

实验内容、实验目的、时间安排

●实验内容:

●设计差分放大器

●对电路进行直流、交流、瞬态分析

●目的:

•掌握模拟集成电路单元模块的设计分析方法

●时间安排:

一次课完成差分放大器的电路设计

实验要求

- ●设计图示差分放大器
 - ●尺寸需调整
- ●放大器性能指标要求
 - ●负载电容C_L=2pF
 - •VDD=5V
 - ●放大管的Vdsat=200±30mV
 - ●对管的m取4的倍数
 - ●低频开环增益>100
 - •GBW>25MHz
 - •PM>60
 - ●共模输入范围>3V
 - ●功耗、面积尽量小



实验结果记录

●请记录如下数据

- ●各晶体管尺寸(m、W、L)
- ●各晶体管的Vdsat
- ●低频开环增益、GBW、PM
- ●直流功耗、瞬态功耗平均值及对应跳变频率
- ●转换速率(上升、下降分别记录)
- ●单位缓冲接法,输入1V跳变时,输出端的信号建立时间(20µV)

● 上升、下降分别记录

●实验方法,参见P5~P32

创建放大器的电路(按下列尺寸设置)





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创建放大器的Symbol



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创建Power的电路图



●如图创建Power的电路

●创建Power的Symbol View

● 仅供仿真时调用!!!

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创建放大器的仿真电路(DC/AC仿真)

●正输入端vp,加激励信号,DC=2.5,AC magnitude=1V
●负输入端vn,大电阻(1G)、大电容(1F)反馈



放大器的仿真电路:





常用Analyses设置

- ●Tran: 瞬态
- ●DC: 直流
- ●AC: 交流

设置完毕后运行Simulation,然后可以查看Simulation Results



Results: MOSFET的直流工作点

●Results->Print->DC Operating Points->鼠标点击元件->弹出对话框

Virtuoso	Analog Design Enviror	nment (1) _	
Status: Ready		T=27 C Simulator: spectre	4
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- View schematic	2 ac 1 16	Vector Circuit Conditions Violations Display	Model Parameters Transient Node Voltages Transient Oversting Points
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>			HBAC Distortion Summary Pole-Zero Summary
			SSU210AUIG2

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Results: MOSFET的直流工作点



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•Results->Direct Plot->AC Gains & Phase->进入Schematic View

Virtuoso	Analog Design Environm	1ent (1)			
Status: Ready	т	=27 C Simulator: spectre	4		
Session Setup Analyses	Variables Outputs Simulation I	Results Tools XA	Help		
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Library LowPower_CXL Cell B6_Vref View schematic Design Variables # Name Value	<pre># Type Arguments 1 dc t 2 ac 1 16 Outpu # Name/Signal/Expr V</pre>	Annotate Annotate Acctor Circuit Conditions Aolations Display Save Save Select Delete	Transient Signal Transient Minus DC Transient Sum Transient Difference AC Magnitude AC dB10 AC dB20 AC Phase		
>	Plotting	mode: Replace =	AC Magnitude & Phase AC Gain & Phase Equivalent Output Noise Equivalent biput Noise Squared Ontput Noise Squared Input Noise		

●View的左下角显示: Select first point

●然后鼠标左键点击vout(First point为输出结点)



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●first point选定后, View的左下角显示: Select second point ●然后鼠标左键点击vp(Second point为输入结点)



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●弹出图示窗口: 两条曲线表示<mark>幅频特性与相频特性</mark>



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●低频增益测量:在较低频率处测量幅频特性曲线的纵坐标值●如图测得的低频增益为52.124dB



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●增益带宽积测量: 幅频特性曲线<mark>幅度为0dB</mark>时对应的频率

●注意:标尺很难完全定位到0dB,所以允许误差在正负50m dB以内

●测得增益带宽积为6.7999MHz



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●相位裕度测量: 使用B标尺在增益带宽积频率处,测相移

●PM (Phase Margin)=180+Phase,图中相位裕度约88°



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●注意:低频增益以及增益带宽积等是否达到放大器 性能指标要求?

