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Design a RF Mixer using ADS

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Abstract - *Radio frequency Mixer is a 3 port device. The complete design and analysis of RF single balanced diode down converting mixer is presented in this paper. The presented RF single balanced diode mixer is realized using a configuration of a 90 degree hybrid coupler and two schottky diodes HSMS282C and a band pass filter. The mixer operates in S band. It is used to down converts the RF Frequency of 2.4GHz to IF Frequency of 180 MHz by a local oscillator of signal frequency of 2.22 GHz. Proposed mixer avoids the need of RF and LO balun. The Simulation results of proposed mixer gives the conversion losses are around 8.801 dB and the amount of isolation are around LO/IF 27 dB, & RF/IF 34 dB noise figure of 6.513dB for DSB and 11.023dB for SSB,VSWR at input port is 1.312. The mixer is designed with microstrip line. The mixer is designed and simulated in ADS2009*.

Key Words: ***Mixers, Single balanced diode mixers, 90 degree Hybrid coupler, , port-to-port isolation, band pass filter.***

1. INTRODUCTION

Mixer is important parts in the RF telecommunication system. A mixer makes a use of the nonlinearity of a diode so that it can generate an output spectrum which is the sum and difference frequencies of two input signals given two it. At receiver side the RF signal and LO signal combines to generate an intermediate (IF) signal [1]. Based on application of mixer there are different mixer designs are available. Applications which demands for high isolation will have to make use of double balanced mixers. Applications requiring low conversion loss, single diode mixers employing schottky diode are the design of choice. Basically there are two types of mixer; Active mixer and a passive mixer are used in communication system. Active mixers are those that use active devices like FET, HEMT, HMT the devices exhibiting negative resistance to achieve gain. A passive mixer uses a nonlinear device like schottky diode that exhibit nonlinear resistance which is positive such mixers are also called as diode mixers [2].

Band pass filter is used to pass the desired frequency component. The input RF signal is multiplied by the DC signal in the schottky diode, LO sine wave and the number of harmonics which result in number of output signals out of which the desired signal is filtered using filter. LO causes to change in the diode's small signal junction capacitance, resistance and thus characterized by conversion loss. Proposed mixer is of passive type of mixer by making the use of the HSMS282C schottky diode [3]. To construct a single balanced mixer with no crossing of transmission line the 90 degree hybrid coupler is use because it avoids crossing of transmission line.

2. SYSTEM MODEL

The input of LO signal is equally split into two schottky diodes. The other input RF signal is also split equally but it is 90° out of phase at the schottky diodes. At the diode stage both LO and RF signals are mixed. The signals coming from the two schottky diodes can be combined together at the intermediate frequency (IF) port. Thus, the output signals combined signal which contain even harmonics of the LO signal. And at the output band pass filter gives down converted signal.

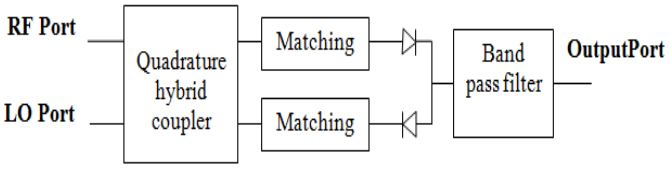


Fig -1: System model [3]

A 90 degree hybrid coupler isolates LO and RF ports. Band pass filter isolates IF port from both the LO port and the RF port. This type of balanced mixer is useful for avoiding air bridges and crossing transmission lines, which that deteriorate the performance of the circuit and also make the manufacture more difficult [3].

3. Design Procedure

3.1 Diode Selection

As the diode is a nonlinear element in mixer, the selection of the diode is very important task in mixer design. The selected diode should have strong non-linearity, low noise,

low distortion and good frequency response in the desired region of operation. The parameters of diode like junction capacitance, series resistance and barrier voltage plays vital role in mixer [2].We selected packaged HSMS282C diode made up of GaAs as it has high cut-off frequency and high breakdown voltage [3].

