Cadence Tutorial

Long Kong

1.1: Tool-setup

1.2: Starting up Cadence 6

1.3: Build a differential pair

Tutorial 1.1: Tool-setup

Go to SEASnet website:

http://www.seasnet.ucla.edu/UnixServers/eeapps

Follow instructions and install *MobaXterm*.

Once installed:

- 1. Start > All Programs > MobaXterm
- 2. Type the following to connect to eeapps:

ssh -X your_user_name@eeapps.seas.ucla.edu

3. Type your password when it asks for it.



Download tool.zip from CCL website:

http://www.seas.ucla.edu/brweb/teaching.html

Unzip it and there are three files: 215a.scs, cds.lib and tool-setup

Create ee215a directory in your home directory:

mkdir ee215a <-- create ee215a directory
cd ee215a <-- go to ee215a
pwd <-- find the current path</pre>

Type the current path at the top left window in MobaXterm, drag in 215a.scs, cds.lib and tool-setup to the ee215a folder, now it looks like this:



Tutorial 1.2: Starting up Cadence 6

At this point you should have completed the setup and be ready to invoke Cadence 6.

Cadence tool is invoked by typing the following at the command prompt:

csh

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source tool-setup

virtuoso &

Cadence tool version 6.1.5 will start and two windows will pop up:

CDS.log window:



Tool news and info window:



Close the tool news and info window by selecting File > Close.

Go back to the CDS.log window and start library manager (Tools > Library Manager). The following window will pop up:

Library Manager: Directoryss.1/ee/ee215u/ee215uta/ee215a (on eeapps03.s	eas.ucla.edu) 🗖 🗖 💌
Eiledit	cā den ce
Show Categories Show Files	View
US_Bths ahdILib basic cdsDefTechLib functional rfExamples rfLib	
Messages	
Log file is "/w/class.1/ee/ee215u/ee215uta/ee215a/libManager Deleting 1 library. Deleting library "Opamp".	r.log".
Delete	

Now you are going to create a new library. In the library browser, select File > New > Library and the following window will pop up:



Type ee215a in the name field.

Click OK.

You should now see the "Technology File for New Library"



Select Attach to an existing technology library option.

Click OK.

"Attach Library to Technology Library" window will pop up:

Attach Library to Techno	ology Library (on eeapps03.seas.ucla.edu)
New Library	ee215a
Technology Library	US_8ths analogLib basic cdsDefTechLib
	OK Cancel Apply Help

Select analogLib from the Technology Library menu.

Click OK.

Next, you will see ee215a in the list of libraries in the Library Manager window.

Library Manager: Directoryss.1/ee/ee215u/ee215uta/ee215a (on eeapps03.s	eas.ucla.edu)
<u>Eile E</u> dit <u>V</u> iew <u>D</u> esign Manager <u>H</u> elp	cādence
Show Categories Show Files Cell ee215a	View
US_8ths ahdlLib analogLib basic cdsDefTechLib <u>ee215a</u> functional rfExamples rfLib	
Messages Deleted library 'Diffpair'.Delete of library "Diffpair" succeeded. Deletion of library done. Created new library "ee215a" at /w/class.1/ee/ee215u/ee215u	ta/ee215

Tutorial 1.3: Build a differential pair

In the library browser, click to select ee215a library and then click File > New > Cellview... to create schematic view for the new cell.

N	New File (on eeapps(03.seas.ucla.edu)
Γ	- File	
L	Library	ee215a 🔽
	Cell	Diffpair
ĺ.	View	schematic
L	Туре	schematic 🧧
L	Application	
l	Open with	Schematics L
L	🔲 Always use thi	s application for this type of file
l	Library path file	
L	'class,1/ee/ee2	15u/ee215uta/ee215a/cds.lib
L		
L		OK Cancel Help

Type Diffpair in the Cell Name field as shown.

Click OK.

After you click OK, Virtouso Schematic Editing window will pop up.

