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An Investigation of new combination of PIN diode for RF/Microwave Switch

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Abstract- This paper presents a new combination of PIN diode switch for low insertion loss and high isolation. The combination is designed for frequency 0.1 to 10 GHz. In new combination we connect the two series-shunt combination one is across the input port and the other one is across the output port with one shunt diode connect between two λ/4 micro strip line. It has been concluded that in new combination the isolation increase and insertion loss decrease as compare to the previous combinations designed. In previous combinations we get ≈25db isolation, but the new combination give the isolation ≈ 76db which is much better compare to previous isolation.

Keywords: PIN Diode EM Simulation, insertion loss, isolation.

I. INTRODUCTION

Microwave communication system has the requirement of a special type of RF switches to increase the performance and equipment reliability. PIN diodes can be used as variable resistors at different RF and microwave frequencies.PIN diodes come in the category of current controlled devices. PIN diode can be used for the attenuating, leveling and amplitude modulating an RF signal using continuous variation of control current of a PIN diode. When control current is switched on or off then device can be used for switching, phase modulating and phase shifting. PIN diodes are very small in size compared to wavelength. High switching speed and low package parasitic reactance. These qualities make it an ideal component for use in broadband RF signal control circuits. PIN diode is able to control large RF signal power while using much smaller levels of control power.

PIN diodes are capable of high switching speed and easily integrated with plane circuitry. Diodes may be connected in series or in parallel. There are certain parameters which tell us about the characteristics of a PIN diode switch. Isolation and insertion loss are the parameters which describe the performance of a PIN diode. Isolation is a measure of the microwave power through the switch that is not transferred to the load, both from Attenuation Loss and Reflection Loss, when the switch is OFF. Insertion Loss is the Transmission Loss through the physical structure of a PIN diode switch. In the forward biased case (the ON state), large values of bias current plus microwave current may flow through the switch structure, causing significant Ohmic Loss. [1]- [11] In the reverse bias case (the OFF or Isolation state), only small values of leakage current flow through the switch, so the reverse bias loss is small.

II. METHODOLOGY

Simulation and designing is performed on the Microwave Office. It is a specialist tool for the 3D. EM simulation of high frequency components. Microwave Office enables the fast and accurate analysis of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects. Generally the combinations of RF microwave switches which are present currently are series, shunt, series-shunt or series-series these combinations are also known as compound switches. [13]-[16] In this paper various PIN diode switches has been investigated for the low insertion loss and high isolation and a new combination has been developed which has better results as compared to the conventional switches

In this paper a new combination of the PIN diode switches has been presented which shows a better isolation and insertion as compared to these switches. Fig. 1 shows the electrical circuit for the new combination.

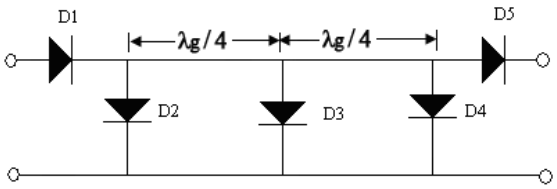

Fig.1 New optimized combination of PIN diode switches.

As shown in the above structure that there is two compound combinations has been used for the optimization. Here at the input series-shunt and at the output shunt-series combination is used with the separation of λ/4 and in between this separation a diode in shunt has been attached after spacing of λ/4 which provides a better and optimized response. The electrical equivalent of this combination is shown in the fig.2 for the different biasing conditions.

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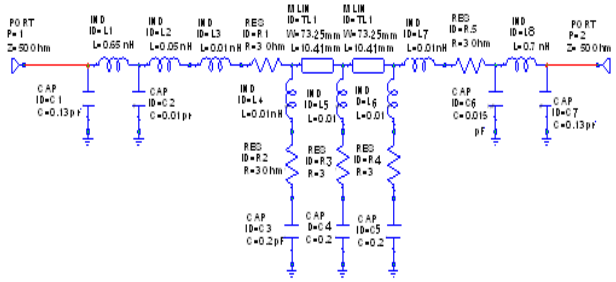

Fig. 2 Electrical equivalent for the new combination when D1, D5-F.B. D2, D3, D4-R.B.

In the above fig. The diodes D1and D5 are in forward biased condition and the diodes D2, D3 and D4 are in reverse biased condition. For this combination of the switch insertion loss should be minimum which is discussed in results. For the same combination the next condition is shown in the fig. 4 in which the diodes D1and D5b are in reverse biased whereas the diodes D2, D3 and D4 are in forward biased condition. The electrical equivalent circuit is shown in the fig. 4.For this case the isolation should be maximum.

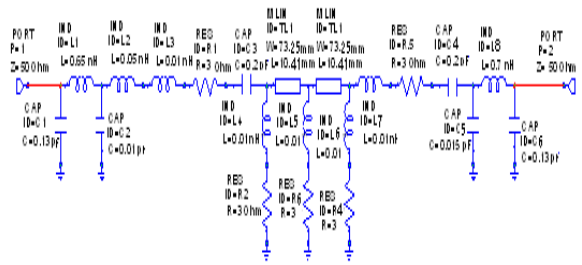

Fig. 3 Electrical equivalent for the new combination when D1, D5 -R.B. D2, D3, D4-F.B.

III. **RESULTS AND DISCUSSION**

For the first case of diode switching the insertion loss should be minimum. The above plotted graph shows the insertion loss when the Diodes D1 and D5 are in forward biased condition and D2, D3,D4 are in reverse biased condition. Table 1 shows the insertion loss of new combination at different frequencies.