3.2 Matching Circuit Design

Under the incentive of the signal power, schottky diode's impedance doesn't appear the standard 50 ohm, hence it need for impedance matching [4]. C1 is the diode's estimated junction capacitance. At RF diode's reactance is obtained by $X_{(RF)} = 1/(2\pi*F_{(RF)}*C1)$ and this get absorbed into RF matching circuit. Similarly, diode's reactance at frequency of LO frequency is given by $X_{(LO)} = 1/(2\pi*F_{(LO)}*C1)$ And this has been absorbed into LO matching circuit. The diode's reactance at IF is double that at RF frequency. The matching circuit was designed to resonate out this reactance and thus match diode's IF impedance to the load [2].

3.3 90° Hybrid Coupler

A 3 dB, 90° hybrid coupler is a four port device. This coupler is used either to equally split an input signal or it combine two signals while keep maintaining high isolation between them [5]. When all ports are matched, the power entering port 1 is evenly divided between port 2 and port 3and there is with a 90°phase shift between these outputs. Port 4 is isolated port as no power is coupled to it [6].

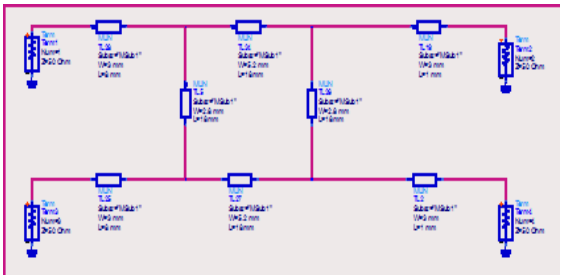
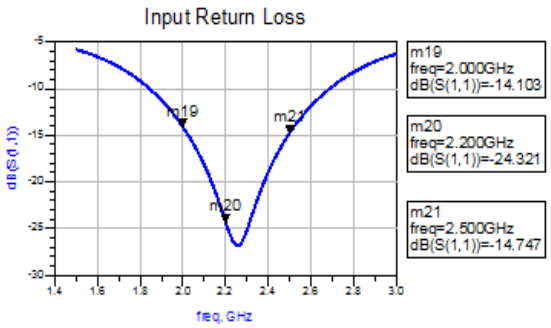


Fig-2: Schematic of 90° hybrid coupler



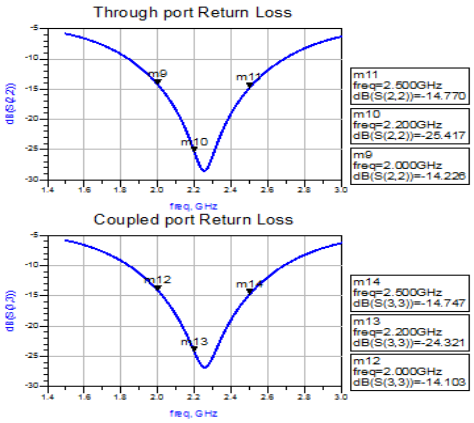


Fig-3: S parameter simulation of 90° hybrid coupler

3.4 Band Pass Filter

Filter is a two port, reciprocal, passive, linear device. It attenuates heavily the unwanted signal frequencies while allowing transmission of wanted signal frequency [7].

