A Review on Various Types of Noise in CMOS Devices

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Abstract—Noise is one of the important issue which has to considered while designing any analog circuit . As far as operational amplifiers are concerned, it is very clear that so get maximum efficient output , the noise has to be eliminated . There are two various types of operational amplifiers which are deployed for various applications but for better results fully differential operational amplifier must be used as the noise produced by this configuration is lesser as compared to single ended . Not only this the offset voltage is also lesser in fully differential amplifiers. This paper gives an overview of opamp design with lesser noise and high SNR ratio with high gain.

Keywords*-Noise , SNR , Thermal Noise*

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I. INTRODUCTION

Noise can be defined as any undesired signal produced by variation in some parameters (Process Variation , Temperature Variation) which couples with the desired signal and obtains as a noisy signal at the output end. As far as communication field is concerned , there are some algorithms which uses noise to improve SNR(Signal to Noise Ratio).Noise is generated due to random process and limits the desired signal that a circuit can process with reasonable but acceptable quality. In analog circuit design there are various parameters which are dependent on one another at the same time , there are parameters which have tradeoff with some other parameter. For example , noise is directly related to bandwidth , linearity and power dissipation and at the same time linearity is also related to bandwidth and further bandwidth is also related with power dissipation . There is difficulty in eliminating noise as it depends on three parameters on bandwidth , power dissipation and linearity .

Noise has many features to understand but this paper restrict the study of noise with analog point of view.in introduction the concept of noise is studied , in section 2 types of nose is studied and section 3 MOS models for noise is described . Most noise sources shows the constant average power over a period given by

$P_{avg}=\lim_{t \text{ approaches } 0} \int v^2(t)/R_l \, dt$ with is period from –T/2 to T/2 for circuit shown below………………..(1)

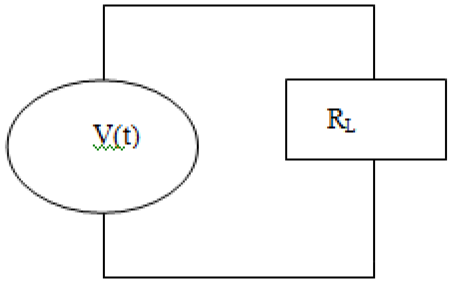

Figure 1 : Illustration for Power Dissipation

Now from equation 1 , if R is assumed to be 1 the average ower is defined as V^2 (t) and unit as watts in the same way the average nose will also be measured in terms of V^2(t).The describe method is explaining the time domain approach to measure noise but as far as frequency domain is concerned , the noise is different at different frequencies and then it is studied under PSD that is Power Spectral Density and noise is expressed as V/(square root of Hz). Since to calculate the PSD , the signal has to pass through a band pass filter and the obtained signal is analyzed at the frequency of band pass filter . To obtain full spectrum the signal has to pass through band pass filter at different frequency then PSD is plotted given by S(f).

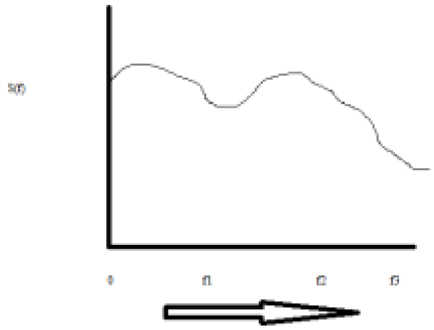

Figure 2 : Power Spectral Density Curve

S(f) is expressed as V^2/Hz and sq root of S(f)=V/(sq root of Hz)

II. TYPE OF NOISE

There are various types of noise

1. Shot Noise :This noise occur due to the quantaum nature of electron flow through a potential barrier (pn junction) , carriers exhibits average rate (dc value) of crossing but individual carriers crosses barrier as a random events. So the noise current is given by

I_n=sq.root($2qI_D\delta f$) …………………………..(2)

From equation 2 I_D is the thermal current in the device and δf is measurement bandwidth

So , shot noise is directly proportional to sq root (I_D)

In Mosfet's Subthreshold current exhibit shot noise .

