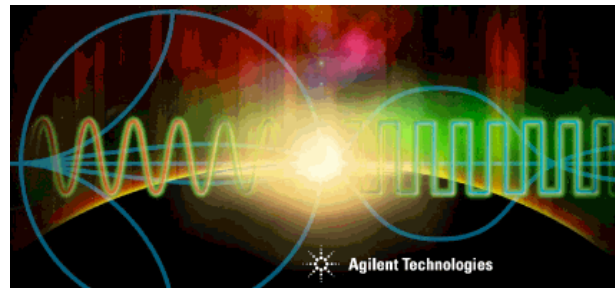


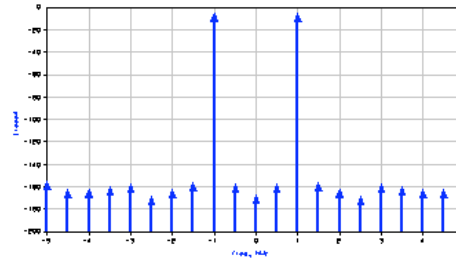
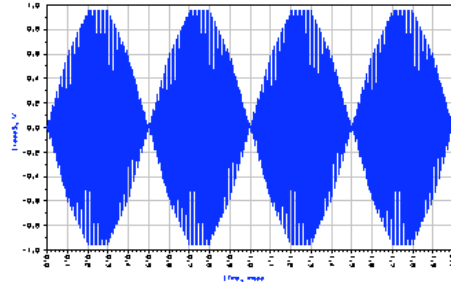
## Topic 8:

# Circuit Envelope Simulation



# What is Circuit Envelope ?

- Time samples the modulation envelope (not carrier)
- Compute the spectrum at each time sample
- Output a time-varying spectrum
- Use equations on the data
- Faster than HB or Spice in many cases
- Integrates with System Simulation & Agilent Ptolemy



Next, what tests can it perform?



# Test circuits with realistic signals

GSM, CDMA, GMSK, pi/4DQPSK, QPSK, etc.

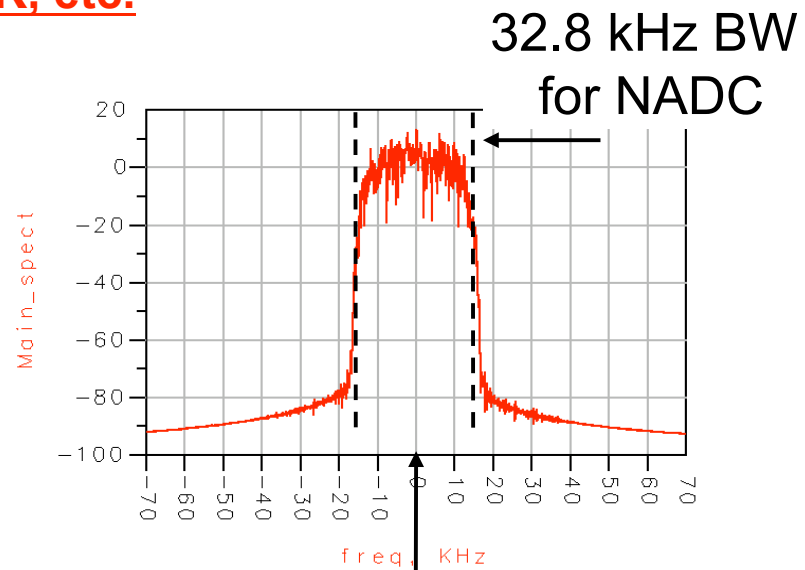
Simulations can include:

- Adjacent Channel Power Ratio
- Noise Power Ratio
- Error Vector Magnitude
- Power Added Efficiency
- Bit Error Rate

**2-tone tests and linearized models  
do not predict this behavior as easily!**

**Also, Envelope can be used for PLL simulations:  
lock time, spurious signals, modulation in the loop.**

Example CE results:

