ACTIVE AND PASSIVE FET MIXER

OLEH,
MUZALIFAH BINTI MUSTAPA
62300

Disertasi ini dikemukakan kepada
UNIVERSITI SAINS MALAYSIA

Sebagai memenuhi sebahagian daripada syarat keperluan
untuk ijazah dengan kepujian

SARJANA MUDA KEJURUTERAAN (KEJURUTERAAN ELEKTRONIK)

PUSAT PENGAJIAN KEJURUTERAAN
ELEKTRIK DAN ELEKTRONIK
UNIVERSITI SAINS MALAYSIA
MAC 2005

ABSTRAK

Di dalam menyelesaikan projek berkaitan dengan rekabentuk litar pencampur aktif dan pasif ini, masalah yang paling utama ialah untuk mendapatkan gandaan penukaran bagi litar pencampur aktif berbanding kehilangan penukaran bagi litar pencampur pasif. Dari segi kelinearan pula litar pencampur aktif adalah pencampur yang tidak linear berbanding litar pencampur pasif yang lebih linear. Selain itu, litar pencampur aktif pula mempunyai sisihan yang lebih tinggi berbanding pasif. Cara-cara projek ini dibuat adalah dengan mengaplikasikan litar daripada simulasi Hp-ads (Hp-Advanced design system) ke dalam litar menggunakan papan bercetak yang bersesuaian dan dianalisa kedua-dua rekabentuk. Keputusan daripada keuntungan penukaran, isu lineariti dan sisihan antara masukan dan keluaran hendaklah dibandingkan melalui kedua-duanya dan dengan teori yang sebenar bagi sesuatu topologi untuk litar pencampur aktif dan litar pencampur pasif. Sebagai tambahan, masalah-masalah yang timbul daripada analisa litar juga dikaji dan ketidaktepatan keputusan yang didapati daripada rekabentuk juga akan dibincangkan. Rekabentuk litar akan dibina menggunakan operasi penukaran frekuensi Litar-litar ini di rekabentuk menggunakan perkakasan dan elemen-elemen yang kos efektif dan mengikut kesesuaian penggunaan praktikal. Maka dapat dikatakan bahawa rekabentuk litar pencampur dan analisa litar dibuat tanpa begitu banyak kerumitan. Oleh itu diharapkan rekabentuk pencampur aktif dan pasif ini dapat diteruskan dan ditingkatkan dalam pelbagai aplikasi di masa akan datang.

ABSTRACT

To accomplish the project for in designing an active mixer and passive mixer, the main problem is to obtain the conversion gain for the active mixer design compared to passive mixer design. From the linearity issue, active mixer design is nonlinear compared to passive mixer design that is more linear. Besides that, the active mixer has better isolation compared to the passive mixer. This project will be created by applying the circuit design into simulation from HP-ADS (Advanced design system) to the circuit board that is appropriate and and analyzation will be made for both designs. The results at the conversion gain, linearity issue, and port-to-port isolation will be compared for both of the design and will be discussed according to the theory. Additionally, all problem that may occur from the design and analyzation will be considered and the inaccurate result from measurement will be discussed. The mixer will be designed in down conversion system. This circuit is designed by using the hardwares and the surface mount chip elements that are in effective cost and applicable with the practical usage. Therefore, the design of mixer and the analyzation can be make without any intricacy. Hopefully the design of the active mixer and passive mixer using FET transistor can be continued and improved for the usage in variety of application in the future.

ACKNOWLEDGEMENT

First of all I would like to thank my parents for their support to help me morally and financially as I am studying here. Without them, I could not be able to complete my study here.

To my supervisor, Dr Widad Bt Ismail, I would like to express my gratitude for her guidance, advise and assistance through my final year project. Her involvement in this final year project has inspired me with strength to work harder for greater achievements. To my second examiner, Dr Mohd Ansor Bin Yusof, thank you for your assistance in this report of my final year project.

I also would like to thanks all the technicians in USM especially En Latiff, En Zahidi , and others for their help and assistance. With their help I could speed up my design connection and do my experiment quickly.

To all my friend and other people in the School of Electronic Engineering USM, I wouldly like to express my thanks as well.

Finally, I hope this project will give benefit for other people who want to study about active and passive FET mixer.

TABLE OF CONTENTS

LIST OF FIGURE

CHAPTER 1

INTRODUCTION

1.1 Application of a mixer

Radio communication requires to be shifted to the baseband signal to a frequency suitable for electromagnetic propagation to the desired destination. At the destination the process is reversed by shifting the received radio frequency signal back to baseband signal to allow the recovery of information. This frequency shifting is known as mixing. Mixer can be used in radio transmitter system or radio receiver system. For example, in communication systems, the RF is the transmission frequency, which is converted to an IF to allow improved selectivity (filtering) and an easier implementation of the low noise and high gain amplification

1.2 Objective

Active and passive mixer will be designed using FETs and their performance in terms of the linearity issue, intermodulation distortion, conversion loss or gain and port-to-port isolation will be investigate and compared.

The scope of the design:-

- Conversion loss/gain
- Linearity issue
- Port-to-port isolation

Conversion Loss/Gain

To determine if there are inherent losses in the frequency conversion process of the mixer. Conversion loss applies to either up-conversion or down-conversion operation of the mixer.

Linearity Issue

The linearity issue of a mixer will be investigated and compared either it is a linear or nonlinear. Usually, active FET mixer is a nonlinear mixer or having a low linearity, as for the passive FET mixer, it is a linear mixer.

Port-to-port Isolation

To determine the isolation between LO to RF ports, LO to IF ports and RF to IF ports and compared between active FET mixer and passive FET mixer.

1.3 Guide Of The Project

Chapter 1 : Introduction

Introduction of the project that involves the application of a mixer and the objective of the project.

