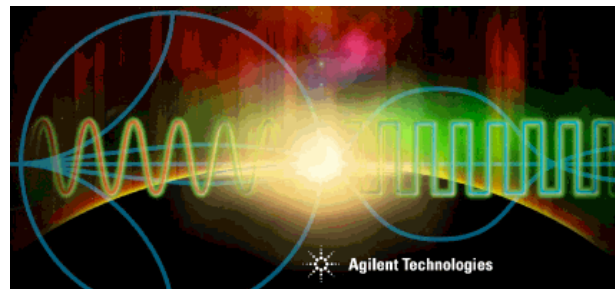


## Topic 2:

# System Design Fundamentals



**BEFORE** starting with system design...some details on the ADS Main window:

# Main Window: File or Project View

- **Use icons or commands:** all icons have commands - not all commands have icons.
- **Right clicking:** on files or objects gives you choices...
- **Dynamic icons & commands:** may change with the tabs, windows, or context...

Click  box to expand or  box to collapse.

VS

More on Main...

BEFORE starting with system design...some details on the ADS Main window:

# Main Window and the File commands...

- Main window is for managing files and projects

**File commands:**

- New Project...
- Open Project...
- Example Project...
- Copy Project...
- Delete Project...
- Include/Remove Projects...
- Archive Project... **Zap projects**
- Unarchive Project...
- Close Project...
- New Design...
- Open Design...
- Copy Design...
- Delete Design...
- Save All
- Close All
- Import... **Spice, Netlist, IFF, etc.**
- Exit Advanced Design System...

Design Kits (foundry specific)  
Design Guide (like templates)

**Next, Tools...** →

# Main Window Tools...

Configuration Explorer: variables

Setup: palettes & simulators

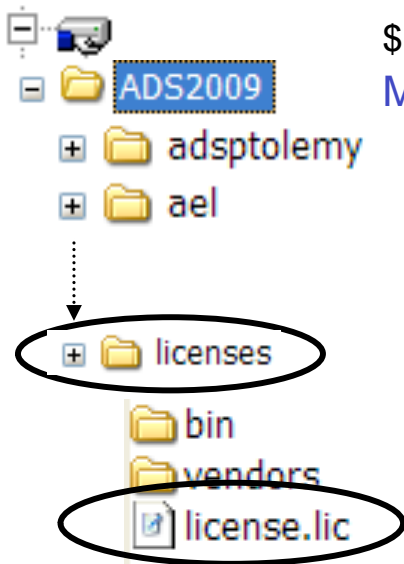
The screenshot shows the 'Advanced Design System 2008 (Main)' interface. The 'Tools' menu is circled in red, and an arrow points to the 'Configuration Explorer' dialog, which displays configuration variables such as SITE\_AEL, SITE\_DSN\_PATH, USER\_AEL, USER\_DSN\_PATH, DATA\_FILES, and AGILEESOPD\_LICENSE\_FILE. Another arrow points from the 'Tools' menu to the 'Main Preference' dialog, which contains various settings like Warning Bell, Error Bell, Large Toolbar Bitmap, Display Project Listing, and Wire Thickness. A third arrow points from the 'Tools' menu to the 'Advanced Design System Setup' dialog, which shows design type options: Analog/RF Only, Both, With Default (selected), Analog/RF Design, and DSP Design. A callout box states: 'Preferences are global, they apply to all projects.' A yellow arrow points to the right with the text 'ADS file structure...'. A blue arrow points down from the 'License Information...' option in the Tools menu with the text 'See next slide'.

# Loading ADS: Directories, Variables, and Licenses

When you load ADS, you are prompted for:

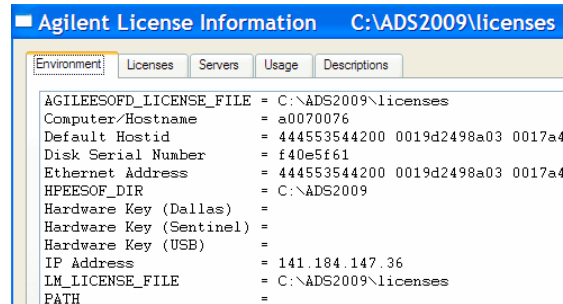
- **Install directory (location of ADS program) - C or D drive on a PC**  
\$HPEESOF\_DIR (UNIX variable) or %HPEESOF\_DIR% (PC variable)
- **Home directory (location of your ADS design work) - C:\users\default on a PC**  
\$HOME (UNIX variable) or %HOME% (PC variable)

