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DESIGN OF MIXER USING FIVE PORT STRUCTURE IN RF FRONT END RECEIVER ARCHITECTURE AND ITS PERFORMANCE EVALUATION

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ABSTRACT

In this paper, the design of five port structures using power dividers and hybrid coupler was done using Advance Design Systems. Micro strip lines were used in the design procedure and the termination is done with 50 ohm resistance. This methodology yields encouraging results in impedance matching, performance improvement and the scattering parameter simulation has been done for the design and simulation results are obtained.

Keywords: port structure, mixer, RF front end receiver architecture, VSWR, power divider, hybrid coupler, return loss, mismatch loss.

1. INTRODUCTION

Communication systems should be designed to accommodate technological advancements at every step of the development and when the up gradation is done these upgraded components are good enough to communicate each other. The software defined radio was developed in early 1990s to surpass these issues. SDR is a reconfigurable communication device, where the functionalities are defined in software**.** By moving the radio functionality from hardware to software, promises to change the economics of deploying the operating wireless network.

In recent past, Wireless transceivers became very prominent in communication arena. Major challenge in the wireless system is inter operability. To communicate between two separate standards is not possible with traditional radio [2 and 4]. The design philosophy of the RF front end subsystems has been the topic of interest for researchers in the past and present with the evolution of novel mechanisms in exploring their design. Low Noise Amplifier design with High Electron Mobility Transistor as the integral component [10] , Band Pass Filter and Mixer designs were underwent various changes those facilitate the thirst of the designer. Six port structures are prominent in the recent past which are intended to microwave as well as millimeter wave applications.

Down conversion becomes simplified by avoiding IF stage and this is possible as the vector ratio of input signals at two input ports can be measured using the four output ports power readings SDR down conversion [3, 11and 12].

Broad band software receiver is one of the efficient architectures that are having ample number of advantages over the successors. Basic difference in the receivers exists in the number of stages sufficient enough to convert RF signal to baseband signal. Direct conversion consists of down conversion; whereas super heterodyne receivers have two or more [5, 11].

2. PORT STRUCTURES

Port strcutures are very useful in the desing of different types of architectures. These architectures are versatile in nature in accordance with the need or specification. For example, in RF front end subsystems like LNA and Mixer in Software defined Radio , Sigma delta architecture becomes vital [9 and 10].

The first six port receiver was proposed in 1994, which is a direct digital receiver. In principle, the six port consists of linear circuits with signal dividers and combiners that are interconnected in such a way that four different vectorial combinations of the reference signal and signal to be receiver signal are obtained. In the recent past six port technology is prominent in RF front end systems. An incident wave vector ratio at two input ports is calculated using the power values at output of four ports. Because of this there is no need of down converting the RF signal to IF [1, 12]. There is no direct path existence between LO and RF ports of these structures. The input signal at the port 1 is combined with the phase shifted signal at port 2; here port 1 and port 2 are input ports. Different phase shifts and attenuation exists between the components because of that the two radio frequency input signals generate different amplitudes and phases at four output ports. The intensity of the four output signals are detected using Schottky diode detectors. Five Port Structure design has also become the topic of interest for researchers because of the developments in the integrated technologies like MMIC and SICL [8].

3. DESIGN OF MIXER USING FIVE PORT STRUCTURE

The design of Mixer is crucial for RF front end sub-system architecture and this becomes feasible with variety of choices that a designer possess. Five Port Structure design has also become the topic of interest for researchers because of the developments in the integrated technologies like MMIC. Five port reflectometers were applied to demodulators and radars in 2004 by Fernando Rangel de Sousa *et al*. A novel method was proposed for calibration based on analytical approach which has laid down new direction to impart adaptability into port structure concept.

In this work an attempt is made successfully to design five port structures for a particular range of specifications, where a great degree of performance is obtained when compared with their counterparts. In this

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the methodology adopted contains micro strip lines which were designed and used to make these structures as competent enough with the changing market needs.

Power dividers and Hybrid couplers are the key components of a five port structure design. Particularly, Wilkinson power divider is an essential component for microwave and millimeter wave antenna arrays. This was first introduced by Wilkinson in 1960 [6]. In order to develop five port junctions, the power divider and hybrid coupler should be designed and synthesized effectively. Port structure designs and evaluation [7] are performed at 5.8 GHz RF frequency. The design simulation process has been carried out in a standard micro strip technology. The simulation Environment provides great flexibility in investigating the performance characteristics.