●如果达不到,可以修改放大器的各管子尺寸,并重 新进行交流分析。

Results: Circuit Conditions

- ●查看电路元件的工作状态: Results->Circuit Conditions
 - 放大管、负载管、电流镜等均应工作于饱和区
 - ●开关管工作于线性区

● 线性区, 红色显示	Results: Circuit Conditions	
	OK Cancel Options	Help
1、选项设置——	Device Operating Conditions Results Saturation <bjt> or Linear <moss< td=""> red Breakdown red</moss<></bjt>	Print
	User Defined Conditions	
	# Enable Color Component Lower Bound Parameter Upper Bound	and/or
2、图中显示 —		
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	Add Delete Change Clear	

单位增益接法的放大器电路: 输入为阶跃脉冲信号

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OK Cancel Apply	efaults Previous Next	Help			—	
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模拟单元电路设计

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瞬态仿真设置

●Analysis->Choose, 弹出窗口选择

ок с	ancel Defaults	s Apply		
Analysis	🔹 🔶 tran	🔊 dc	\diamondsuit ac	🔷 noise
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	\diamondsuit pz	🔷 sp	🔷 envip	⇔pss
	\diamondsuit pac	🔷 pstb	🔷 pnoise	🔷 pxf
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🗌 Tran	sient Noise			

精度设置 Conservative:精度高 Moderate:中等精度 Liberal: 仿真速度快

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信号建立时间测试

- ●第一步: 将标尺A放置于平台区靠右的区域
- ●第二步:将标尺B从A点往左移动,直到|Delta Y|≈ 20µV

●第三步:将标尺A移动到跳变起始点,测Delta X,即为建立时间



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信号建立时间测试

●Delta X,即为建立时间

●测得的建立时间为405.901ns



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●A点:跳变点右侧; B点:远离斜率变化区域

●测得转换速率为10.0975MV/sec



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功率测试(保存Power信号的设置)

●Outputs->Save All...->弹出Save Options窗口->如下设置

Sa	e Options	
OK Cancel Defaults Apply		Help
Select signals to output (save)	_ none _ selected _ lvlpub _ lvl	🔳 alipub 🔄 ali
Select power signals to output (pwr)	_ none _ total _ devices _ subc	૬૮૮૬ 📕 સા
Set level of subcircuit to output (nestlvl)		
elect device currents (currents)	selected nonlinear all	
Set subcircuit probe level (subcktprobelv)	
Select AC terminal currents (useprobes)	yes no	
Select AHDL variables (saveahdlvars)	selected all	
Save model parameters info	—	
Save elements info	-	
Save output parameters info	-	
Save primitives parameters info	■	
Save subckt parameters info	-	
Save asserts info		
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功率测试 (瞬态功耗平均值)

●Tools->Results Browser->弹出窗口中点击OK

- ●在Results Browser中
 - Schematic->psf->Run1->tran-tran->110->pwr->双击鼠标

	Results Browser	
	Commands	Filter: .* Help
10单元的功耗	schematic/	

功率测试 (瞬态功耗平均值)

●双击鼠标后弹出Calculator窗口

●选择Special Functions->Average,然后点击Print

●平均功耗为: 111.529µW

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功率测试 (直流功耗)

●在Results Browser中

Schematic->psf->Run1->dcOp-dc->I10->pwr

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chematic/ chematics/ chemati	I5.MP0.m0:pwr MN2 I5.MP1.m0:pwr MN3 I10 MP0 I10.MN0.m0:pwr MP1 I10.MN1.m0:pwr net7 I10.MN3.m0:pwr net20 I10.MP0.m0:pwr pwr 0.0001116301923359821 I10.MP1.m0:pwr pwr V0 V1 Vout Vout2 analysisType description net12 net014 net020 net023 pwr vdd!	

直流扫描

Analyses->Choose->dc->Component Parameter

- ●点击Select Component,然后在Schematic中选择扫描源 alling, try test schematic --
 - Component
 - Parameter |

 Component Name Parameter Name Parameter Name Tati 酒 的 記 止 		Ready	OK Cancel Default Apply Hel
Parameter Name * xf sens dcmatch stb * pz sp env(p) pss * pac psb pnoise pxf * psp qpxf qpsp hbac * bbnoise measure C Analysis Save DC Operating Point • • Hysteresis Sweep • • * select Component Hame ************************************	Component Name	Sheet Options Migrate Calibre	Analysis √tran ♦ dc √ac √noise
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集成电路设计实习一单元实验三 模拟单元电路设计



●输出电压随直流量的变化



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