(C:) **Install DIR**



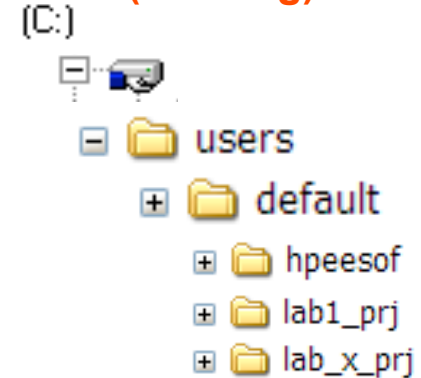
## LICENSE Variable and File:

A variable points to the license.  
The default is: AGILEESOF\_LICENSE\_FILE =  
\$HPEESOF\_DIR / licenses / license.lic or .dat  
Main window: Tools > License Information:



**NOTE:** License files contain code words for the simulators. Licenses can be networked or keyed to individual computers (node locked) using a hardware key (dongle) or Ethernet card (MAC address).

**Home (working) DIR**

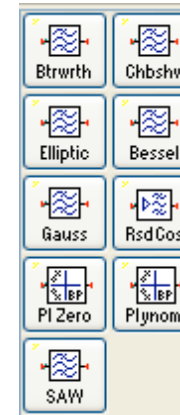
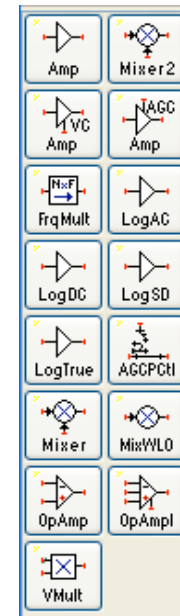
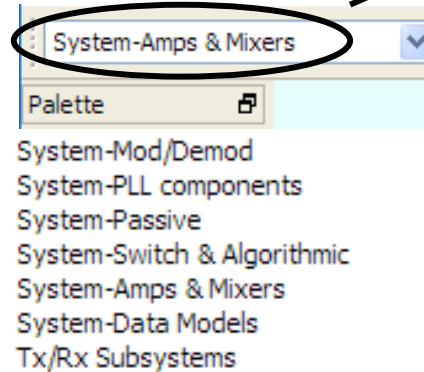


**System design...**



# SYSTEM DESIGN: palettes, libraries, and components.

- System design is at the higher level, no circuit components are required.
- However, system components can be integrated with circuit components.
- The simulation and data display are the same for system and circuit.



Typical RF system design...

