# 4 X 4 BEAMFORMING NETWORK PHASE SHIFTER CONTROLLERS

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**Abstract**
This paper is present the design of switch and phase shifters for development of 4 X 4 beamforming network phase shifter and controllers. PIN diode will be use as a switch to control RF signal and PIC as a switch controller. There are two type of method to control the switch, by time and by RF power. In this project, PIC 16F877 (Microchip Company) will be used to control the time of switching. This controller will be design in separate board and will used C language for programming. Beside that DC biasing circuit also will be constructing to control the PIN diode. The operating frequencies are selected at 2.4 GHz.
***Keyword****: Microstrip, Phase shifters, PIC, PIN diode, 2.4GHz.*

## 1.0 Introduction

For the traditional base station antenna with wider azimuth beam width will cause the serious effects of multi-path and RF interference. The effects of multi-path and RF interference will degrade the performance of communication [1]. In order to reduce the effects of multi-path and RF interference and increase the channel capacity of communication system, several narrower antennas with different type of angle of band width will be used to replace one single wider antenna beam pattern [1]. For that switching system is needed to steer the signal.

## 2.0 Switch, Controller and Phase Shifter Configuration

In RF communication, switching of antennas can be done with active components like PIN diodes, Varactor diodes, other type of diode and some type of transistors. Semiconductor diodes have been used for many years as RF switching elements. In the RF and microwave ranges, the switch serves the simple purpose which is implied by its name, it operates between one of two modes, ON or OFF. In the ON state, the switch is designed to have the least possible loss. In [2], PIN diode is used to switch between Digital Communication System (1710-1880MHz) to the WLAN (2400-2484 MHZ). In order to ON/OFF bias the diode, the end of the meandered strip is connected to a grounded pad through an inductor (56nH). The inductor works as an RF block a DC short and thus the DC voltage can be supplied to the diode with the RF signal [2]. See figure 1.


Figure 1 show the position of switch and inductor [2].

While in [3], the project used MEMS switch to controlled beam steering. Two switchable directional patterns are achieved by changing the connection states of the MEMS switch. See figure 2 (a) and (b).

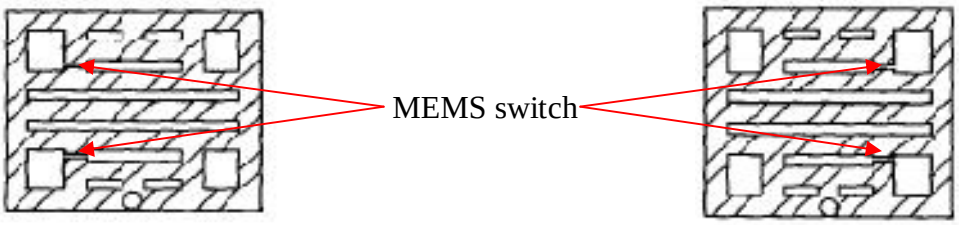


Figure 2 (a) shows the connection of MEMS switch for sate one [3].

Figure 2 (b) shows the connection of MEMS switch for sate two [3].

For state one in figure 2(a), switch in left and right parts of the patch are off and on, while for state two, switch in the left and right parts are on and off [3]. For that the switches have been used for many applications to control the RF signal and to switch between two or more type of frequency.

Phase shifter is used to change the transmission phase angle of a network or to adjust transmission phase in a system, there are 4 type of phase shifter that has been review that is Switch Line Phase Shifter, Loaded Line Phase Shifter, Reflection Phase Shifter and Switch Filter Phase Shifter.

In [1], [4], the switch line phase shifter method has been selected to make the project successes. Switch line is easier to implement and design because it only just a single line for one type of angle and need RF diode to control it.

There are two methods that have been used to control the RF signal, 1st used RF power and the other one used DC biasing circuit. In [5], timer 555 is used to control the switch and the project need DC biasing circuit to make sure output from the logic circuit can drive the diode to on or off mode. While in [2], the diode is control by using RF power, when there is signal, the diode will automatically turn to on state and when there is no signal the diode will on the off state.