Chapter 2: Literature Review

Introduction of basic block design of active and passive mixer using FET transistor. This chapter involves additional definition for certain aspects for active and passive FET mixer. Thus it will include wide overview topic of the process of frequency conversion and mixer characteristics, which include conversion loss, linearity issue and port-to-port isolation.

Chapter 3: Software analysis

This chapter includes the calculation and design of the circuit using HP-ADS simulation. To produce the best result of conversion loss and gain, the lump element value that have been ordered will be considered in designing the active and passive FET mixer.

Chapter 4: Fabrication

This chapter consists of the layout design and the hardware material that will be used for the measurement. Most of the components are from the Hewlett Packard Company, Agilent and FARNELL industries. This chapter will discover more about the hardware implementation.

Chapter 5: Results and Measurements

The result of the measurements which include the linearity issue, conversion loss and port-to-port isolation will be compared and analyzed. It will be investigated upon theory basic of the active and passive FET mixer. This chapter also consists of the main reason and probability that may occur in obtaining the best result especially for active FET mixer design. It will be compared with the passive FET mixer design and the theory performance for the active and passive mixer design.

Chapter 6: Conclusion and suggestion

Summary and conclusion about other opinion on obtaining the accurate result and why the design of active dual gate FET mixer cannot be as accurate as possible as it should be. It will include what the opinion and suggestion in the design for the future project.

CHAPTER 2

LITERATURE REVIEW

2.1 <u>The Fundamental Of Mixer</u>

Mixers are three port active or passive device. Additionally, mixers are frequency translation devices that translate signals up or down in frequency without changing them in any other way. They are designed to yield both a sum and difference in frequency at a single output port when two input frequencies are inserted into the other two ports. This process is called the frequency conversion or heterodyning. It is used to increase or decrease a signals frequency.

If the output frequency to be produced is lower than the input signal, it is called the down conversion. In contrast, if the output frequency to be produces is at a higher frequency than the input signal, it is called the up conversion. Mixing is produced by the non-linear behaviour of mixing devices such as diodes, transistors, FET and bipolar transistor. For this project we used FET instead of diodes. It is because the major advantage of FET mixers than diodes mixers is the ability to provide several decibels of conversion gain, while most diode mixers exhibit at least 5 to 6 dB loss. Besides that, Field-effect transistor (FET) mixers have gained more popularity in recent years. The primary reason is because they are generally better suited for the MMIC (monolithic microwave integrated circuit) technology than diodes. FETs do not require the nonplanar balun structures commonly required by balanced diode mixers. Another problem for the design of diode mixers is the difficulty of fabricating high-quality diodes. Additionally, FETs often have relatively high series resistance instead of diodes.

A mixer is fundamentally a multiplier. The difference frequency in the IF results from the product of sinusoids. Mixers produce wanted sum and difference frequencies as shown in Figure 2.1.1 along with nonlinear distortion of the signals passing through them.

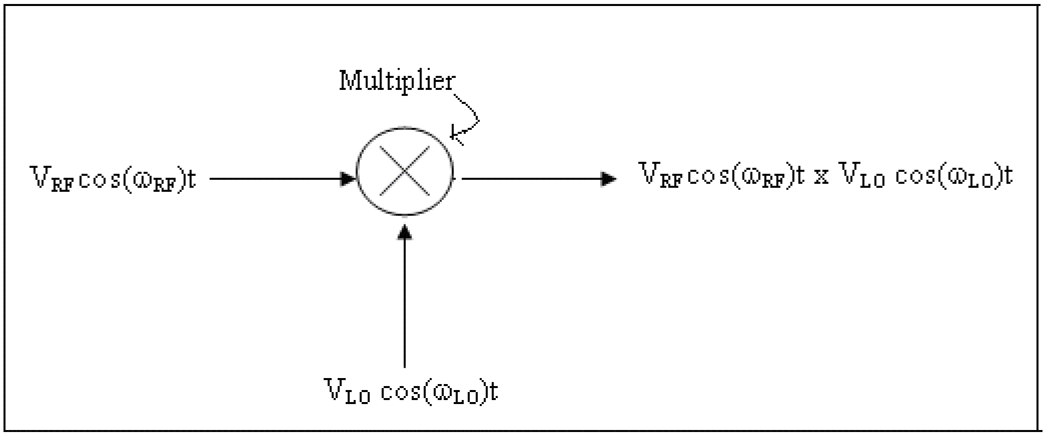


Figure 2.1.1 Basic mixer process

Therefore, the basic mixer design should be capable of injecting the signals to be mixed and producing a strong mixing product that can be extracted by maximizing the efficiency of the conversion. Figure above shows that unwanted spurious product can also produced along the wanted products. The spectrum has an LO frequency below the IF which is known as low-side injection. Thus, in general the mixer produces a range of frequencies given by **m**RF$\pm$**n**LO where **m** and **n** are integers. The noise and unwanted signals that are produced at the same IF frequencies as the RF can severely damage the system performance. Normally, filtering or combining/balanced mixers are normally used to help reduce the level of unwanted spurious output in order to enhance performance.

2.2 Types of mixer

There are three basic classification of the mixer:-

- **Single device mixers**

  This basic mixers have an IF output consisting of f_s, f_{LO}, f_s-f_{LO}, f_s+f_{LO} and spurious output. It also exhibit little isolation between each of the mixer's three ports and resulting in undesired signal interactions and feed through to another port.

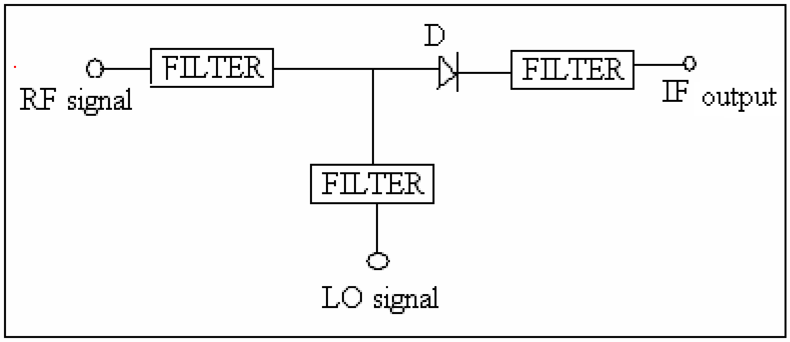


Figure 2.2.1 Single ended mixer configuration

- **Single-balanced mixers**

  Strongly attenuate either the original input signal or LO but not attenuate both and have less mixing product output compared to the unbalanced type.