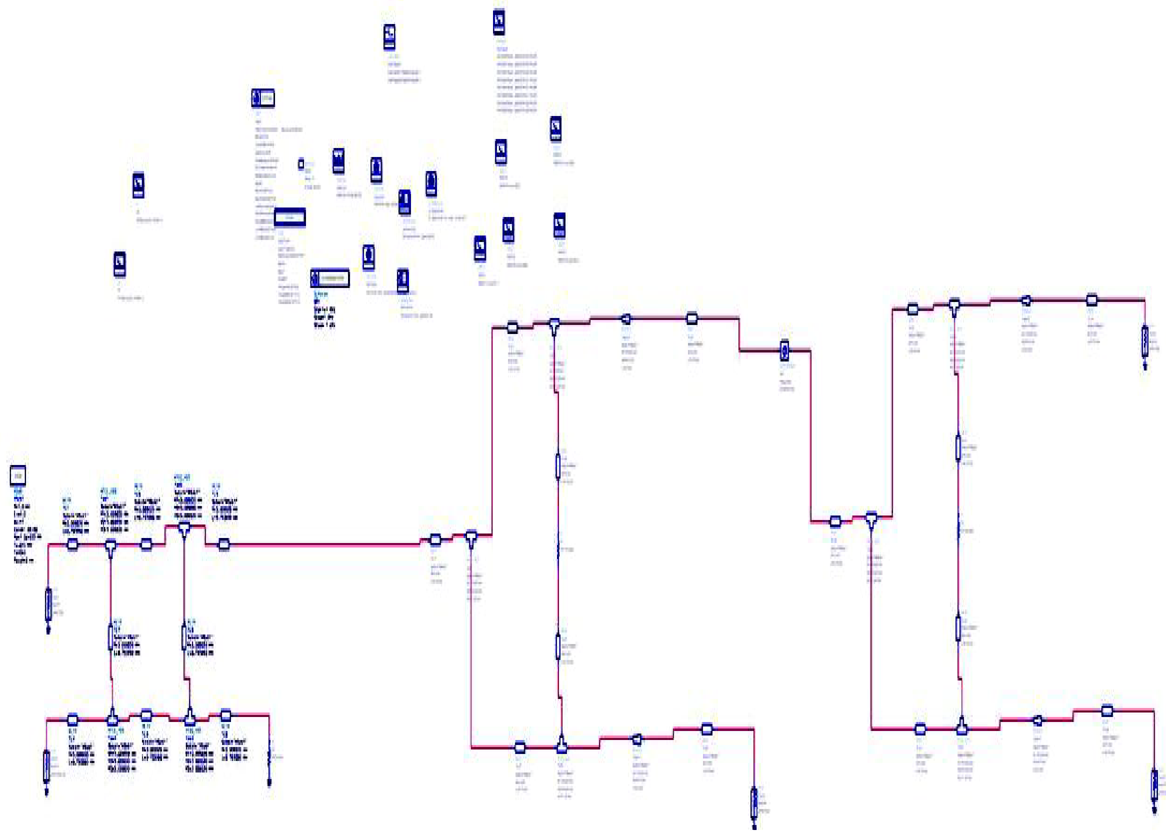

Figure-1. Five port structure design using hybrid coupler and power divider.

VSWR values return loss and mismatch loss values of Figure-1 is helpful in concluding that five port structure applied in full SDR flow is better in performance for high frequency applications.

4. RESULTS AND DISCUSSIONS

This section represents the simulated results obtained for the design in the Figure-1. VSWR values at 5.8 GHz are obtained for all the ports in the design including input ports. Figures 2, 3, 4, 5 and 6 represents the VSWR values at the respective ports.

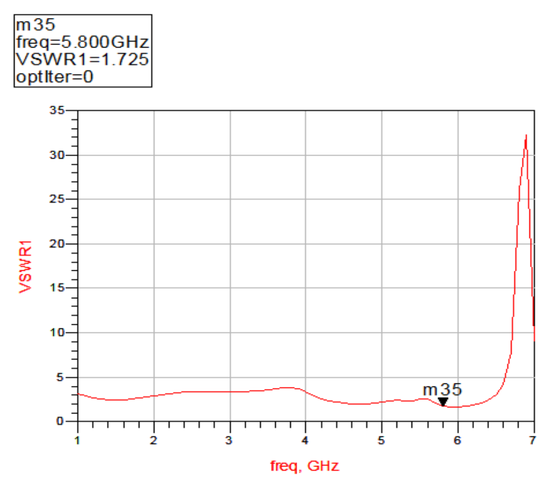

Figure-2. VSWR at the input port 1.