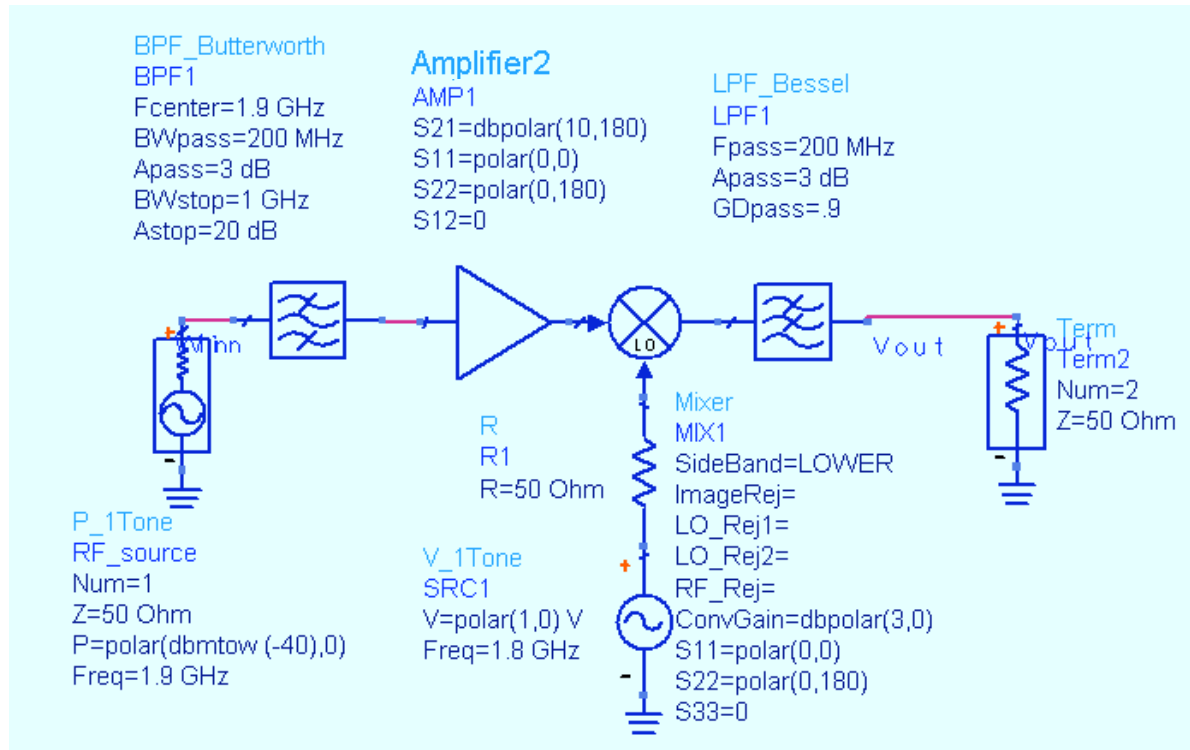


**Component Library**

Search	Search	Search
Component	Description	Library
AGC_Amp	Voltage-controlled ampl...	System-Amps...
AGC_PwrControl	AGC loop power control	System-Amps...
Amplifier2	RF System Amplifier, Po...	System-Amps...
AmplifierVC	Voltage Controlled Amp...	System-Amps...
FreqMult	Frequency Multiplier	System-Amps...
LogACDemod	Demodulating AC Logar...	System-Amps...
LogDC	DC Logarithmic Amplifier	System-Amps...
LogSuccDetect	Successive Detection Lo...	System-Amps...
LogTrue	True Logarithmic Amplif...	System-Amps...
Mixer	RFSytem Mixer, Polyno...	System-Amps...
Mixer2	RF System Mixer, Polyn...	System-Amps...
MixerWithLO	RF Mixer with internal I...	System-Amps...
OpAmp	Operational Amplifier	System-Amps...
OpAmpIdeal	Ideal Operational Ampli...	System-Amps...
VMult	Voltage Multiplier	System-Amps...

# Typical system design uses: behavioral models!

## What are behavioral models?



- Behavioral models are equation based.
- Equations describe node I and V and can also reference tables.

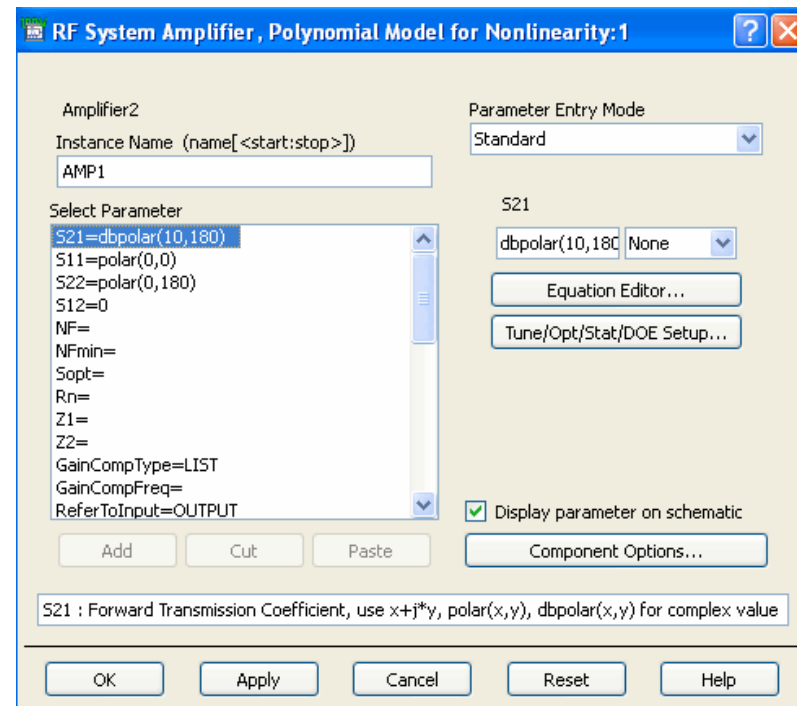
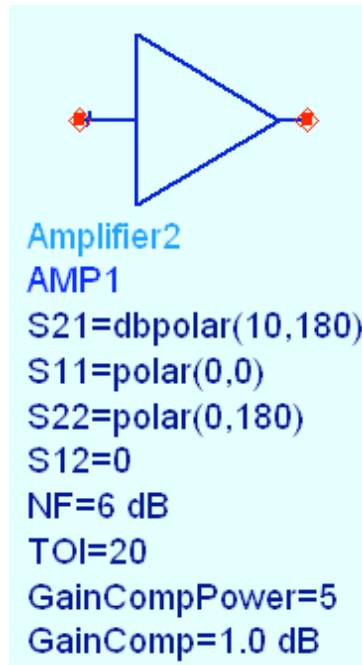