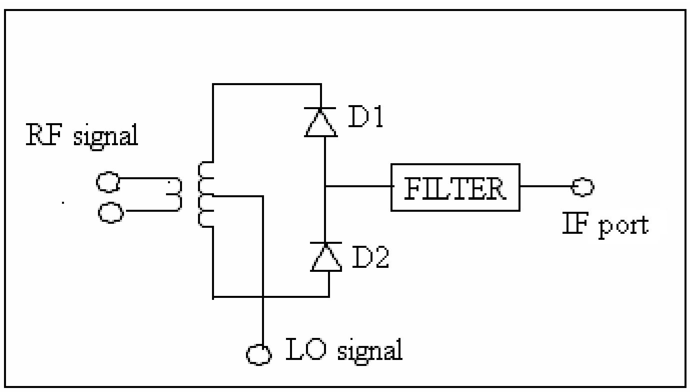


Figure 2.2.2 Single-balanced mixers configuration

- **Double-balanced mixers**

  Superior IF-RF-LO interport isolation, the output is only the sum and difference frequencies of the input signal and the LO signal. Significantly by attenuating three quarters of the possible mixer spurs, thus easier filtering it.

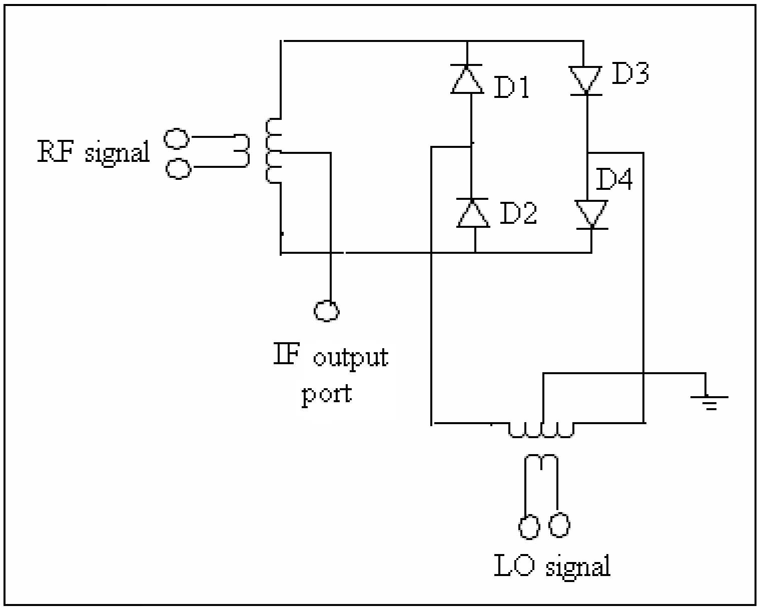


Figure 2.2.3 Double-balanced mixers configuration

2.3 <u>Down Conversion Theory</u>

For down conversion, the signal at radio frequency (RF) is converted to a lower Intermediate Frequency (IF) or baseband and vice versa for up-conversion (IF frequency to RF frequency). The down conversion allows improved selectivity (filtering) and easier implementation of low noise and high gain amplification. Down conversion theory states that the frequency for Radio frequency port and local oscillator port are larger than the Intermediate frequency port where RF/LO > IF.

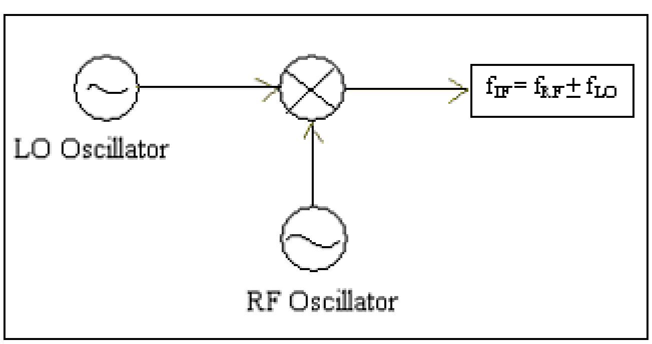


Figure 2.3.1 Down Conversion system

The analysis from down conversion is realized from the equation below.

LO signal:- $V_{LO}(t) = \cos \omega_{LO} t$ (2.3.1)

RF signal: - $V_{RF}(t) = \cos \omega_{RF} t$ (2.3.2)

The output of the idealized mixer is the product of the LO and IF as followed:-

$$V_{IF}(t) = KV_{RF}(t)\, V_{LO}(t) = K \cos \omega_{RF} t \cos \omega_{LO} t \quad (2.3.3)$$

$$= K/2\, [\cos 2Л (f_{RF} - f_{LO})\, t + \cos 2Л (f_{RF} + f_{LO})\, t] \quad (2.3.4)$$

K is a constant of voltage conversion loss. The output consists of the sum and differences of the input signal frequencies and the desired IF output can be selected by using the low pass filter.