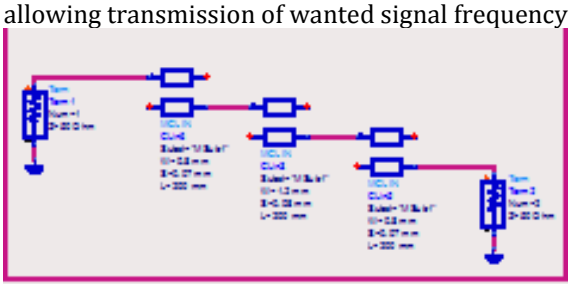


Fig-3: Schematic of BPF

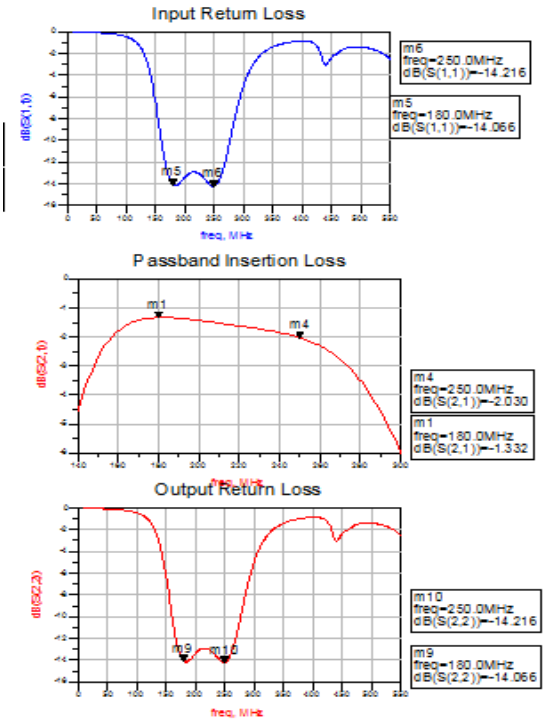


Fig-4: S parameter simulation of BPF

4 SIMULATIONS

In simulation the mixer model is simulated using ADS and the obtained results of simulation are as shown below.Simulation in ADS allows to make changes in system design so that we can achive the desired vlues of results.

Its needed to simulate each circuitThe conversion loss and the output spectrums are obtained using component seprately and then simulating a whole design.HB simulator in ADS.S parameter results are obtained using S parameter simulator.The best results are obtained by sweeping the level of RF and LO.

Below different figure shows the simulation reults of designed mixer for conversion loss or gai,mixer port isolation,the differenet S parameters of the mixer,input and output spectrum,noise figure.

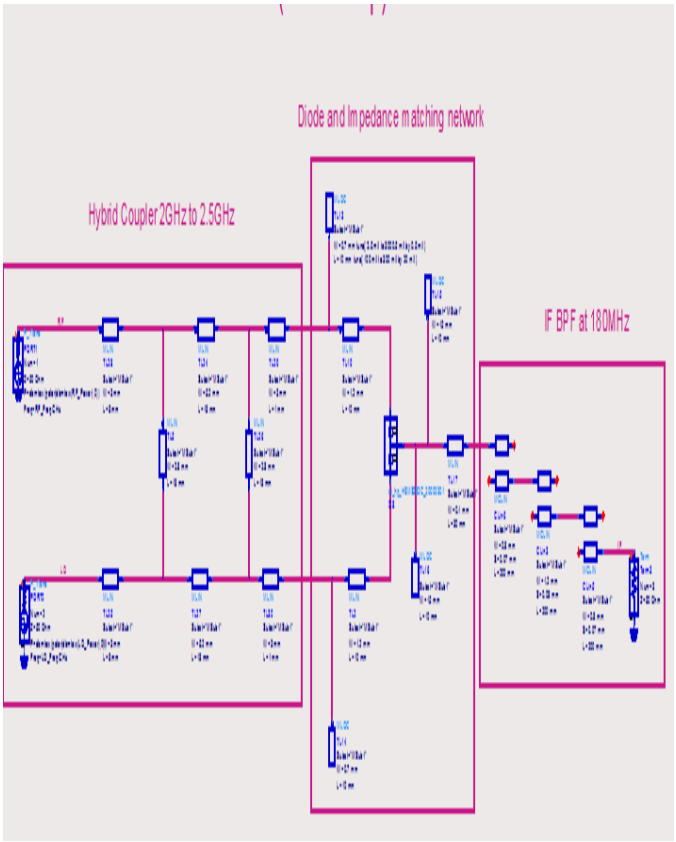


Fig-5: Schematic of single balanced diode mixer

Table-2: Values of noise figure

noisefreq	NFssb	NFdsb
180.0 MHz	11.023	6.513

It's clear from above table that NF for SSB is nearly double than the noise figure of DSB.