## 3.0 RESULT

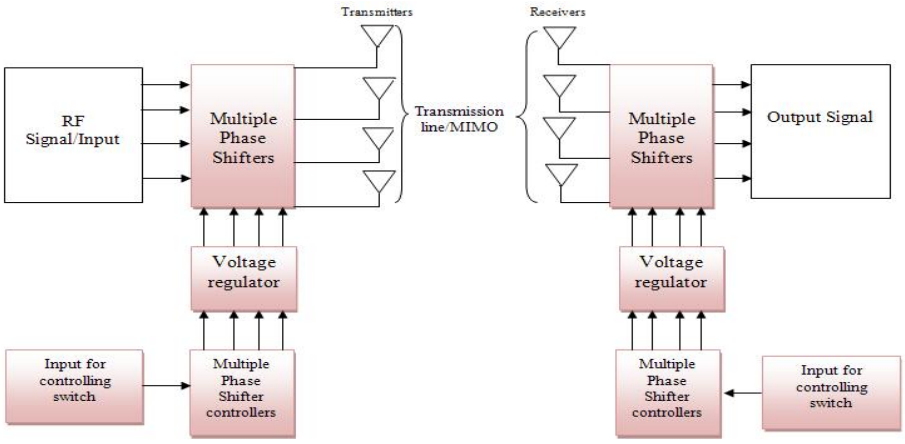


Figure 3 show the block diagram for 4 x 4 beamforming network phase shifter controller.

The main focus for this project is the system that can control multi phase shifter. In controller part, PIC16F877 from Microchip Company will be used to control the PIN diode, the output for the PIC will be assure can drive the PIN diode. The reason PIC has been chosen are 1st, it can be program many time because the time for switching can be varies and the other reason is the PIC need only a low voltage to operate. Figure 4 below shows the multi phase shifter for the project, there will be 5 different angle that are 0°, 45°, 90° ,135° and 180°.

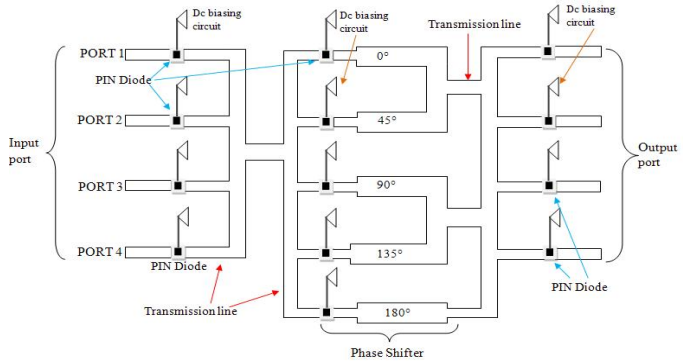


Figure 4 show there are 5 different of phase shifter by using switch line technique.

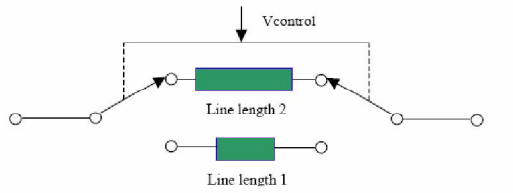


Figure 5 show switch line phase shifter technique.

Figure 5 shows switched line phase shifter, the circuit used PIN diode to switch the line. The lengths of the two lines are different according to the phase. The different of the two line state is given as:

$$\Delta\phi = \frac{2\pi}{\lambda_g}(l_2 - l_1) \qquad [4]$$

$l_1$ is the length of the first length
$l_2$ is the length of the second length
$\lambda_g$ is the operation wavelength
$\Delta\phi$ is the differential phase.

| Ports | A1 | A2 | A3 | A4 | β |
|---|---|---|---|---|---|
| 1 | 0° | -45° | -90° | -135° | 45° |
| 2 | -90° | 45° | -180° | -45° | -135° |
| 3 | -45° | -180° | 45° | -90° | 135° |
| 4 | -135° | -90° | -45° | 45° | -45° |

Table 1 show the different β of each output port

Table 1 will be used to determine the output angle for each output port, different port have different angle so that it will make sure the signal does not mix one another.

## 4.0 CONCULION

There are many ways to implements phase shifter, but for this project switch line technique has been chose to make it successes. PIN diode has been selected for RF diode because of its ability to control RF signal with small amount of voltage.

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