$$f_{IF} = f_{RF} - f_{LO} \quad (2.3.5)$$

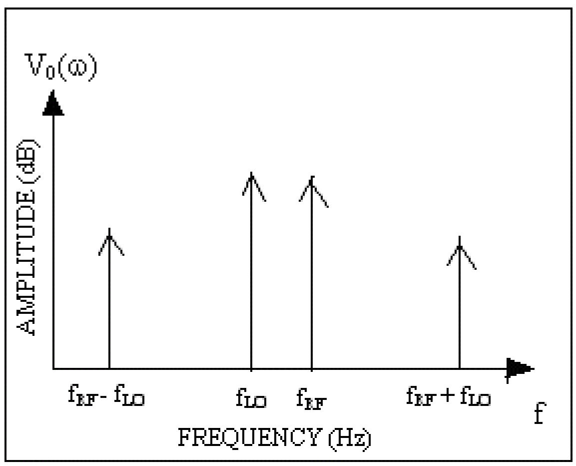


Figure 2.3.2 The spectrum of input and output signal for down Conversion

2.4 Mixer characteristic

Conversion Loss

The ratio of the IF output power to RF input power of one sideband (at either F_{LO} + F_{RF} expressed in dB). It shows the measure of how efficient a mixer is in producing the frequency translation. Mixer design requires impedance matching at three ports, complicated by the fact that several frequencies and their harmonics are involved. Ideally, each mixer port would be matched at its particular frequency either RF, LO or IF and undesired frequency products would be absorbed with resistive loads, or blocked with reactive terminations. Resistive loads increase mixer loss; however, reactive loads can be very frequency sensitive. In addition, there are inherent losses in the frequency conversion process because of the generation of undesired harmonics and other frequency products. Conversion loss accounts for resistive losses in a mixer as well as loss in the frequency conversion process from RF to IF port. Conversion loss applies to both up-conversion and down-conversion. Since the RF stages of receivers operate at much lower power levels than do transmitters, minimum conversion loss is more critical for receivers because of the importance of minimizing losses in the RF stages of receiver noise figure.

Practical passive mixers typically have conversion losses between 4 and 7 dB in the 1-10 GHz range. Active mixer has lower conversion loss, and may even have conversion gain around 0-2dB. Conversion loss (L_c), is defined as the ratio of available RF input power to the available RF input power to the available IF output power. The value is in dB:

$$L_c = 10\log \frac{\text{available RF input power}}{\text{available IF output power}} \geq 0\text{dB} \qquad (2.4.1)$$

or

[Conversion Gain = P_{out} (dBm) – P_{in} (dBm)] (2.4.2)

(The negative value of the conversion gain will give the conversion loss value).

ISOLATION

It measures the mixer circuit balance. When the leakage or feed thru between mixer ports is very small, isolation will be high. It shows how much an input signal is attenuated when measured at another mixer port.

LO to RF isolation

The amount by which the LO drive level is attenuated when measured at the RF port while the RF port is terminated by 50Ω.

LO to IF isolation

The amount by which the LO drive level is attenuated when measured at the IF port while RF port terminated by 50 Ω.

RF to IF isolation

The amount by which the RF drive level is attenuated when measured at the IF port while the IF port is terminated by 50Ω.

Linearity Issue

Linearity of a mixer is one important characteristic to determine whether it is a passive mixer of an active mixer. The linearity issue can be proven by plotting the graph of output power P_{IF} versus input power $P_{RF.}$ For a passive or active FET mixer, the I-V curve characteristic from the FET transistor that will be used can affect the linearity of a mixer.

Normally it is best to unbiased the drain at V_{ds}=0 for the passive FET mixer so that it can provide linearity of the mixer. At this point it indicates that it is at the ohmic region and linear region, so that it will improve the linearity of passive mixer. This is contrast than the active FET mixer, where the point is located in the saturated region where it is a nonlinear region so that the active FET mixer will provide the nonlinearity of the mixer.

2.5 <u>FET MIXER</u>

However in this project, the mixer device that will be used is the FET (Field-effect-transistor) mixer and nowadays the become more attractive because its advantage compared to diode mixers is their ability to provide conversion gain while diode mixer normal produce loss at least 5 to 6 dB. It can also operate well at higher microwave frequency.

Field-effect-transistor (FET) mixers have gained considerable popularity in recent year. The primary reason for their increased use seems to be the related progress in GaAs monolithic microwave integrated circuit (MMIC) technology. The active FET mixer has an advantage for nowadays technology because it can provide several decibels of conversion gain.

2.6 <u>Types of FET mixer</u>

In many applications, there are two types of FET mixer that is the active FET mixer and the other one is passive FET mixer. For the design of FET mixer, there are certain types of topology or configuration such as single-gate FET mixers, dual gate FET mixers, balanced FET mixers with either single-gate or dual-gate devices, and doubly balanced FET mixers.

As for the design of passive FET mixer, the single ended FET mixer will be used. The Figure below shows a block diagram of a single gate FET mixer.

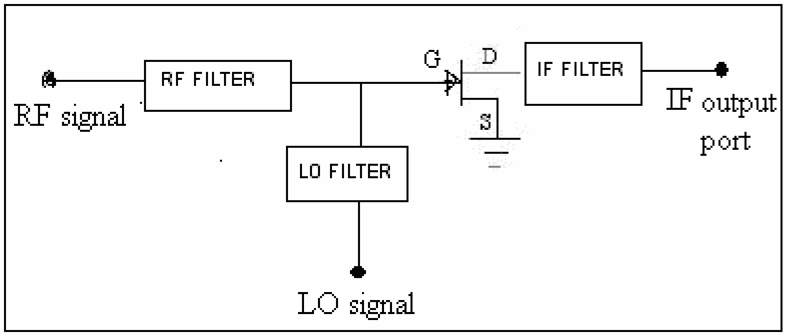


Figure 2.6.1 Single-ended mixer configuration

The mixer of the single ended configuration consists of MESFET and RF, LO and IF matching circuits. This type of configuration is used compared to other configuration is because it this type of mixer is generally use to provide conversion loss.

Compared to the passive FET mixer, dual gate FET mixer for active FET mixer will de used in this project. A dual gate FET mixer is similar in structure to a single-gate device, except that it includes a second gate between the first gate and the drain. This gate has several effects on the device's operation. Its primary use is to control the small signal transconductance of the first gate and thereby the RF gain of the device; this makes the second gate useful for automatic or manual gain control. The fact that the mixing of dual gate FET mixer is in a saturation region or nonlinear for I-V characteristic of FET transistor, it can exhibit lower conversion loss or several few dB of conversion gain.