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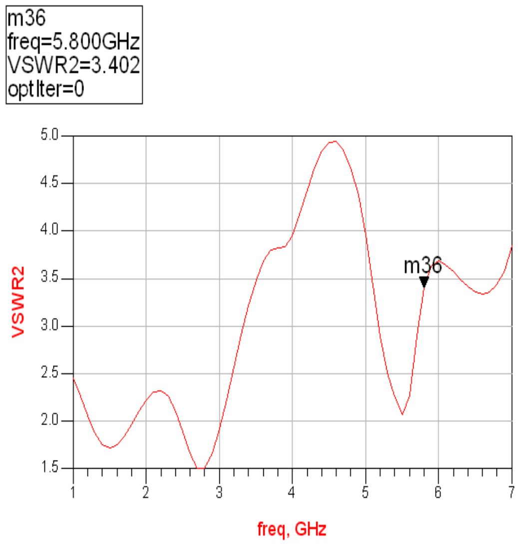

Figure-3. VSWR at the input port 2.

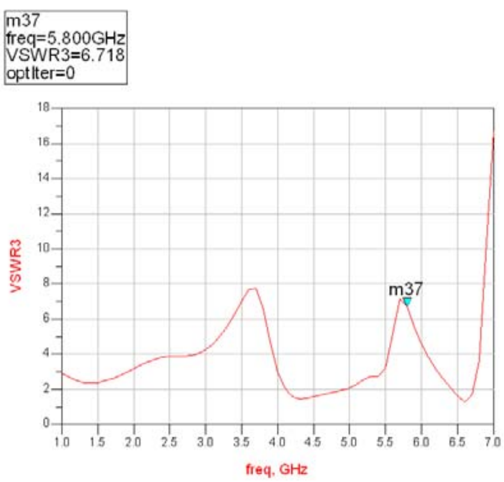

Figure-4. VSWR at the output port 3.

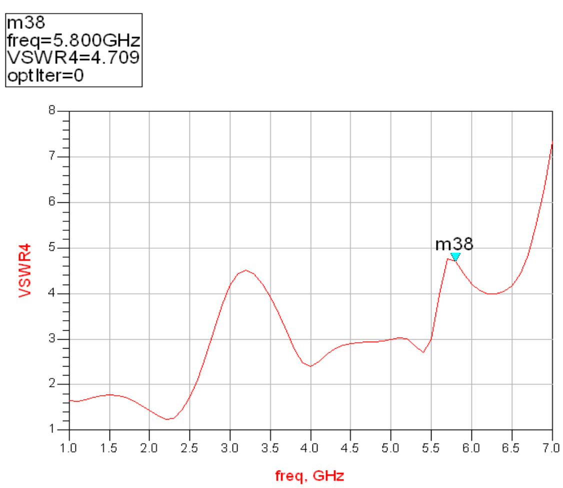

Figure-5. VSWR at the output port 4.

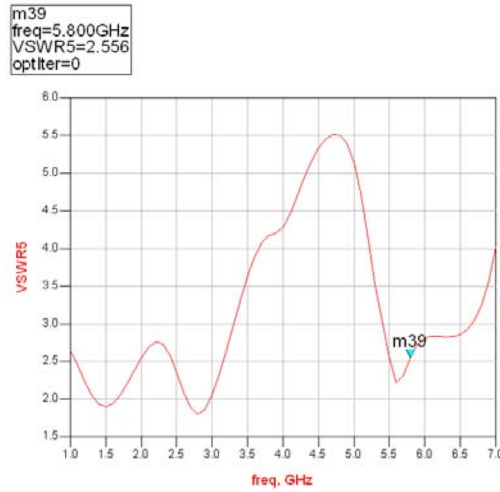

Figure-6. VSWR at the output port 5.

Table-1 represents the RL (return loss) and ML (mismatch loss) at different output ports at 5.8 GHz for the five port structure shown in the Figure-1. whereas, Figure-7 represents the comparison of the RL and ML values for the data of Table-1.

Table-1. Return loss and mismatch loss for the five port structure at the output ports.