**NOTE:** You can also use measurement / data based models. For example: SNP components, Mixer IMT, Amplifier P2D, AmpH1H2 and others in the System libraries.

# Typical system component: Amplifier

## Behavioral model

Polynomial equations describe nonlinearity:



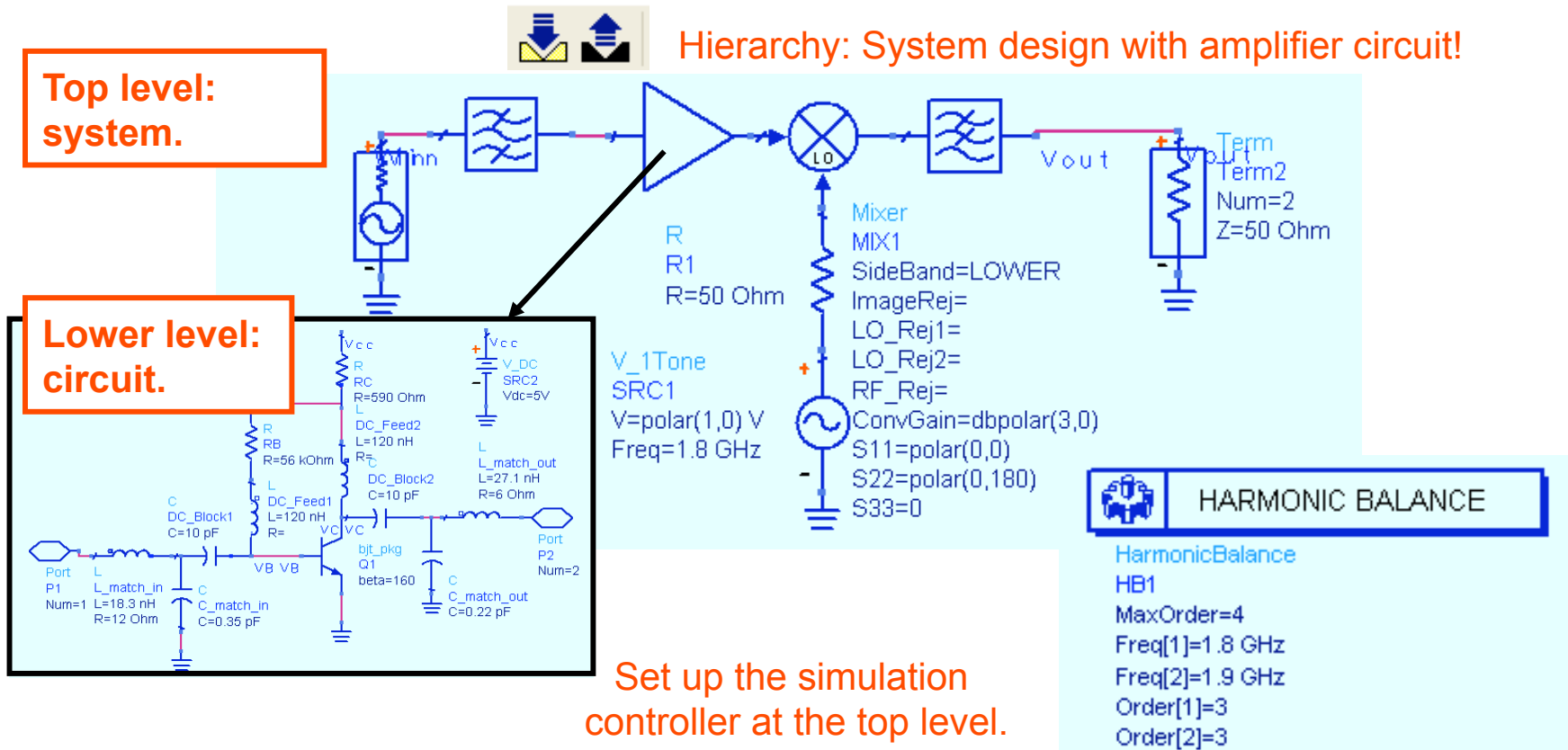
You specify the behavior:

**NOTE:** Other ADS components (AmplifierS2D) can be used with measured data.



# Simulation is the same: system or circuit

Therefore, you can combine circuit and system designs for simulation as they are completed!

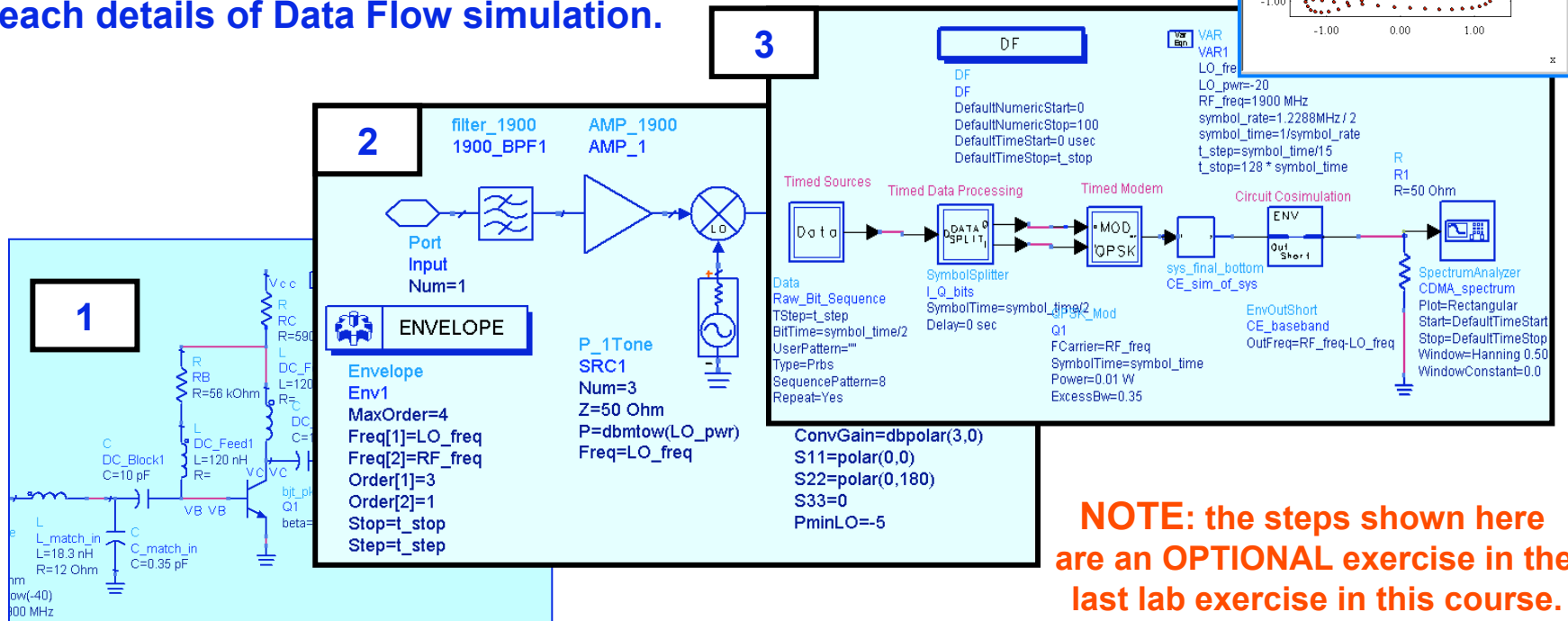
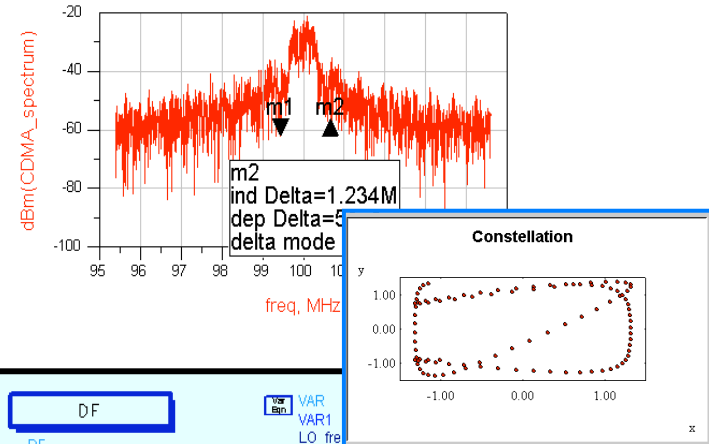