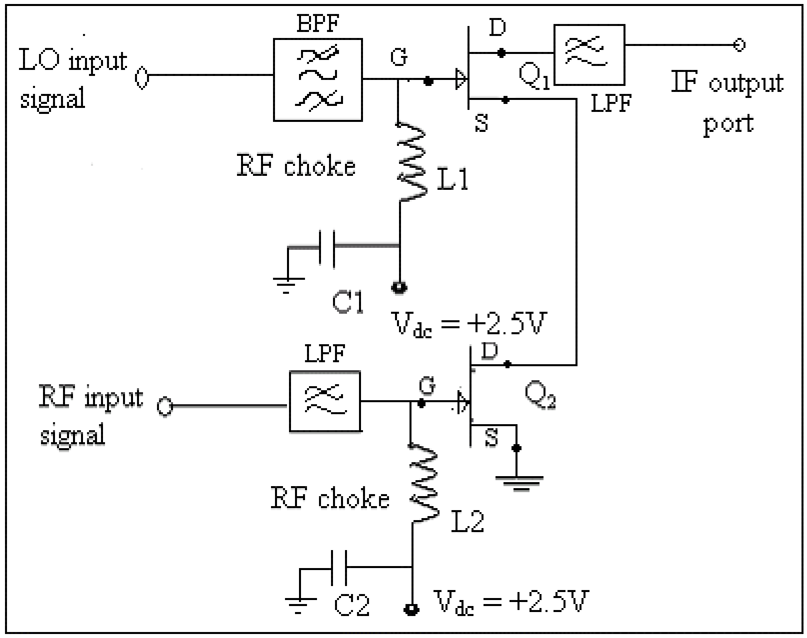


Figure 2.6.2 Dual gate FET mixer configuration

The advantage of dual gate FET mixer configuration is that it has better RF-to-LO port isolation than single-ended gate FET mixer configuration. Balanced dual gate FET mixers are also possible to be used in several applications but usually it requires hybrids for all three ports, and thus may be relatively complicated circuits.

2.7 Filters application

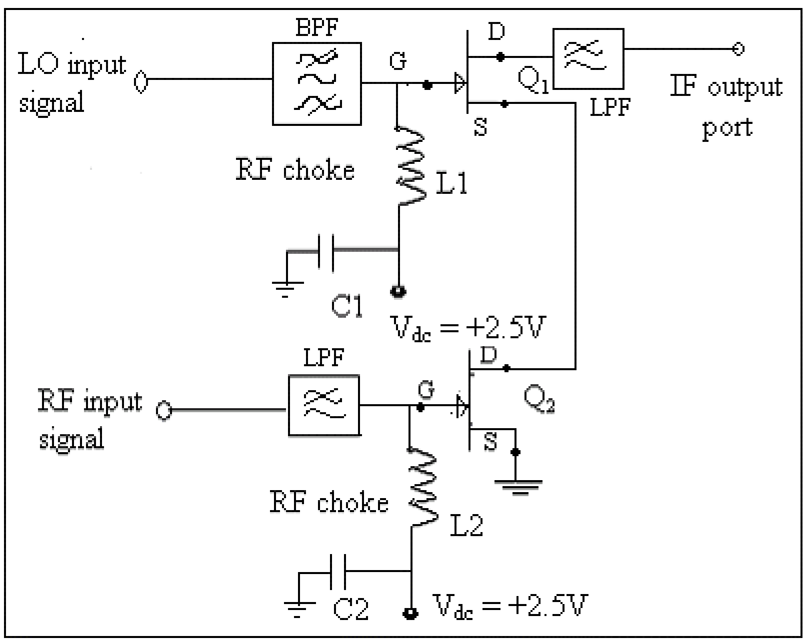
Filters are two-port networks used to control the frequency response in an RF or microwave system by allowing transmission at frequencies within the pass band of the filter, and attenuation within the stop band of the filter. Common filter responses include low-pass, high-pass, band-pass, and band stop filter. As for the active and passive mixer we use only low-pass and band-pass filter so that it can prevent high frequency and damage the FET chip. Filters are indispensable components in wireless systems, used in receivers for rejecting signals outside the operating band, attenuating undesired mixer products, and for setting the IF bandwidth of the receiver.

2.8 ACTIVE FET MIXER

Dual gate FET mixers are normally used because for the single FET mixer, filtering is required to separate the RF and LO inputs which occur on the same port.

2.8.1 Dual gate FET mixer

This topology use a cascade arrangement of two transistors as shown in Figure 2.8.1.1 below:-



-

Figure 2.8.1.1 Active FET mixer configuration

Matching if RF is achieved by applying well-known amplifier techniques for amplifier to the bottom devices while the LO signal is often resistively matched to the top device. The advantage of this structure is that the LO and RF signals are inherently isolated. It can be used to develop compact mixers with conversion gain rather than loss; the disadvantage is that they tend to have lower linearity than passive design.

Because of the capacitance between the gates is low, the dual gate FET mixer has good RF-to-LO isolation. An important property of dual gate FETs is that both devices in the series connected pair can remain in current saturated region from the I-V characteristic of HEMT transistor that will be used. The current saturated region is used to perform the nonlinearity of the mixer.

For the design of active dual gate FET mixer, gate pumped topology by using the RF choke with be applied. Either gate pumped topology or drain pumped topology can be applied for the mixer, but the source pumped is not encourage because it is somewhat harder to implement and can provide may problem in stability.

2.9 PASSIVE FET MIXER (Resistive FET mixer)

The resistive FET mixer performs like a voltage controlled resistor by varying the gate voltage Its I/V characteristic is necessarily a function of two voltages, the gate-to-source and drain-to-source voltages.