Virtuoso Schematic Editor L Editing: ee215a Diffpair schematic (on eeapps03.seas.ucla.edu)	- • ×
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Paine A	
Property Editor ? X	
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Immouse L: schSingleSelectPt() M: ddsOpenLibManager() R: sr	hHiMousePopUp()
1(3) Command Options	Cmd: Sel: 0

Important note: When you print any schematic from screenshot, remember to set the background color to white in MS office. For example, you can set transparent color of the above window to be white:

Virtuoso Schematic Editor I. Editing	g: cel	215a	Diffp	air s	chen	natic	(on	eca	pps0	3.50	asa	icla.	adu)																	X
Launch <u>F</u> ile <u>E</u> dit <u>V</u> iew <u>C</u> r	reate	Cł	nec <u>k</u>	0	<u>p</u> tion	s <u>N</u>	<u>∕</u> ligr:	ate	<u>W</u> in	dov	/ 1	lelp																сā	d e	nce
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1(3) Command Options																												Cn	nd: S	el: 0

Next, we will create simple schematic consisting of three NMOSs, two loading resistors, and a few bias voltage sources. To create an instance, you can click Create > Instance in the Virtuoso schematic editor or simply use shortcut key 'i'. The following dialog will appear:

Add Instan	ce (on eeapps03.seas.ucla.edu)
Library	Browse
Cell	
View	symbol
Names	
🗹 Add W	ire Stubs at: Q all terminals
Array	Rows 1 Columns 1
	🕰 Rotate 🛛 🕼 Sideways 🛛 🚭 Upside Down
	Hide Cancel Defaults Help

Click **Browse** to select a library component.

Another window will show up:

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Library Browser - Add Instance (on eeapps03.s	eas.ucla.edu)	
Show Categories		
Library	Cell	View
analogLib	nmos4	symbol
US_eths ahdILib basic cdsDefTechLib ee215a functional rfExamples rfLib	lopamp iprbs iprobe ipulse ipwl isfim isin isource bdmr mtline mtline mtline mtline mtline n1port n2port n3port n4port nbsim4 njfet nmes4 nmos4 nmos4 nodeQuantiby	View Lock Size auCdl auLvs hspiceD spectre spectre symbol symbol_xform
Close	Filters Dis	Help

Choose analogLib library, nmos4 cell, symbol view. (note: while you are doing this, the Add instance window is getting updated as well).

Click Close and point your mouse cursor over the Virtuoso editing window.

Left click to place the instance into a desired location. As you move the mouse away, you will see a contour for another instance (shown in yellow); press 'Esc' key to exit from Add Instance mode and the yellow symbol will disappear.

Virtuoso Schematic Editor L Editing	g: ee215a Diffpair schematic (on eeapps03.seas.ucla.edu)	- • ×
Launch <u>F</u> ile <u>E</u> dit ⊻iew <u>C</u> r	reate Chec <u>k</u> O <u>p</u> tions <u>M</u> igrate <u>W</u> indow <u>H</u> elp	cādence
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mouse L: schSingleSelectPt()	M: schHiObjectProperty() R: sch	HiMousePopUp()
1(3) >		Cmd: Sel: 0

Now, add instance of another NMOS device (press 'i') and click Sideways,

Add Instand	e (on eeapps03.seas.	ucla.edu)	-		×	
Library	analogLib			Browse		<u> </u>
Cell	nmos4					
View	symbol			at the second second		
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🗹 Add Wi	re Stubs at: 🔾 all terminals 🧕) registere	d terminals c	only 🛄		
Array	Rows	1	Columns	1		
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Model nar	ne					
Width				_		
Length		_				
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Source dif	fusion periphery					
Drain diffu	sion periphery					
Drain diffu	sion res squares					
Source dif	fusion res squares					
Drain diffu	sion length					
Source dif	fusion length					
Multiplier						
Temp rise	from ambient					
\leq					\geq	
		Hide Ca	ancel De	faults	Help	

Place it to the desired location.



Now we can adjust the size of the transistors by editing instance properties. Left click on the NMOS to select the component. Then, press 'q' to modify its properties. Set Model name to nch (pch for PMOS), Width to 26um, Length to 180nm, S/D diffusion area to 1.56e-11 and periphery to 53.2u (calculation provided in handout).

Apply To Only curre	ent 🔽 instance 🔽	
Show Show	🗹 user 🗹 CDF	
Browse	Reset Instance Labels Display	
Property	Value	Display
Library Name	analogLib	off 🔽
Cell Name	nmos4	off 🔽
View Name	symbol	off 🔽
Instance Name	MO	off 🔽
	Add Delete Modify)
CDF Parameter	Value	Display
Model name	nch	off 🔽
Width	26u M	off 🔽
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Length Source diffusion area Drain diffusion area Source diffusion periphery Drain diffusion periphery Drain diffusion res squares Source diffusion res squares	1.56e-11 1.56e-11 53.2u M 53.2u M	off V off V off V off V off V

Click OK and repeat this for another NMOS. Add one more NMOS as the tail current source and set the W/L to 14um/180nm.