# Also, ADS has Data Flow simulation

Data Flow simulation (Ptolemy) is 3 levels here:

- 1 - Circuit design
- 2 - System designs with Envelope or Transient
- 3 - Data Flow (Ptolemy): bits, sinks, TK plots

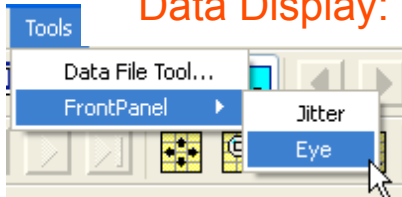
DSP and CommSys courses teach details of Data Flow simulation.



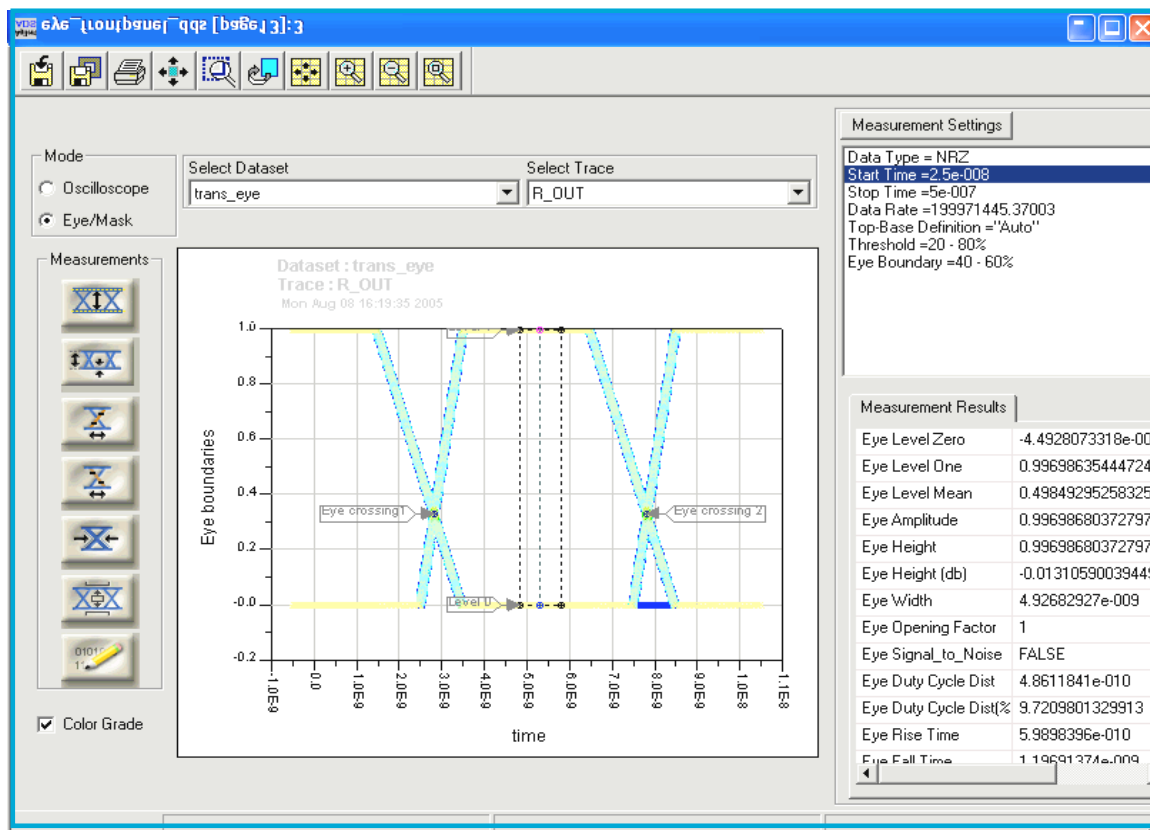
**NOTE:** the steps shown here are an **OPTIONAL** exercise in the last lab exercise in this course.