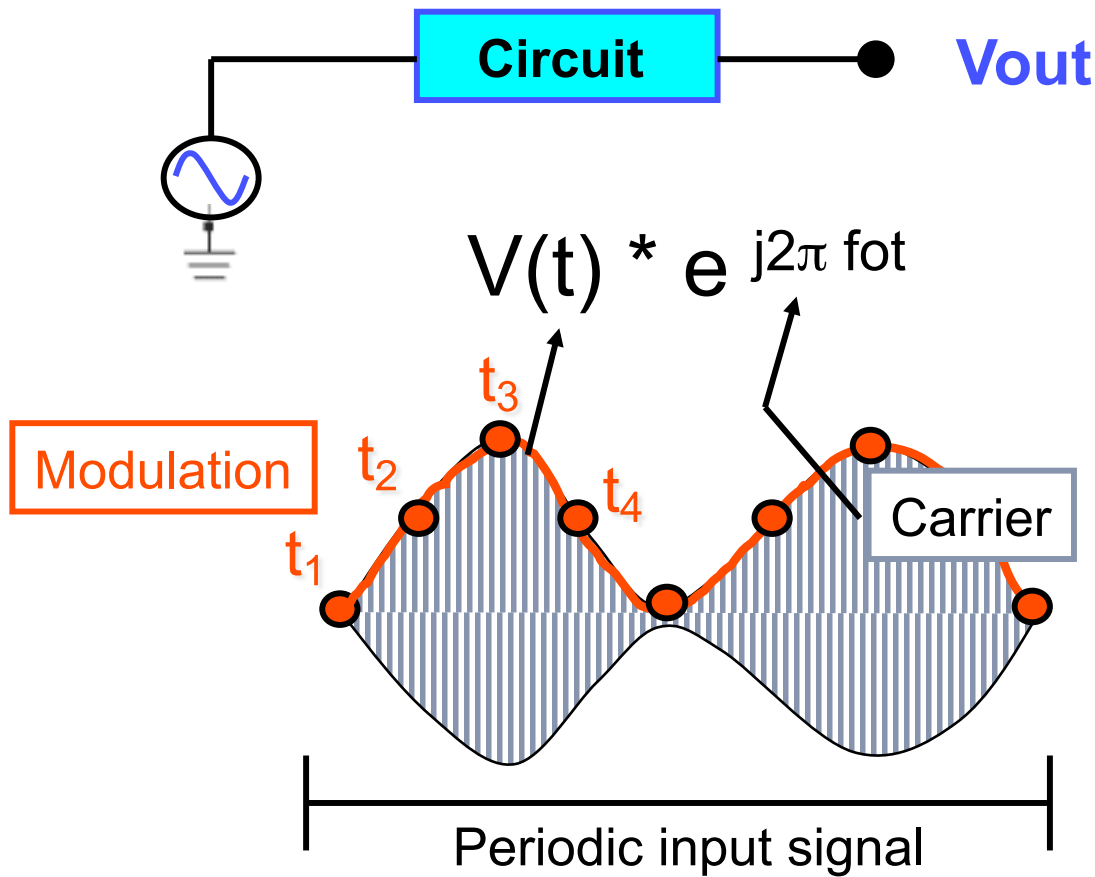


890 MHz  
carrier

Next, how it works...



# Circuit Envelope Technology



Time sample the envelope and then perform Harmonic Balance on the samples!

More... 

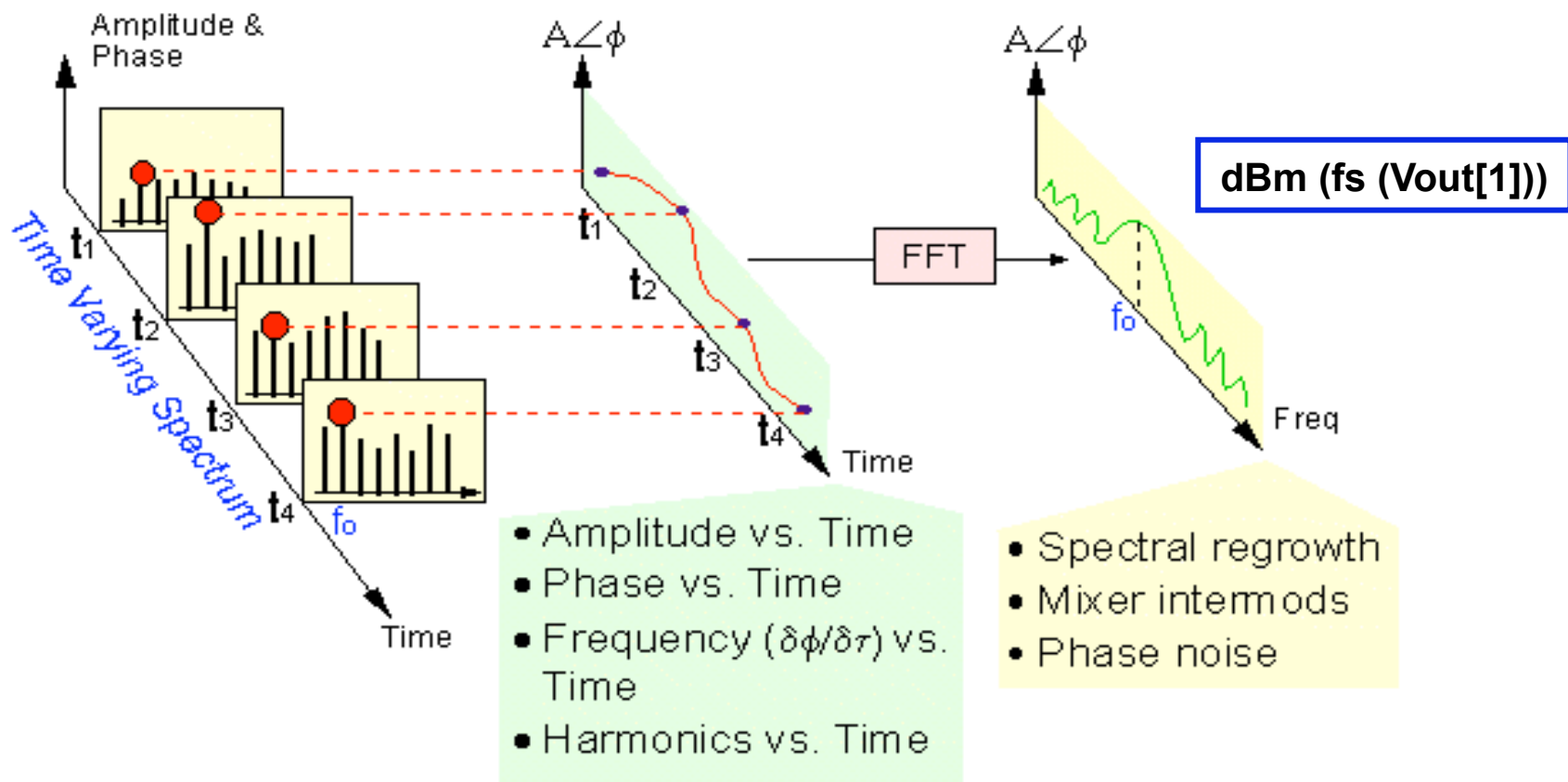
NOTE:  $V(t)$  can be complex - am or fm or pm

