Research Paper Engineering

Design and Simulation of 2.4Ghz Rf Mixer Using Passive Devices On ADS

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ABSTRACT

In this paper the design methodology of RF mixer at 2.4GHz is presented. A single balanced mixer is described based on quadrature 3 dB hybrid coupler,schottky diode and band pass filter. By using simulator based design strategy,The design methodology provides an efficient and practical approach with appropriate reference to the theory.The project application is basically for WLAN.As the RF is 2.4GHz local oscillator frequency is taken as 2.46GHz downconverted to Intermediate frequency 60MHz.To perform simulations,Agilent ADS software is used.

KEYWORDS hybrid coupler,bandpass filter, Intermediate frequency(IF),Conversion loss,portisolation,LO level

INTRODUCTION

INTodays world, communication systems offer very high data rates which are mostly digitally transmitted.High carrier frequencies and high bandwidth with lowering noise figure are the reasons for achieving such a fast communication.Operating signal processing and modulation subsystems at intermediate frequency, compatibility and cost of the system can be maintained. In case of high frequency requirement upconversion is done and for low frequency ,downconversion of RF signal using local oscillator is performed. Downconversion is done at the receiver end while upconversion is used to transmit signals.Based on the behavioural level, RF circuit simulation can be done using latest circuit simulator which enables the designer to design the same using different methodologies. Evaluation of the performance of the architecture and the system is done by building RF circuits in familiar simulation environment without first implementing the circuit. This ensures the gain, noise and nonlinearity budgeting, and frequency planning for the circuit.RF mixers are indispensible device found in all the fields of modern communication systems,product detector and modulator.It also works as a phase detector in phase modulation schemes,WIFI applications etc.

PERFORMANCE MEASURES

To evaluate the performance of RF mixer at 2.4GHz , Measures used in this paper are defined.

Conversion loss:It can be defined as the measure of efficiency in providing frequency translation between input RF signal and output IF signal in a

mixer.It is the gain or loss of signal power resulting from conversion of RF frequency to IF frequency.Since two sidebands are produced after mixing so it is generally defined for a single side band.Conversion loss would be 3dB lower than the single side band if two sidebands are considered.All conversion loss are with respect to LO level:

Level 7:+7dBm Level 17:+17dBm Level 23:+23dBm

Mixer linearity:Conversion loss varies with RF input level.In general 10dB difference is maintained between RF signal level and LO signal level.Ex::LO level=+10dBm RF level=0dBm,If the ratio increases beyond 10dB,conversion loss also increases with RF level. IF output level does not follow RF input level.

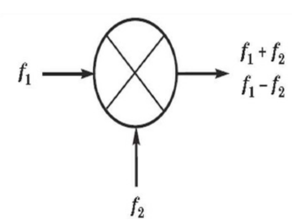
1dB compression point: As RF input increases IF output follows linearly. At certain point IF output doesnot follow RF input linearly and deviates by 1dB .The point is called 1dB compression point.Under this condition conversion loss is 1dB higher than it was when RF signal was smaller.1dB compression point indicates maximum output. It also indicates dynamic range and linearity of the mixer.

Port isolation:The amount of power leaked from one port to other port of a mixer either RF or IF ports is called port isolation.It is also the difference between input signal power and leaked power to other ports.

RF Mixer

Mixer

RF mixer provides one of the key building blocks in RF design, enabling frequencies to be translated from one band to another by multiplying two signals together as shown in fig1.The term mixer is generally reserved for circuits that change a RF signal to some intermediate value known as intermediate frequency or IF and require input from local oscillator (LO)to do so.RF mixing is not similar to audio mixing where several signals are added together linearlygiving several sounds together. It involves instantaneous level of a signal affecting the level of the other signal at the output. Two signal levels multiplying together at any given instant in time and the output is a complex waveform which consists of the product of the two input signals.If the required output frequency is lower than the input frequency then its called downconversion of signal. Intermediate frequency is the difference of the two input signals.



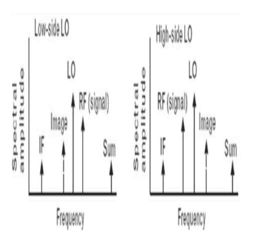


Fig1 Ideal figure of RF mixer Fig2 Downconversion

Branchline coupler/ Quadrature 3dB hybrid coupler:

Branchline couplers are 3dB 4 port directional couplers having 90° phase difference between the output ports.These coupler consist of four ports namely input port through port coupled port and isolated port .Quadrature hybrid coupler is made by two main transmission lines shunt-connected by two secondary (branch lines).It has a symmetrical four port as shown in fig 3. First port is the Input port, second is through or direct port ,Third port is coupled port and the fourth port is the Isolated port. The second port is also called as direct or through port. Due to the symmetry of the coupler any of these ports can be used as the input port but at same time the output ports and isolated port changes accordingly.