For the second case of diode switching when diodes D1, D5 are in reverse biased condition and D2.D3, D4 are in forward biased condition then isolation should be better. The variation of isolation with respect to frequency is shown in fig. 5

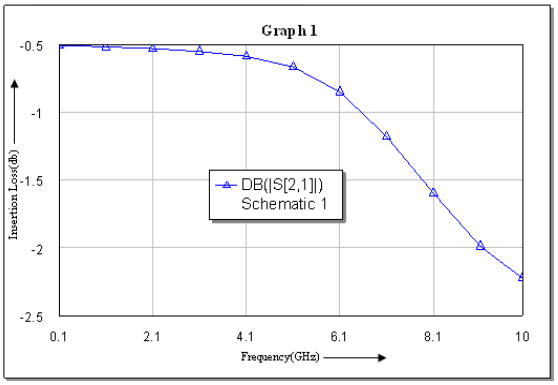

Fig. 4 Simulated Insertion Loss in New Combination

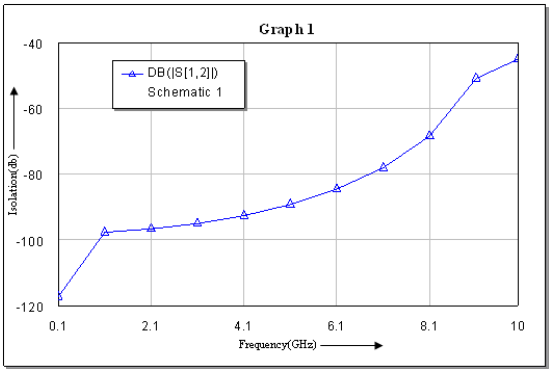

Fig. 5 Simulated Isolation in New Combination

Fig. 4 and fig. 5 shows the insertion loss and isolation of the PIN diode switch at a particular frequency 8GHz. From these two results we can see that the both insertion loss and the isolation has been optimized in this new combination of PIN diode switches. For the verification of the results there are two cases, in first case input and output diodes are in forward biased condition and remaining diodes are in reverse biased condition in which it is found that the insertion loss is very low for the new combination as compared to the conventional switches. For the second case of the switch the input and output diodes are in reverse biased condition and remaining are in forward biased. It is observed that in second case the isolation is high which verifies that the new combination is better.

IV. **CONCLUSION**

PIN Diode Switches are widely in RF/Microwave, Radar RF Routing, Antenna Testing, Phase shifter etc. [12] In practical it is always desirable to have lower insertion loss and high isolation RF/Microwave switches as a key parameter to describe a performance of a RF/Microwave switch [17].In this paper the various combinations of PIN diode switch have been investigated for low insertion loss and high

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isolation switches. According to the literature Survey several designers have reported the design of PIN diode RF/Microwave PIN diode switches at a particular band of frequency [18]-[19]. The combination used by maximum available literature are series mount shunt mount, tee combination, reactive tuning. In this paper we have investigated all combinations of PIN diodes for low insertion loss and high isolation switch with frequency band of 0.1 to 10 GHz and presented a new combination. To know the insertion loss and isolation of various combinations have been simulated using Microwave office software, and then a new combination has been designed by taking the reference of previous research. In new combination we connect the two series-shunt combination one is across the input port and the other one is across the output port with one shunt diode connect between two $\lambda/4$ micro-strip line. The research has been concluded in new combination the isolation increase and insertion loss decrease as compare to the previous combinations designed. In previous combinations we get ≈25db isolation, but the new combination give the isolation ≈ 76db which is much better compare to previous isolation.

REFERENCES

[1] H.Takshu, "Estimation of equivalent circuit parameters for a Millimeter- Wave GaAs PIN diode switch", *IEEE Proc.-circuits Devices system*, vol.150, no.2, April-2003, pp. 92-94.
[2] Jar-Lon Lee, Donna Zych, Elias Reese and Denis M.Drury,"Monolithic 2-18 GHz Low Loss on Chip Biased PIN Diode Switches", *IEEE* Transactions on Microwave Theory and *Techniques*, vol.43, No.2, Feburary1995, pp 250-256.
[3 [3] Kevin W.Kobayashi, "A 50MHz-30GHz Broadband Co-Planar Waveguide SPDT PIN Diode Switch with 45-db Isolation",IEEE Microwave and Guided wave letters,vol.5,no.2,Feburary 1995, pp 56-58.
[4] [4] Md.Yunus, Rahman Wagiran, "Design of a Microstrip SPDT PIN Diode Switch",ICSE-2002,pp 465-469.
[5] Agilent Application Note-5989-7618EN, RF/Microwave Solid State Switch and their Applications.
[6] Agilent Application Note-1050, A Low Cost Surface Mount Power Limiter.
[7] Agilent Technologies Application Note-1072 Surface Mount Switching PIN diode.
[8] Agilent Technologies Application Note-1049 A low distortion PIN diode Switch Using Surface Mount device.
[9] Micro semi Application Notes-#710, Nano Mount Switch for Microwave Applications.
[10] Micro semi Application Note- Loral Microwave -FS1, PIN diode RF Switch Design.
[11] Micro semi Technologies Corporation Application Note-Series-701 PIN Diode Fundamental.
[12] Sky works Application Note-200312, Design with PIN diode.
[13] Sky works Application Note-2000823, PIN diode Basics.
[14] M/A-COM Application Note-SMPP Series, Surface Mount PIN Diodes. Alpha Industries Application Note-APN1002
[15] Alpha Industries Application Note-APN1002, Design with PIN Diode.
[16] Hewlett Packard Application Note-957, Broadbanding the Shunt PIN diode SPDT Switches.
[17] Hewlett Packard Application Note-929, Fast Switching PIN diodes.