Next, add loading resistor to the schematic (cell res from analogLib library), then instantiate DC voltage source (cell vdc from analogLib library) to bias the transistors. After that, add two sine waves as the differential inputs (cell vsin from analogLib). Set Amplitude to 1mV, Initial phase to 0 and Frequency to 1MHz. The other sine wave has the same amplitude and frequency but with an initial phase of 180.

	Browse	Rese	t Instance Labels	Display			
	Property		Value	Liopicy		Display	
1	Library Name	analog	(Lib			off 🔽	
I	Cell Name	vsin				off 🔽	
	View Name	symbol				off 🔽	
I	Instance Name	Vo				off 🔽	
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	CDF Parameter		Value			Display	
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Second fi	requency name					off 🔽	
Noise file	name					off 🔽	
Number c	of noise/freq pairs	0				off 🔽	
DC volta	ge					off 🔽	
AC magn	itude					off 🔽	
AC phase	е					off 🔽	
XF magn	itude					off 🔽	
PAC mag	Initude					off 🔽	
PAC pha	se					off 🔽	
Delay tim	е					off 🔽	
Offset vol	Itage					off 🔽	
Amplitude	e	1m	V			off 🔽	
Initial pha	ase for Sinusoid	0				off 🔽	
Frequenc	:y	1M	Hz			off 🔽	
Amplitude	e 2					off 🔽	
Initial nha	ase for Sinusoid 2					off 🗸 🗸	

The schematic should look like this (use Create > Wire menu or simply press 'w' key to enter wiring mode / 'Esc' to exit):

EE215A



It is a good practice to periodically save your work by clicking on Check and Save button. You can also save your work from the drop-down menu File > Save (or File > Check and Save).

Invoke simulation environment by choosing Launch > ADE L from the Virtuoso schematic editor window. Note: If you are asked to check the license for "Analog_Design_Environment_XL", choose Yes or Always. The Analog Design Environment window will pop up:

👫 Virtuoso Analog Design Environment (1) - e	e215a Diffpair schematic (on eeapps03.seas.ucla.edu)
Launch S <u>e</u> ssion Set <u>u</u> p <u>A</u> nalyses <u>V</u> ari	ables <u>O</u> utputs <u>Simulation Results</u> <u>Tools</u> <u>H</u> elp cadence
🎼 🌮 🦵 27 🛛 👌 🎾 🖆	
Design Variables Name Value	Analyses ? 8 × Type Enable Arguments }
	×
	Outputs ? / / × Name/Signal/Expr Value Plot Save Options
>	Plot after simulation: Auto Plotting mode: Replace
mouse L:	M: R: R: Ready T-27. C Simulator anastro

The first step is to setup simulation environment, including models, input sources, type of analysis etc.

Setup > Model Libraries and set the Model Library File to 215a.scs inside the ee215a folder and set Section to mos as shown below.

5	pectre0: Model Library Setup (on eeapps03.seas.ucla.edu)	×
ſ	Model File Section	
	Kitobar Model Files Mw/class.1/ee/ee215ut/ee215a/215a.scs Mos Click here to add model file>	
l		J.
		×
l	OK Cancel Apply	Help

Click OK and go to Analyses > Choose, following entry form will show up.

Choosing Analyses Virtuoso Analog Design Environment (1) (on						
Analysis	🖲 tran	🔾 dc	🔾 ac	🔾 noise		
	🔾 xf	🔾 sens	🔾 dcmatch	🔾 stb		
	🔾 pz	🔾 sp	🔾 envlp	🔾 pss		
	🔾 pac	🔾 pstb	🔾 pnoise	🔾 pxf		
	🔾 psp	🔾 qpss	🔾 qpac	🔾 qpnoise		
	🔾 qpxf	🔾 qpsp	🔾 hb	🔾 hbac		
	🔾 hbnoise					
Transient Analysis						
Stop Time 10u						
Accuracy	Accuracy Defaults (errpreset)					
🗌 🗌 consei	🗌 conservative 🛄 moderate 🛄 liberal					
Transient Noise						
Dynamic Parameter						
Enabled 🕑				Options		
OK Cancel Defaults Apply Help						

Specify the Stop Time to 10u and click OK.