Port number	VSWR	RL (Return loss)	ML (Mismatch loss)
3	6.718	2.61 dB	3.46 dB
4	4.709	3.75 dB	2.38 dB
5	2.556	7.18 dB	0.92 dB

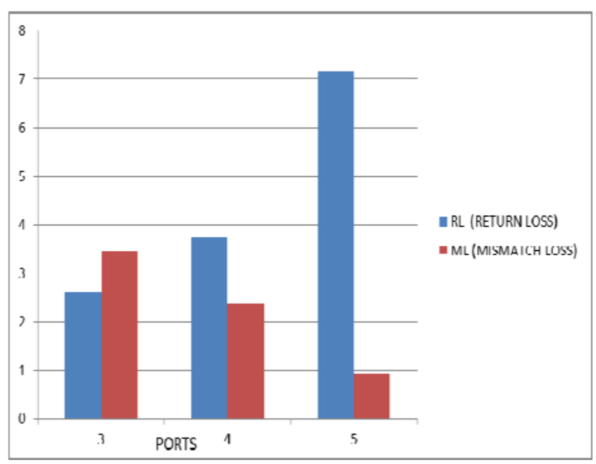

Figure-7. Comparison of return loss and mismatch loss at the output ports.

5. CONCLUSIONS

The variation of the VSWR at the input and output ports were obtained and the return loss as well as

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mismatch loss was calculated at the output ports. In most of the cases , it is observed that the return loss is more than mismatch loss expressed in dB. These results are very encouraging so that this design of five port structure will serve as the efficient alternative for the mixer stage in the RF front end receiver architectures. This also leads in future works towards reduction of the MMIC area , there by the cost of the production.

REFERENCES

[1] Atsushi Honda, Kei Sakaguchi, Jun-ichi Takada and Kiyomichi Araki, "A Study of Nonlinearity Calibration for Six-Port Direct Conversion Receivers", Proceedings of the IEEE Topical conference on Wireless Communication Technology. 03, pp. 40-41, 2003.

[2] Balwant Godara and Alain Fabre, "State of the Art for Differential Circuits in Wireless Transceivers: A New Wideband Active Balun in SiGe BiCMOS Technology", Turkish Journal of Electrical Engineering and Computer Sciences. Vol. 14, No. 3, pp. 355-386, 2006.

[3] Bugo T., Klippenstein B., Saizew M., Woods M. and Helaoui M., "Dual-band receiver using passive six-port downconversion technique suitable for multi-standards and SDR applications", Microwave Conference Proceedings (APMC), 2010 Asia-Pacific. pp. 1312-1315.

[4] Cotter W. Sayre. 2004. "Complete Wireless Design", McGraw-Hill Companies. p. 117.

[5] de la Morena-Alvarez-Palencia C., Burgos-Garcia M. and Rodriguez-Aparicio D. 2010. Three octave six-port network for a broadband software radio receiver", Proceedings of the Microwave Conference (EuMC). pp. 1110-1113, 2010.

[6] Eccleston, Kimberley Wallace, Yeo Swee Ping, "Planar Microstrip Microwave Power Divider with Co-linear output ports", Engineering Research. Vol. 13, No. 1, pp. 10, 1998.

[7] Eireiner T. and Muller T., "Six-Port Receiver for mm-Wave - Concept, Evaluation and Implementation", Proceedings of the 14th IST Mobile and Wireless Communications Summit, 2005.

[8] Fabrizio Gatti1, Maurizio Bozzi, Luca Perregrini1, Ke Wu and Renato G. Bosisio, "A New Wide-Band Six-Port Junction Based on Substrate Integrated Coaxial Line (SICL) Technology", Proceedings of the IEEE Mediterranean Electro technical Conference. pp. 367-370, 2006.

[9] Karthikeyan K.V, Vasudevan.N, "Analysis of Performance of Sigma Delta Architecture in Software Defined Radio", Proceedings of the RSTSCC. 13-15 November 2010, pp. No. 164-166, 2010.

[10] V.J.K. Kishor Sonti and V. Kannan, "Parametric Influence on Noise in High Electron Mobility Transistor LNA", Journal on Electronics Engineering, ISSN 2229-7286, Vol. 2, No. 3/ pp. [37-42]/ March-May, 2012.

[11] Walter Tuttlebee,Mark Beach, Paul Warr and John MacLeod, "Software Defined Radio: Enabling Technologies", John Wiley and Sons. pp. 32, 2002.

[12] Xinyu Xu, Ke Wu and Renato G. Bosisio, "Software Defined Radio Receiver Based on Six-Port Technology", Proceedings of the International Microwave Symposium Digest. Vol.2, pp. 1059-1062, 2003.