Performance measures

1. Isolation Loss: It is the ratio of the isolated port to the input port in dB
2. Insertion Loss:It can be defined as the ratio of the output port to the input port in dB
3. Return Loss:It can be defined as the ratio of the signal power at output of one port when signal is inputted through the same port in terms of dB

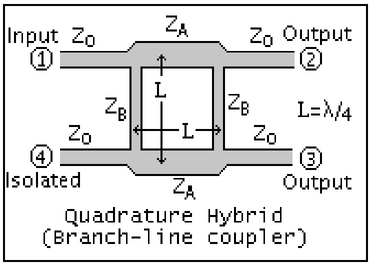


Fig 3 ideal figure of branchline coupler

Scattering matrix of branchline coupler is given by eq1

$$[S]=\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & S_{23} & S_{24} \\ S_{13} & S_{23} & S_{33} & S_{34} \\ S_{14} & S_{24} & S_{34} & S_{44} \end{bmatrix}$$

......eq1

TABLE1 DESIRED SPECIFICATIONS

Property	Desired value
LO(MHz)	2460MHz
RF(MHz)	2400MHz
IF(MHz)	60MHz
LO power(dBm)	Greater than 0dBm
RF power(dBm)	Less than -10dBm

Design Methodology

Initial Design:

Design a Branchline coupler using distributed elements and lumped elements at 2.4GHz Frequency.The mixer which is being dealt with is a RF mixer so practically distributed elements will be ideal for the use of coupler design. Design a band pass filter using lumped elements at 60MHz which is the IF frequency. Simulate the designed coupler and filter separately and check out the results. Insert two schottky diodes of required specifications as shown in Fig and simulate the circuit.

Branchline coupler design using distributed elements:

For the design of the coupler following dielectric parameters are selected:

a. Er = 4.6
b. Height = 1.6 mm
c. Loss Tangent = 0.0023
d. Metal Thickness = 0.035 mm
e. Metal Conductivity = 5.8E7 S/m

2. Calculate the wavelength from the given frequency specifications as follows

$$\lambda_g \approx \frac{c}{f\sqrt{e_r}} \text{ - eq2}$$

c -velocity of light in air
f – frequency of operation of coupler
e_r - dielectric constant of substrate

The physical parameters are synthesized using Linecalcof ADS. The physical parameters of the microstrip line

ForZ0,50Ω width = 2.9mm Length = 16.8mm
For Z0/√2 ,35Ω width = 5.08mm Length= 16.23mm