Your Analog Design Environment window should now look like this:



Start the simulation by clicking on "Netlist and Run". Then the output log window pops up:

/w/class.1/ee	e/ee215u/ee215uta/simulation/Diffpair/spectre/schematic/psf/s		
<u>F</u> ile <u>H</u> el	p	cādence	e
tempe errpr metho ltera relre cmin gmin	offects = all eset = moderate do = traponly atio = 3.5 of = sigglobal = 0 F = 1 pS		^
tran tran tran tran tran tran tran tran	time = 283.8 ns (2.84 %), step = 83.33 ns time = 783.8 ns (7.84 %), step = 83.33 ns time = 1.784 us (12.8 %), step = 83.33 ns time = 2.284 us (22.8 %), step = 83.33 ns time = 2.284 us (22.8 %), step = 83.33 ns time = 3.284 us (32.8 %), step = 83.33 ns time = 3.784 us (37.8 %), step = 83.33 ns time = 4.284 us (42.8 %), step = 83.33 ns time = 4.284 us (42.8 %), step = 83.33 ns time = 5.784 us (47.8 %), step = 83.33 ns time = 5.784 us (57.8 %), step = 83.33 ns time = 5.784 us (57.8 %), step = 83.33 ns time = 6.284 us (52.8 %), step = 83.33 ns time = 5.784 us (57.8 %), step = 83.33 ns time = 5.784 us (57.8 %), step = 83.33 ns time = 7.284 us (72.8 %), step = 83.33 ns time = 7.284 us (72.8 %), step = 83.33 ns time = 7.784 us (77.8 %), step = 83.33 ns time = 7.784 us (77.8 %), step = 83.33 ns time = 7.784 us (82.8 %), step = 83.33 ns time = 7.784 us (82.8 %), step = 83.33 ns time = 7.784 us (82.8 %), step = 83.33 ns time = 9.784 us (82.8 %), step = 83.33 ns time = 9.784 us (97.8 %), step = 83.33 ns time = 9.784 us (97.8 %), step = 83.33 ns time = 9.784 us (97.8 %), step = 83.33 ns	(833 m²) (833 m²)	
Notice fr Trape F	rom spectre during transient analysis `tran'. zoidal ringing is detected during tran analysis. Please use method=trap for better results and perfo	ormance.	
Initial c Intrinsic Total tim Time accu Peak resi	condition solution time: CPU = 0 s, elapsed = 727.1 c tran analysis time: CPU = 12.998 ms, elapsed = ne required for tran analysis `tran': CPU = 18.997 mulated: CPU = 178.972 ms, elapsed = 559.194 ms, ident memory used = 28.9 Mbytes.	.77 us. : 15.6529 ms ms, elapsed	
finalTime modelPara element: outputPar designPar primitive subckts:	OP: writing operating point information to rawfile meter: writing model parameter values to rawfile. writing instance parameter values to rawfile. "ameter: writing output parameter values to rawfile amVals: writing netlist parameters to rawfile. s: writing primitives to rawfile. writing subcircuits to rawfile.	÷. •.	-
		×	

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After simulation is done, go to Results > Direct Plot > Main Form. There are three pop-up windows: What's New in Virtuoso Visualization and Analysis XL, Direct Plot Form, Virtuoso(R) visualization & Analysis XL. The Direct Plot Form pop-up window looks like this:

Direct Plot Form (on eeapps06.seas.ucla.edu)
Plotting Mode Append
Analysis
● tran
Function
● Voltage 🛛 ◯ Current
O Power O Noise Measurement
O PLL Noise PSD
Select Net
Prepenc Differential Nets Instance with 2 Terminals
Add To Outputs 🖵
> Select Net on schematic
OK Cancel Help

Select **Differential Nests** to plot the one net in reference to another one.

Go to schematic, click the two input nets and then two output nets, the corresponding voltage waveforms are plotted in the "Virtuoso(R) and Visualization & Analysis XL" window:



To change the background color, go to Graph > Properties, the following window shows up:

Graph Properties (on eeapps06.seas.ucla.edu)				
General Strips	Graph Options			
Graph Title 🍝 Transient Re	esponse	☑ Default		
User Title 🍝				
Title Font 🍝 🛛 Helvetica				
Color 🚔 📰 Backgro	und 🗌 Use Gradient			
		Close Apply		

Change the color to white and click OK. The "Virtuoso(R) and Visualization & Analysis XL" window now looks like this:



Now you are able to monitor more voltage and current waveforms at other nodes and can build circuit on your own.