# ADS also has a built-in Eye Diagram

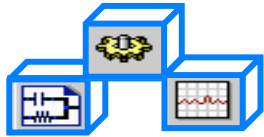
Data Display:



Or Oscilloscope... with numerous front panel-like settings. Data is from Transient analysis (real & not complex) - usually a baseband signal.



Use of this tool is covered in the ADS signal integrity course...



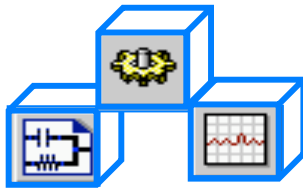
What the lab is about ...

Lab 2:

# System Design Fundamentals

# Steps in the Design Process

You are here:



- Design the RF sys behavioral model receiver
- Test conversion gain, spectrum, etc.
- Start amp\_1900 design – subckt parasitics
- Simulate amp DC conditions & bias network
- Simulate amp AC response - verify gain
- Test for noise contributions
- Simulate amp S-parameter response
- Create a matching topology
- Optimize the amp in & out matching networks
- Filter design – lumped 200MHz LPF
- Filter design – microstrip 1900 MHz BPF
- Transient and Momentum filter analysis
- Amp spectrum, delivered power, Zin - HB
- Test amp comp, distortion, two-tone, TOI
- CE basics for spectrum and baseband
- CE for amp\_1900 with GSM source
- Replace amp and filters in rf\_sys receiver
- Test conversion gain, NF, swept LO power
- Final CDMA system test CE with fancy DDS
- Co-simulation of behavioral system

# RF receiver system: S-parameters

S-21 measurement tests conversion gain:

**Converted Freq = 100 MHz IF**

**Enable for behavioral system models only.**

**Plot results from 2 simulations: 10 dB and 20dB amp S21**

Simulation Setup:7  
Simulation mode: Local  
Dataset: rf\_sys\_10dB

Scattering-Parameter Simulation:5  
S\_Param Instance Name: SP1  
Frequency Conversion:  Enable AC frequency conversion  
S-parameter freq. conv. port: 1

Plot: dB(S(2,1)) vs freq, GHz  
m1: freq=1.900GHz, dB(S(2,1))=12.313  
m2: ind Delta=0.000, dep Delta=10.000, delta mode ON

# Harmonic Balance simulation using an HB Noise Controller

HB simulation: phase noise and spectrum of IF:

HB NOISE CONTROLLER

NoiseCon  
 NC1  
 NLNoiseStart=10 Hz  
 NLNoiseStop=10.0 kHz  
 NLNoiseDec=5  
 CarrierFreq=100 MHz  
 PhaseNoise=Phase noise spectrum  
 NoiseNode[1]=Vout

BPF\_Butterworth  
 BPF1  
 Fcenter=1.9 GHz  
 BWpass=200 MHz  
 Apass=3 dB  
 BWstop=1 GHz  
 Astop=20 dB

Amplifier2  
 AMP1  
 S21=dbpolar(10,180)  
 S11=polar(0,0)  
 S22=polar(0,180)  
 S12=0