For a FET to work as a mixer, four main important steps must be taken as follows:

- The LO is applied to the FET’s gate together with DC gate bias.
- RF is applied to the drain.
- IF is filtered from the drain.
- No dc bias is applied to the drain, (V_{ds}=0V).

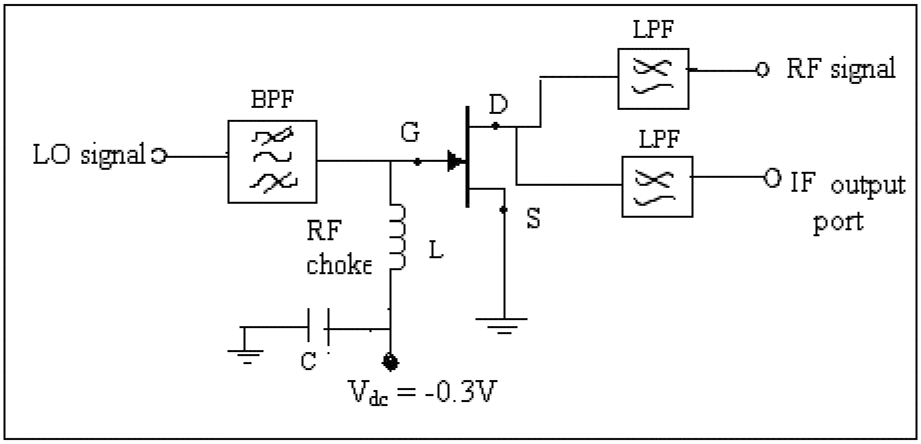


Figure 2.9.1 Single resistive FET mixer

The LO signal at the gate varies the drain-to-source conductance which is similar to diode mixer but the main difference is that no DC current flows due to that variation The results in a strongly reduced LO power consumption that is suitable for wireless applications. The channel of the PHEMT transistor that will be used, at low drain-to-source voltages or V_{ds}=0V is a very linear resistor. This characteristic of ohmic region from the I-V curve of transistor is very useful to get the linearity of the passive FET mixer.

The resistance of this linear channel can be varied by applying an LO signal to the gate. The LO voltage changes the depth of the depletion region under the gate and thus the resistance of the entire channel. This range of resistances is entirely adequate to achieve good conversion performance in a resistive mixer. Thus it is clearly that a mixer that uses the resistive channel or the linearity from the FET transistor to provide frequency conversion is called a FET resistive mixer.

Appropriate filtering is required to separate the RF from the IF and to prevent LO leakage from pumping the drain conductance. The gate should be short circuited at the RF frequency to prevent the RF voltage from introducing nonlinearity by varying the channel conductance.

CHAPTER 3

SOFTWARE ANALYSIS

3.1 ACTIVE FET MIXER CALCULATION

The schematic below is a schematic of an Active FET Mixer design. For the LO input we are using a 'Band pass Filter', as for the RF input we are using a 'Low Pass Filter' and for the Output RF we are using the 'Low Pass filter' lump elements. The calculation for active FET mixer will be included in Appendix 3.

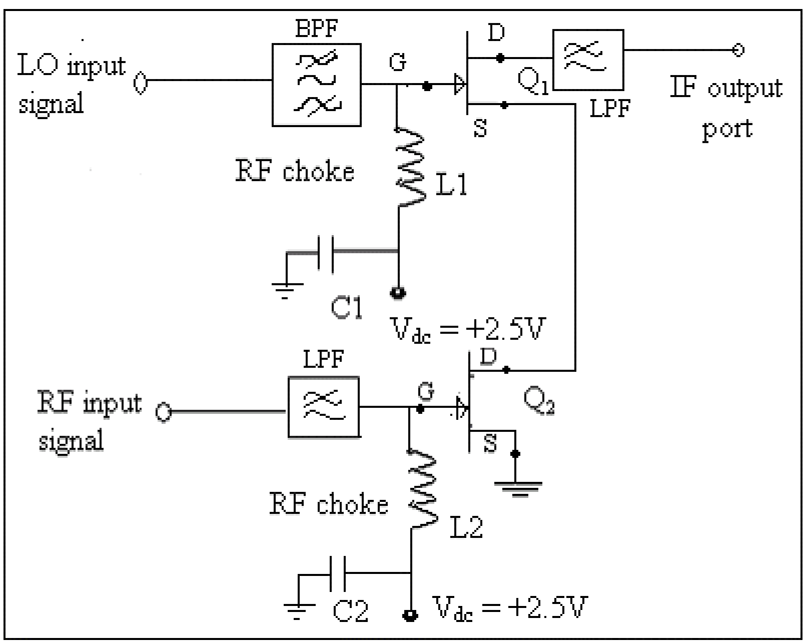


Figure 3.1.1 Active Dual Gate FET mixer

3.2 PASSIVE RESISTIVE FET MIXER

The schematic below is a schematic of a Passive FET Mixer design. For the LO input we are using a 'Band pass Filter', as for the RF input we are using a 'Low Pass Filter' and for the Output IF we are using the 'Low Pass filter' lump elements. For the calculation for passive resistive FET mixer please refer to Appendix 4.