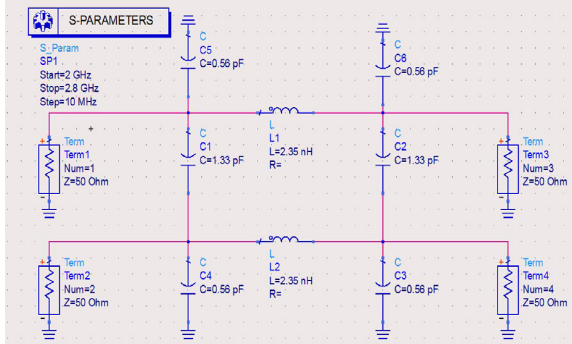


Fig3 Branchline coupler using lumped elements

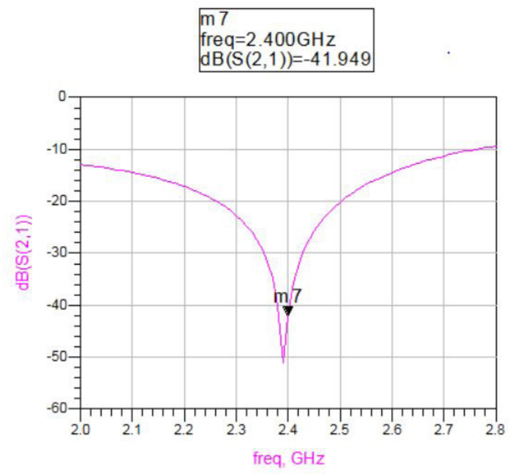


Fig4 Isolation loss of the lumped branch line coupler

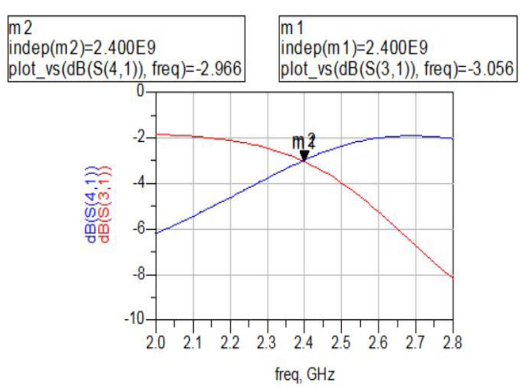


Fig5 Insertion loss of the lumped branchline coupler

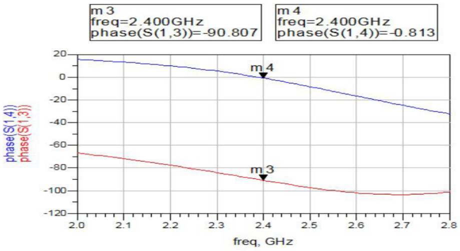


Fig6 Phase plot of the lumped branchline coupler

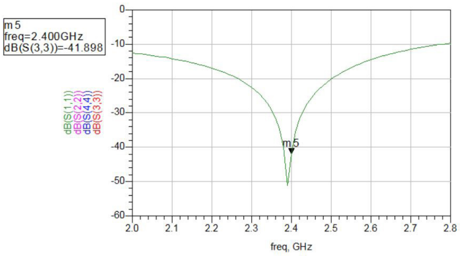


Fig7 Return loss of lumped branchline coupler

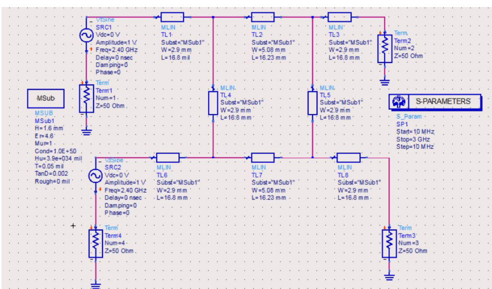


Fig8 Branchline coupler using distributed elements

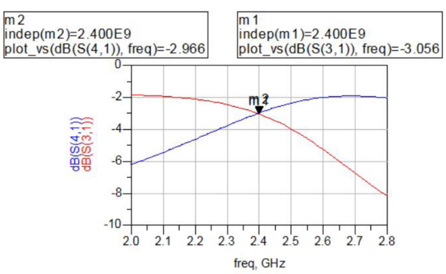


Fig9 Insertion loss of distributed Branchline coupler

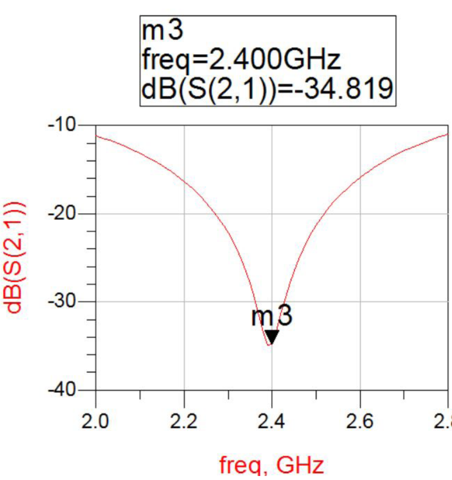


Fig10 Isolation loss of distributed branchline coupler

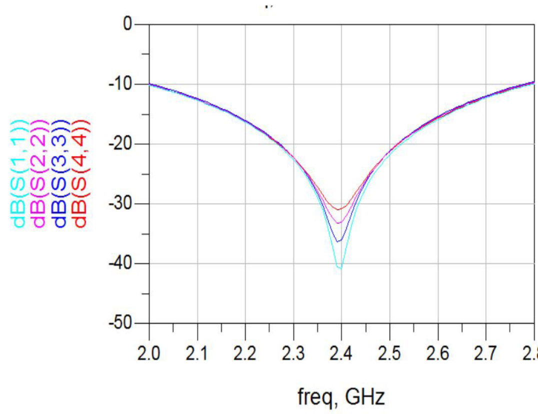


Fig 11 Return loss of distributed branchline coupler

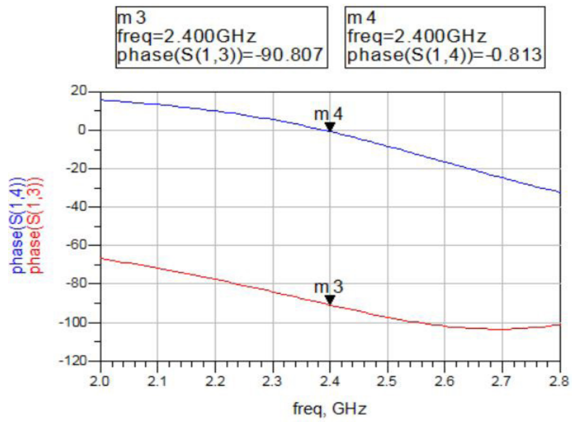


Fig12 Phase plot of distributed branchline coupler

Bandpass filter design

Band pass filter is theoretically designed using the prototype filter and lumped element values are calculated which is then converted according to the required frequency of operation and with the help of ADS the design is simulated and results are obtained

