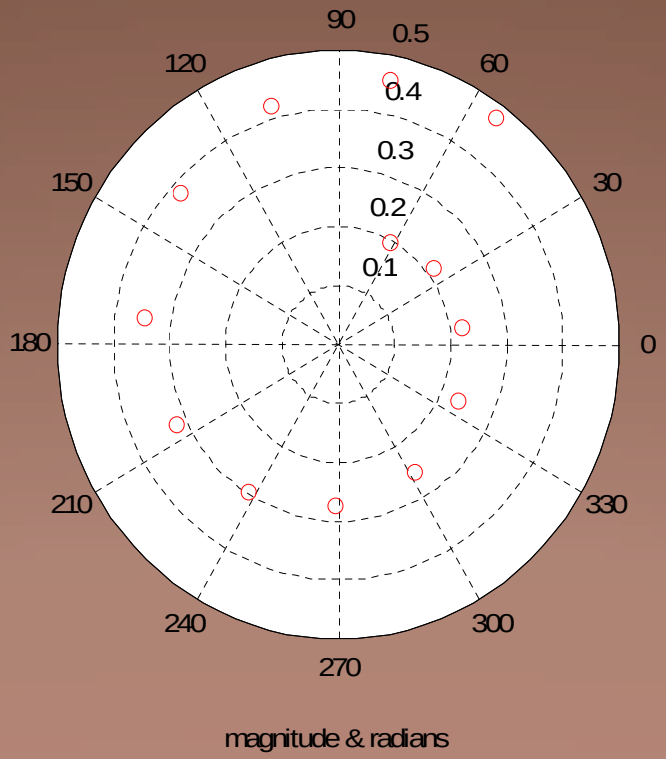
6. Measurement Results

- Step by step increment in phase



6. Measurement Results

- Polar representation



6. Measurement Results

- Table showing numerical values

Steps	*dBS_{21}*	*Θ^0 of S_{21}*
0	-6.463 *dB*	53.972^0
1	-6.751 *dB*	78.221^0
2	-7.498 *dB*	106.335^0
3	-8.434 *dB*	137.743^0
4	-9.144 *dB*	172.730^0
5	-9.938 *dB*	-154.773^0
6	-10.525 *dB*	-122.782^0
7	-11.219 *dB*	-91.174^0
8	-11.837 *dB*	-57.491^0
9	-12.606 *dB*	-24.315^0
10	-13.071 *dB*	7.274^0
11	-13.476 *dB*	37.341^0
12	-14.081 *dB*	61.643^0

7. Brief Overview of Radar and their types

Radar (or radio detection & ranging) is an electromagnetic system for the detecting and locating the reflecting objects such as aircraft, ships, space craft, vehicles and people.

- It operates by radiating energy into space and detecting the echo signal reflected from an object or target.
- Elementary components include transmitter, receiver and antenna.
- ***Continuous Wave Radar*** transmits energy in a continuous manner. A small proportion of energy is reflected by the target and returned to the receiver.
- Two types of Continuous Wave Radar include Continuous Doppler Radar and Frequency Modulated Continuous Wave Radar.

7. Brief Overview of Radar and their types

- ***CW Doppler Radar*** sends continuous signal in the form of sine waves rather than pulses. It uses Doppler Effect to detect the frequency change caused by a moving target.
- **Advantages & Disadvantages**

a. Accurate measurements of relative velocities while using low transmitting powers, simple circuitry, low power consumption and smaller equipment.
b. Unaffected by the presence of stationary targets.
c. Measure a large range of target speeds quickly and accurately.
d. A limitation in the power that it can transmit which results in the limitation of its maximum range.
e. It cannot specify the range of the target.
f. It can easily get confused by the presence of a large number of targets.

7. Brief Overview of Radar and their types

- ***Frequency Modulated Continuous Wave Radar*** can also determine the range.
- This can be accomplished if if the transmitted carrier is frequency modulated.
- The use of FM requires an increase in the bandwidth of the system, thus more information is conveyed.
- ***Phased Array Radar*** large number of radiators are used instead of only one radiator.
- This technology makes possible the radiation of the moving beam by a stationary antenna.

7. Brief Overview of Radar and their types

- This beam steering can be achieved by the introduction of variable phase difference in the individual radiator's feeders.
- ***Pulsed Radar*** transmits pulses by a highly directional parabolic antenna at the target instead of continuous signal.
- Pulse repetition frequency (PRF) or pulse repetition rate (PRR) is controlled by a master timer.