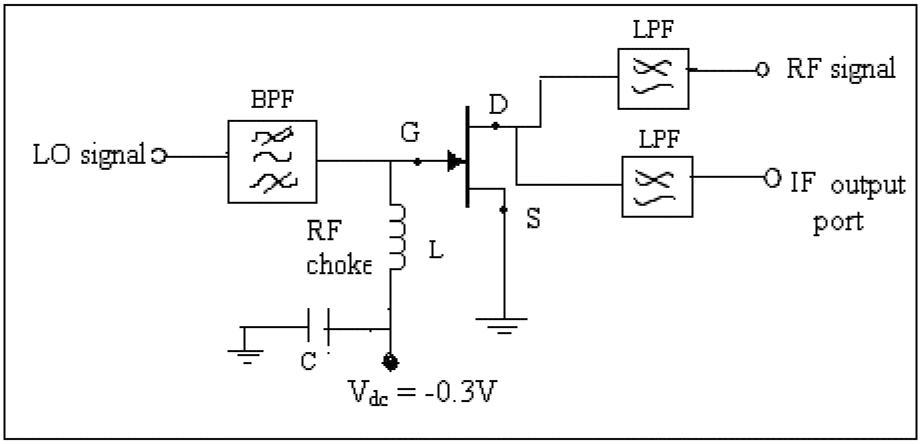


Figure 3.2.1 Resistive FET mixer circuit

The value for lump element at LO port for active and passive FET mixer is same. As for the value of lump element at RF port and IF port are also the same. But the voltage power supply for active FET mixer is +2.5 V and the voltage power supply for passive FET mixer is -0.3 V. This value of voltage V_{gs} of power supply is accordingly from the I-V curve characteristic of PHEMT transistor that will be used.

LO input : 3.0GHz

Band Pass Filter elements

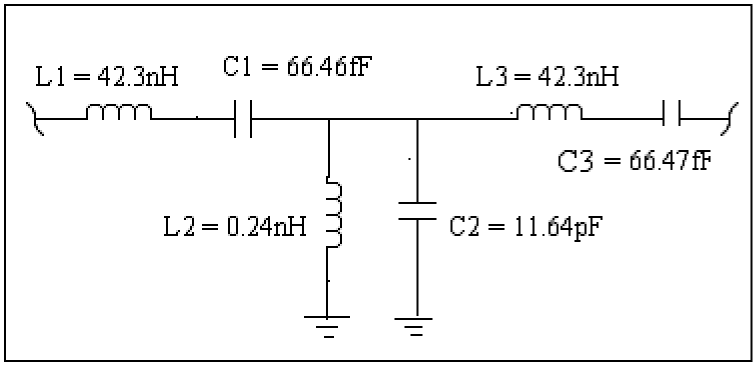


Figure 3.2.2 Band pass filter basic circuit

The Band pass filter has been designed using a 0.5 dB equal-ripple response, with N=3. The center frequency or the frequency for the filter is 3.3 GHz and the impedance Z_0 is 50 Ohm. Fractional Bandwidth, Δ is 10%. To see the calculation for the band pass filter, refer to Appendix 3.

g_1 = 1.5963 = L1'

g_2 = 1.0967 = C2'

g_3 = 1.5963 = L3'

g_4 = 1.0000 = R4'

The elements alternate between series and shunt connections and g_k has the following definition where:-

N = order

g_o = { generator resistance /generator conductance}

g_k = {inductance for series inductors / capacitance for shunt capacitors }
(k=1 to N)

g_{N+1} = {load resistance if g_N is a shunt capacitor / load conductance if g_N is a series inductor }

A matter of practical design procedure, it will be necessary to determine the size, order, of the filter. This is usually dictated by a specification on the insertion loss at some frequency in the stop band of the filter.

RF input : 3.3GHz

Low Pass Filter elements

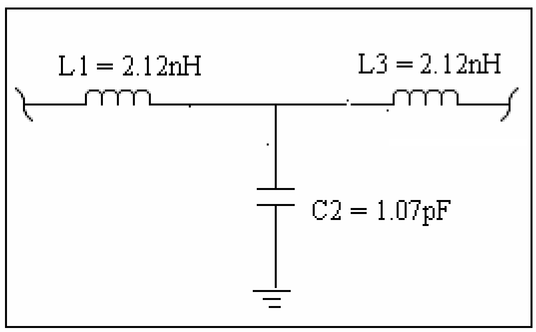


Figure 3.2.3 Low pass filter basic circuit for RF port

For RF input filter, Chebyshev Low Pass Filter design is used.

$g_1=g_3$ = 0.8794 = g_n

g_2 = 1.1132

The elements alternate between series and shunt connections and g_k has the following definition where:-

N = order

g_o = { generator resistance /generator conductance}

g_k = {inductance for series inductors / capacitance for shunt capacitors }
(k=1 to N)

g_{N+1} = {load resistance if g_N is a shunt capacitor / load conductance if g_N is a series inductor }

To see the calculation of low pass filter at RF port, refer to Appendix 3

IF Output : 300 MHz

Low Pass Filter elements

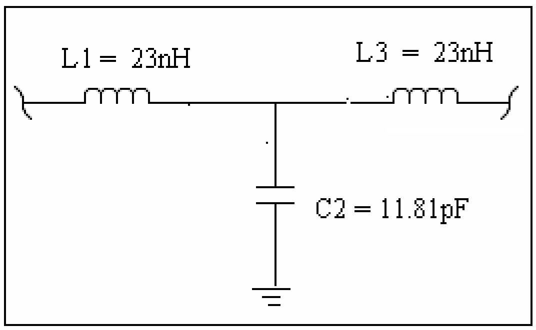


Figure 3.2.4 Low pass filter basic circuit for IF port

For IF output filter, the Chebyshev Low Pass Filter design is use

$g_1 = g_3 = g_n = 0.8794$

$g_2 = 1.1132$

where:

N = order

g_o = { generator resistance /generator conductance}

g_k = {inductance for series inductors / capacitance for shunt capacitors } (k=1 to N)

g_{N+1} = {load resistance if g_N is a shunt capacitor / load conductance if g_N is a series inductor }

To see the calculation for low pass filter at IF port, refer to Appendix 3

The value of the lump element at the **LO short circuit (3.0 GHz)**

To see the calculation for LO short circuit at 3.0 GHz, refer to Appendix 3. Biasing is very important to prevent capacitance between the gates of FET to the drain of FET transistor.