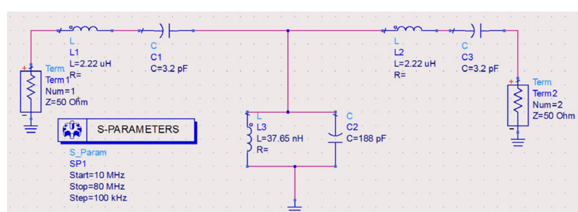


Fig 13 Band pass filter design using lumped elements

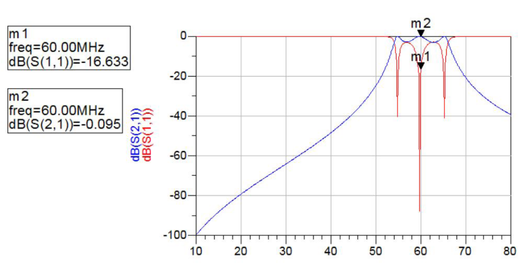


Fig14Bandpass filter output

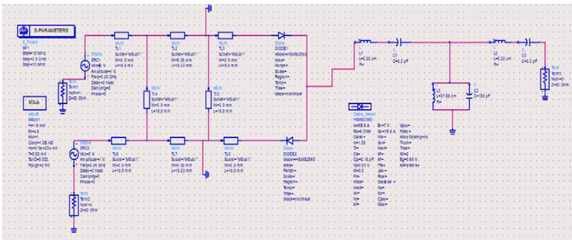


Fig15Final circuit implementation of Single balanced mixer

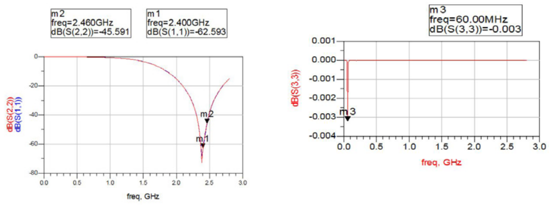


Fig16 Isolation loss of single balanced mixer

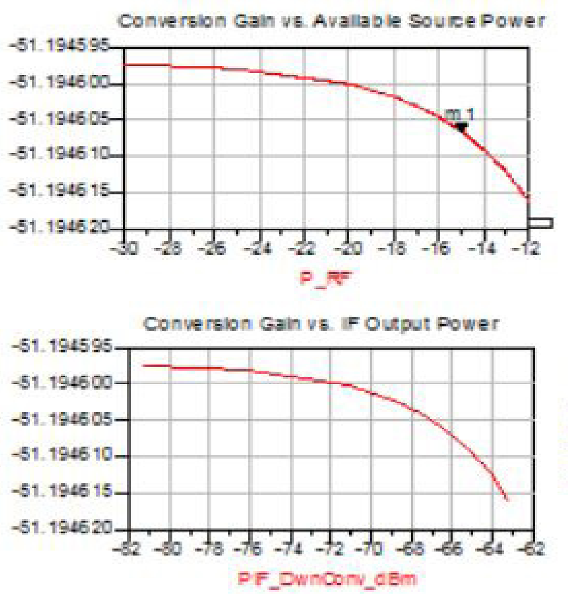


Fig17 Conversion Gain Plot

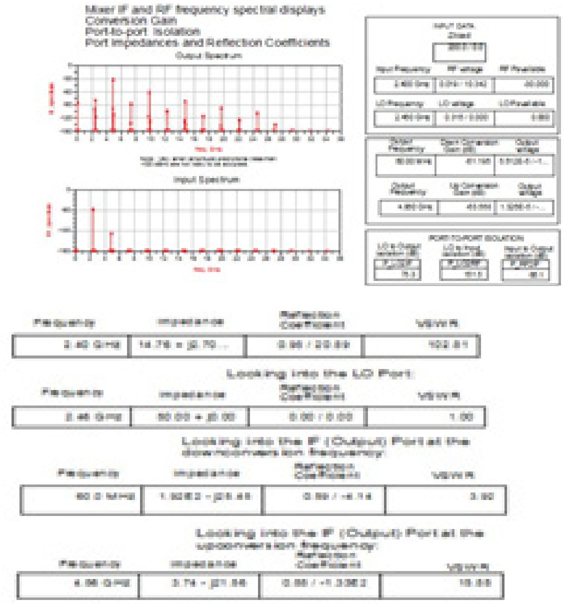


Fig18 Mixer RF and IF spectral output

Conclusions

In this paper, the methodology of designing andsimulating a RF Mixer 2.4 GHZ is presented. The values ofits performance parameters which are according to its desiredvalues are shown.

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