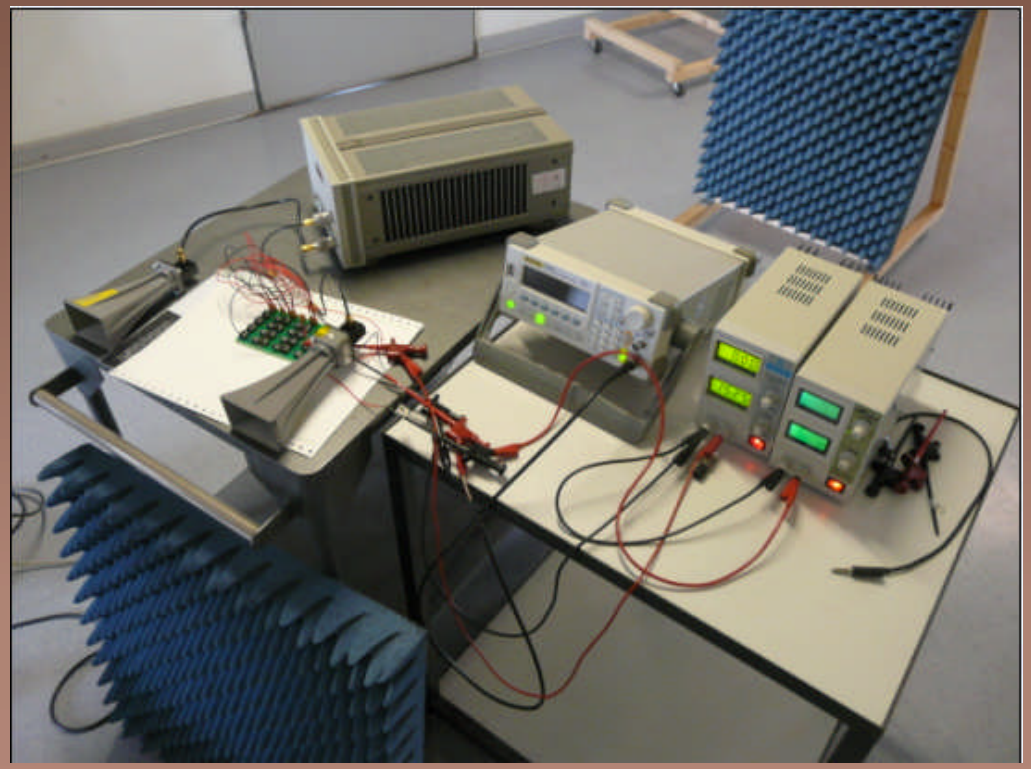
8. Phase Shifter with Doppler Radar

- Doppler Effect is the principle behind the working of Doppler radars.
- ***Doppler Effect*** is the change in the observed frequency of a source due to the relative motion between source and the receiver.
- Operation of Doppler radar is as follows:

a. The signal is sent from the transmitter to the target.
b. Reflection of the signal from the target in every direction occurs.
c. From this reflected signal frequency is determined.
d. If the frequency of the reflected signal appears to be increased, then the motion of the target is towards the receiver.
e. Otherwise, if it is moving away from the receiver then the frequency of the reflected signal decreases.

8. Phase Shifter with Doppler Radar

- Phase shifter setup with radar



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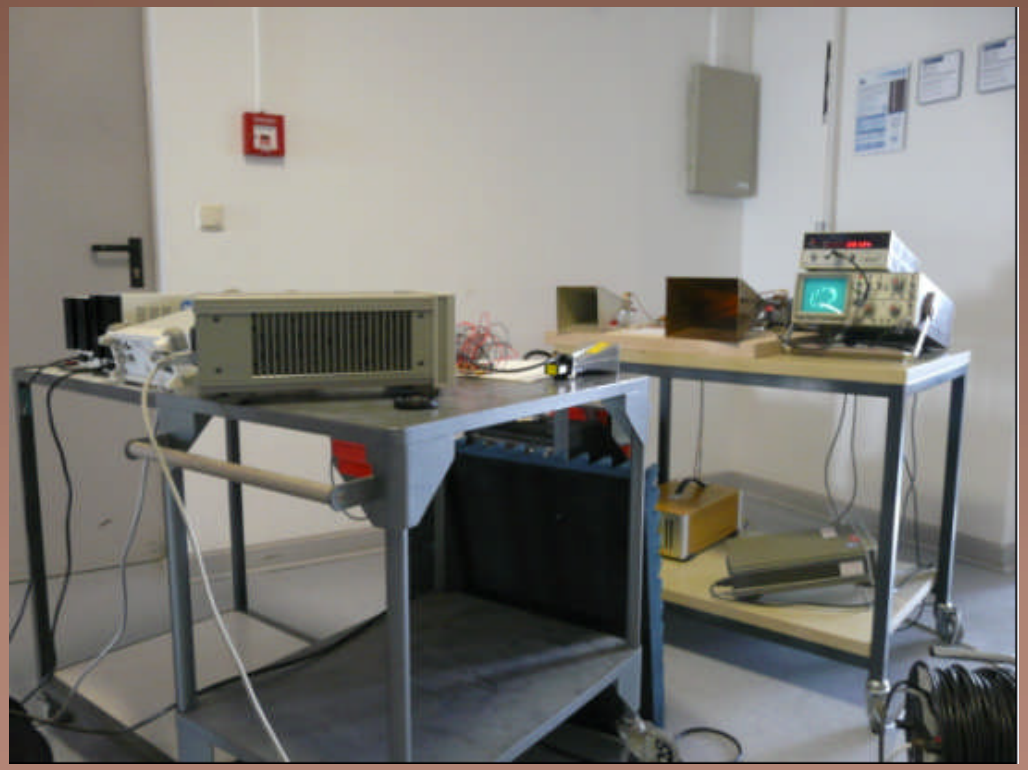

9. Conclusions

- The phase shifter produces more 360 degrees of phase shift.
- It has reasonably low value of -20 dB for dBS_{11} for both states.
- It can be used as an analog or discrete phase shifter.

Thanks for your Attention!!!