University of California
College of Engineering
Department of Electrical Engineering and Computer Sciences

B. E. Boser
H. Khorramabadi

Homework 10 Solution

EECS 247
Fall 2003

1 It is given that

$$\Delta I_d = I_{SS}\left[\frac{\Delta v_i}{(V_{gs}-V_{th})}\right]\left\{1-\frac{1}{4}\left[\frac{\Delta v_i}{(V_{gs}-V_{th})}\right]^2\right\}^{1/2} \tag{1}$$

Using the Taylor series expansion $(1-x^2)^{1/2} \approx 1-\frac{x^2}{2}$ (for small values of x), equation (1) yields

$$\Delta I_d = I_{SS}\left[\frac{\Delta v_i}{(V_{gs}-V_{th})}\right]\left\{1-\frac{1}{8}\left[\frac{\Delta v_i}{(V_{gs}-V_{th})}\right]^2\right\}$$

$$\Rightarrow \Delta I_d = I_{SS}\left[\frac{\Delta v_i}{(V_{gs}-V_{th})}\right]-\frac{I_{SS}}{8}\left[\frac{\Delta v_i}{(V_{gs}-V_{th})}\right]^3$$

$$\Rightarrow \Delta I_d = \underbrace{\left[\frac{I_{SS}}{(V_{gs}-V_{th})}\right]}_{\alpha_1}\Delta v_i - \underbrace{\left[\frac{I_{SS}}{8}\frac{1}{(V_{gs}-V_{th})^3}\right]}_{\alpha_3}\Delta v_i^3 \tag{2}$$

Hence,

$$HD_3 = \frac{1}{4}\frac{a_3}{a_1}V_{in}^2 = \frac{1}{32}\frac{1}{(V_{gs}-V_{th})^2}V_{in}^2 \tag{3}$$

If $HD_3 = 1\%$, given that $V_{gs}-V_{th} = 1V$,

$$V_{in} = \sqrt{32 HD_3} = \sqrt{32\times 0.01} = 566mV \tag{4}$$

2

$$IM_3 = \frac{3}{4}\frac{a_3}{a_1}V_{in}^2 = \frac{3}{32}\frac{1}{(V_{gs}-V_{th})^2}V_{in}^2 \tag{5}$$

If $IM_3 = 1\%$, given that $V_{gs}-V_{th} = 1V$,

$$V_{in} = \sqrt{\frac{32}{3}IM_3} = \sqrt{\frac{32}{3}0.01} = 327mV \tag{6}$$

3 From definition, at IIP_3:

$$IM_3 = 1$$

$$\Rightarrow V_{in}^2 = \frac{32}{3} 1 = 10.67V^2$$

$$\Rightarrow V_{in,rms}^2 = \frac{1}{2} 10.67V^2 = 5.33V^2 \tag{7}$$

Hence,

$$IIP_3 = 10\log\left(\frac{V_{in,rms}^2}{R \times 1mW}\right) = 10\log\left(\frac{5.33V^2}{50\Omega \times 10^{-3}W}\right) = 20.28dBm \tag{8}$$