2. Johnson Noise

It occurs due to random carrier motion (drift , diffusion)gives rms as

$S_n(f)=kt\delta f$……………………(3)

From above equation , it can be said that

$S_n(f)$ is directly proportional to T

3. 1/F noise(flicker noise)

Due to number of fluctuations occurring due to defects , interface states , flicker noise is observed . This noise is inversely proportional to frequency as shown in figure 3

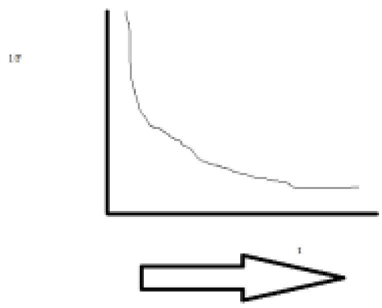

Figure 3: Flicker Noise

4. GR Noise

Generation and recombination of carriers in semiconductor (devices) results in statistical variation of number density. This leads to noise also known as RTN(Random Telegraph Noise)

5. Popcorn Noise

It is also known as burst noise .This kind of noise occurs due to channel effect in MOSFET. It shows $1/f^2$ dependencies. Discrete Modulation of channel current by capture and emission of carriers in the channel leads to Popcorn Noise.

In general the noise can be categorized into two ways in Opmaps

A. *Man-Made Noise*

It occurs due to signal coupling , substrate coupling and due to final power supply rejection .

This kind of noise can be eliminated by

1. Fully differential circuit
2. Proper layout of the circuit

B. *Electronic noise due to devices*

It effects the circuit in such a way that the minimum detectable signal is limited

There is a trade off between noise and power dissipation. Low noise requirement dictates the use of large capacitor and or large g_m.

III. MOS NOISE MODELS

There are basically two noise models

1. McWhorther's model:

According to this channel , the noise is produced by trapping and de-trapping of mobile carriers in the channel.

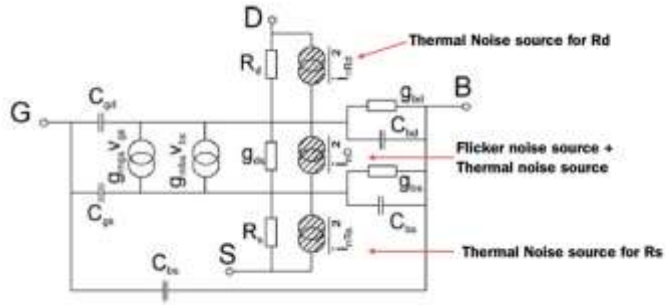

Figure 4: MOS equivalent circuit for noise model

2. Hooges' model

According to this flicker noise is attributed to mobility fluctuation .These fluctuations can also induce fluctuation in the channel mobility of the remaining carriers in the channel since the traps act as coulombic Scattering site when they capture a carriers

If comparison made between both the noise models it is observed that both involves different equations at different regions as shown below in figure 5.

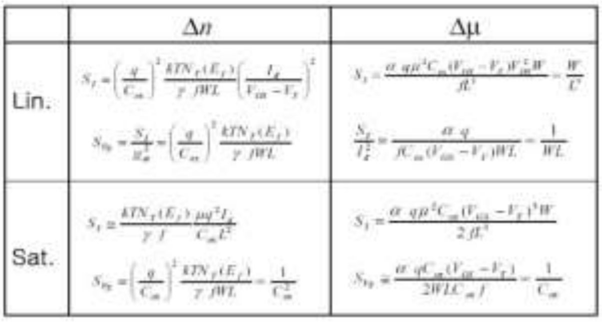

Figure 5: δn (McWhorther'smodel)&δn(Hooges' model)

IV. CONCLUSION

From above discussion it is clear that noise is an important aspect , which need to be understood while designing any circuit in analog electronics as minute fluctuations results in great loss og signal and hence poor effieciency .

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