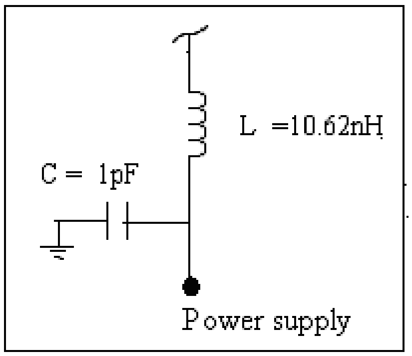


Figure 3.2.5 RF choke at LO port at the gate of FET

The value for the lump element at the **RF short circuit (3.3GHz)**

To see the calculation for RF short circuit at 3.0 GHz, refer to Appendix 3. This biasing is for dual active FET mixer which uses two gates of FETs.

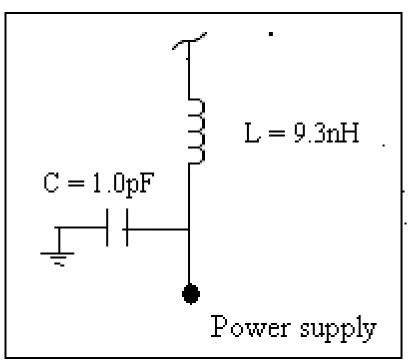


Figure 3.2.6 RF choke at RF port at the gate of FET

3.3 The output simulation result

The simulation result consists of the simulation result for Band Pass Filter at LO port, the Low Pass filter at the RF and IF port. This will include the overall simulation result for active and passive FET mixer.

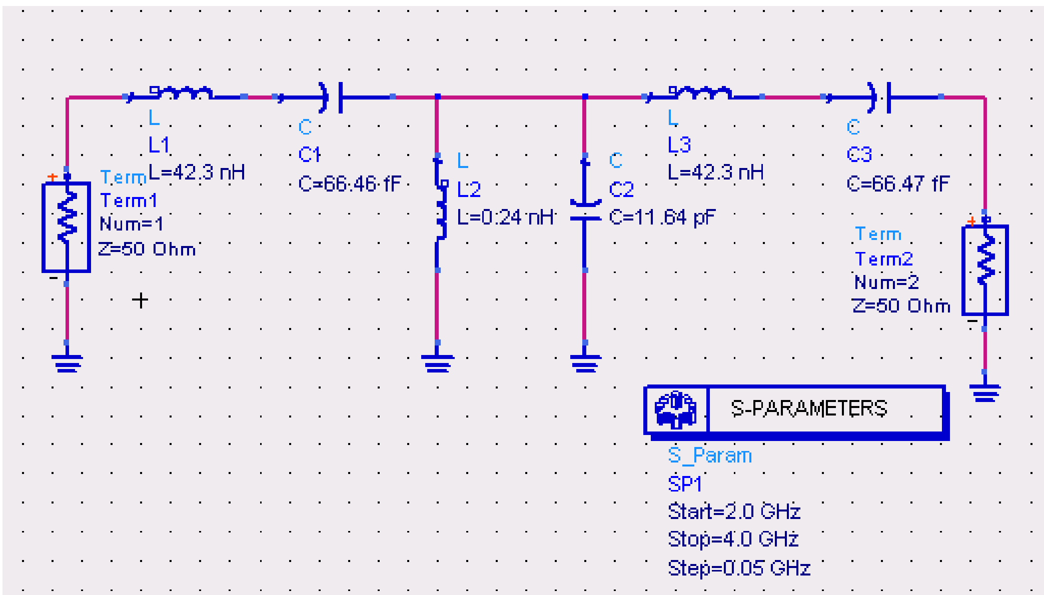


Figure 3.3.1 Circuit simulation without microstrip line for LO port

To simulate the filter design, S-parameter simulation is performed. The design for Band Pass Filter include the lump element of capacitor and inductor. This design should give a ripple response at about 3.0 GHz.

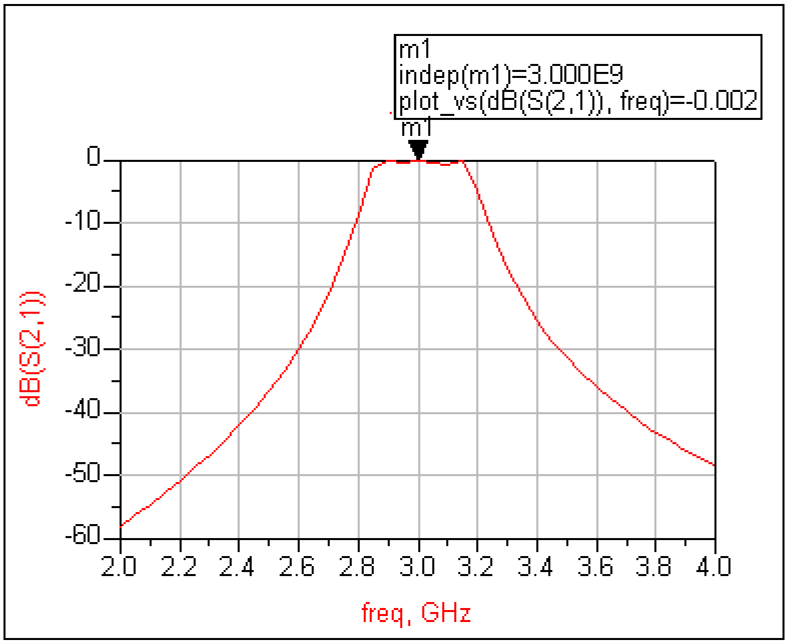


Figure 3.3.2 Simulation result for Band pass filter at LO port

The simulation result for Band pass filter at LO port for both active and passive FET mixer meets the specification within the range of frequency of 3.0 GHz. Thus the lump element value for capacitor and inductor is quite reasonable to obtain the result of band pass filter.

Low-pass filter at RF input for frequency of 3.3GHz:-

This Low-pass filter can be used in both active and passive FET mixer at the RF input. In active FET mixer design, it is used to avoid damage the FET chip component.