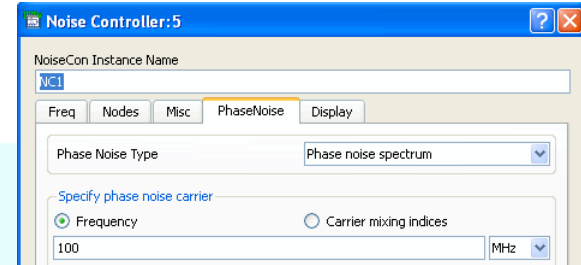
LPF\_Bessel  
 LPP1  
 Fpass=200 MHz  
 Apass=3 dB  
 GDpass=.9

HARMONIC BALANCE

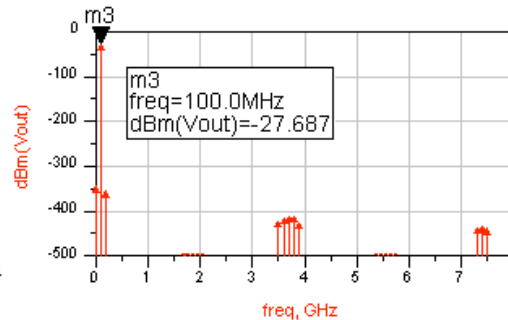
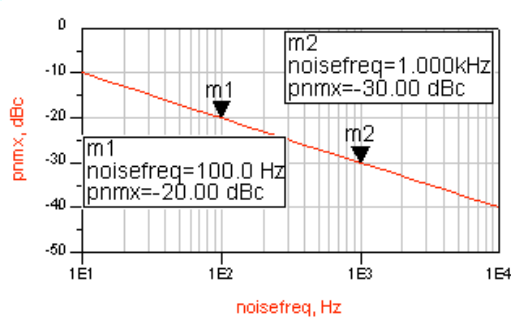
HarmonicBalance  
 HB1  
 MaxOrder=4  
 Freq[1]=1.8 GHz  
 Freq[2]=1.9 GHz  
 Order[1]=3  
 Order[2]=3  
 Noisecon[1]="NC1"  
 NoiseConMode=yes

P\_1Tone  
 RF\_source  
 Num=1  
 Z=50 Ohm  
 P=polar(dBmtow(-40),0)  
 Freq=1.9 GHz  
 Pac=polar(dBmtow(-40),0)

OSCwPhNoise  
 OSC1  
 Freq=1.8 GHz  
 P=dbmtow(0)  
 Rout=50 Ohm  
 PhaseNoise=list(10Hz,-10dB, 100Hz,-20dB, 1kHz,-30dB, 10kHz,-40dB)



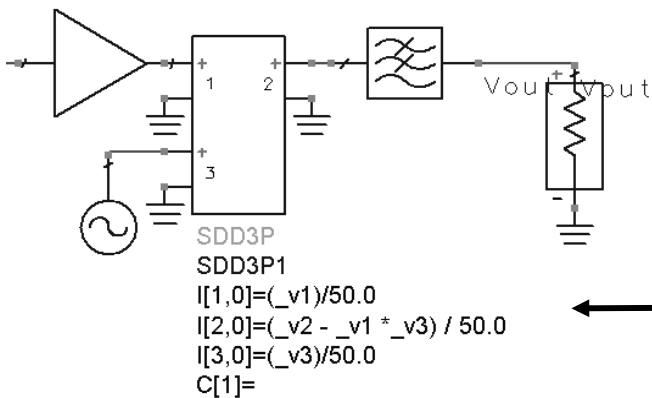
Set up LO with phase noise.



Plot phase noise and spectrum.

# OPTIONAL: SDD used as a mixer

SDDs can define non-linear behavior...this is a brief introduction:



**HARMONIC BALANCE**

HarmonicBalance  
HB1  
MaxOrder=4  
Freq[1]=1.8 GHz  
Freq[2]=1.9 GHz  
Order[1]=3  
Order[2]=3

**TRANSIENT**

Tran  
Tran1  
StopTime=4/100MHz  
MaxTimeStep=1/(2\*1800M)

Non-linear node currents are defined by equations:  $I = \_V / Z$ .

**HB results:** Fundamental tones, harmonics, difference and sum frequencies are plotted. However, because no conversion gain is accounted for in the SDD equation, the results have a lower magnitude than the behavioral model mixer. Also, Transient results compare within 0.1dB of HB using **fs** function.

