1/f MOSFET Noise model for Low Noise MOSFET Amplifier Design with MATLAB .M Files - By SPG Technical Staff.

Introduction: 1/f noise in MOSFETs is a subject for continual study. Multiple noise models have been derived and studied. Each of these have some advantages and disadvantages. At SPG we have used a simple model of 1/f MOSFET noise for some time. It has served its purpose in allowing us to at least estimate the 1/f noise for our design purposes. By using some kind of thumb rule, most appropriate to a particular design it is quite possible to use this model effectively.

The model is presented below with credit to the source. The calculation based on this model has also been coded into a MATLAB .M file that is available for the user. The original author of the paper is: Chorng - Kuang Wang. This model is further described in a Memorandum No. UCB/ERL M79/78 issued by UC Berkeley.

The model is defined by the following equation for the mean squared noise voltage for 1/f noise of the MOSFET at low frequencies: (This is the mean square voltage in a 1 Hz bandwidth.)

$e_{ni}^2 = [1.178e\text{-}39 / (Cox^2 * W * L * f)] * 4.0 * Nss$ (1)

Here Cox is the gate oxide capacitance (in Farads/cm^2), f (Hz) is the frequency of interest, Nss (cm^{-2} ev^{-1} is the surface state density, W(um) is the width of the MOSFET, L(um) is the length of the MOSFET.

The MATLAB M File is shown below:

```
function y=mosnoise(tox,w,l,f,nss)
% This function calculates mosfet 1/f noise. Call with mosnoise(tox,w,l,f,nss) where
% tox is oxide thickness in microns, w is width of transistor in microns, l is
% length of transistor in microns, f is frequency in Hz and nss is surface
% state density of the mosfet.

cox=(.0347/tox)*1e-7; ( Calculates the gate oxide capacitance from tox)
w1=w*1e-4;
l1=l*1e-4;
f1=1.178e-39;
f2=cox*cox*w1*l1;
f3=(nss*f1)/f2;
f5=f3/f;
y=sqrt(f5);
end
```

In this equation the effect of drain to source bias has been effectively neglected since noise is almost independent of $V_{ds.}$ (Note that this noise is for the saturation region of operation). Using this equation and the MATLAB file, noise parameters for the device can be analyzed.

This analysis can then be used design low noise MOSFET amplifiers. To simplify the task note that the noise of the MOSFET can be restated as:

e_n = sqrt(An/WL)

Here An is a constant that can be calculated from the above equation if the value of Nss is known. The foundry should be able to supply this value for the devices. In a MOSFET analog circuit each gate will have a 1/f noise source. This noise source can be evaluated using the above M - FILE and its effects can be studied. The circuit can then be designed using standard MOSFET design equations. (See a forthcoming paper for these design equations on this Web Site).