Table -1: Values of conversion loss when RF level sweeps

RF_Power	conversiongain
-5.000	-3.802
-4.000	-4.802
-3.000	-5.802
-2.000	-6.802
-1.000	-7.801
0.000	-8.801
1.000	-9.801
2.000	-10.801
3.000	-11.801
4.000	-12.800
5.000	-13.800
6.000	-14.800
7.000	-15.799

From above table we came to know that as increase the negative value of RF power the conversion gain goes on increasing and vice varsa

Table-3: Values of conversion loss when LO level sweeps

LO_Power	conversiongain
-5.000	-8.803
-4.000	-8.803
-3.000	-8.803
-2.000	-8.803
-1.000	-8.803
0.000	-8.803
1.000	-8.803
2.000	-8.803
3.000	-8.802
4.000	-8.802
5.000	-8.802
6.000	-8.802
7.000	-8.801
8.000	-8.801
9.000	-8.800
10.000	-8.799

Above table concludes that by sweeping the LO level to any direction the conversion gain remains almost same.

The below figure shows the spectrum for LO, IF, RF for the simulated mixer.

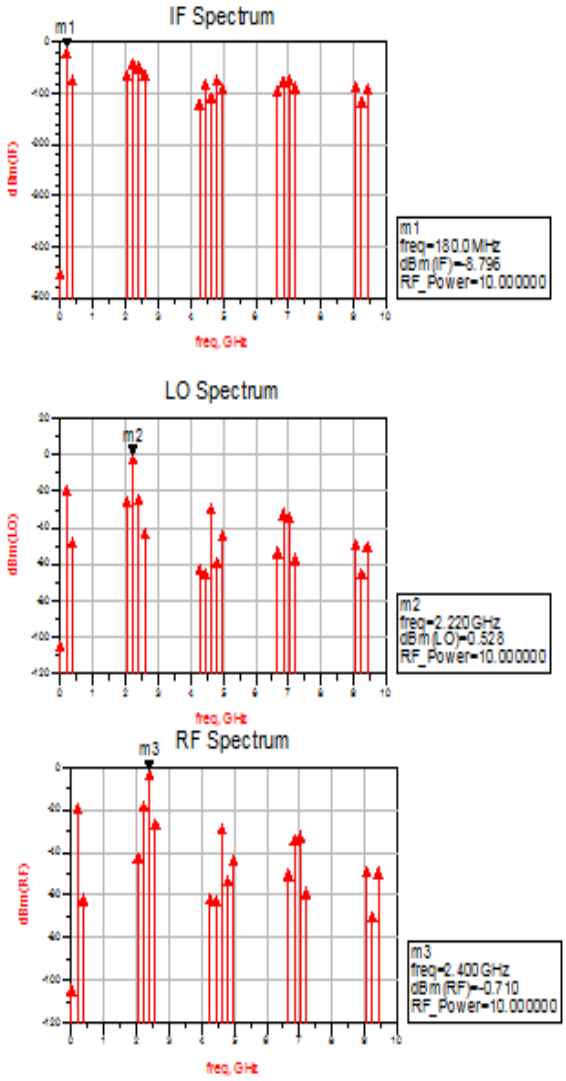


Fig-6: Spectrum of IF, LO, RF respectively

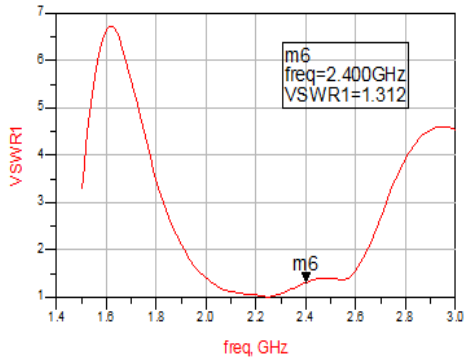


Fig-8: VSWR

Above figure shows the VSWR at input is 1.312.

5. CONCLUSIONS

This paper presents design of single balanced diode mixer is demonstrated in ADS2009. From the S parameter and HB simulation we obtained conversion loss is 8.801dB.The isolation obtained between RF / IF is 34dB and between LO/IF its 27dB.Noise figure for SSB is 11.023dB and for DSB its 6.513dB.Achived VSWR at input port is 1.312.

Mixer is designed using microstrip lines which make mixer design easier with good results. This mixer can easily usable in applications like heterodyne receivers, WLAN, WIFI, etc.

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