# ...more on CE Technology

Next, an example...



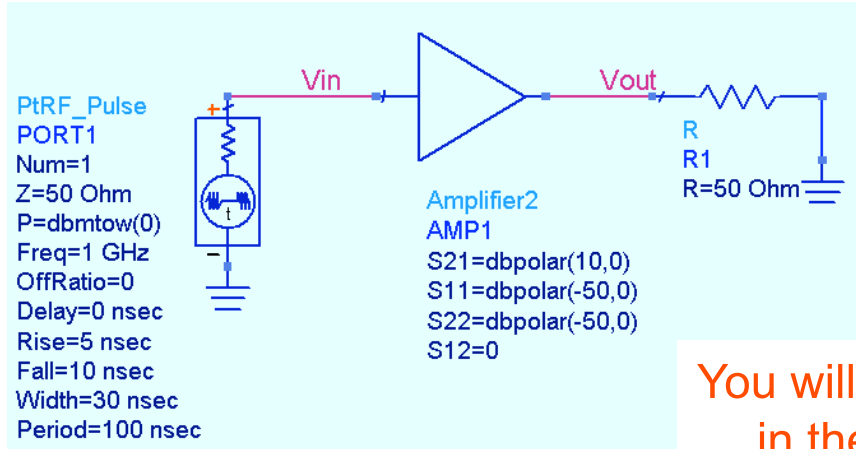
Captures time and frequency characteristics:



# Example: AMP with RF pulse


ENVELOPE

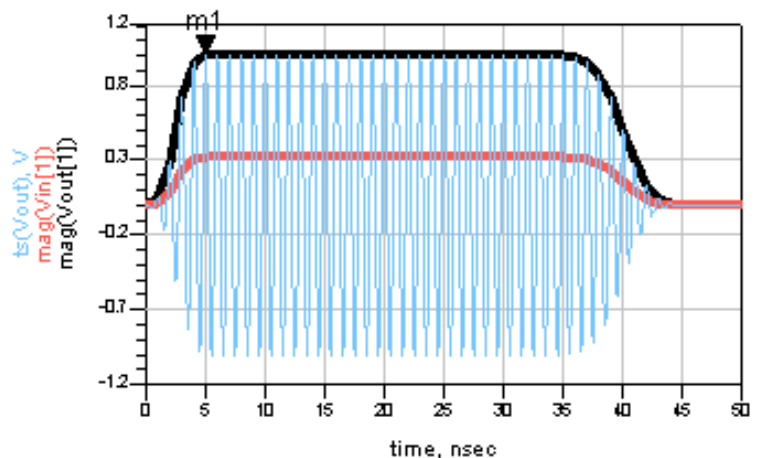
Envelope  
Env1  
Freq[1]=1 GHz  
Order[1]=5  
Stop=50 nsec  
Step=1 nsec



You will do this in the lab!

Step time is critical for sampling the envelope: rise, fall, and modulation rate. Therefore, Step (sample time) is NOT the same as Transient.

- mag of Vout [1]: envelope
  - mag of Vin [1]: envelope
  - ts of Vout: signal
- ...where [1] is the carrier: Freq[1].



Next, the controller setup...



# Envelope Setup tab in the controller

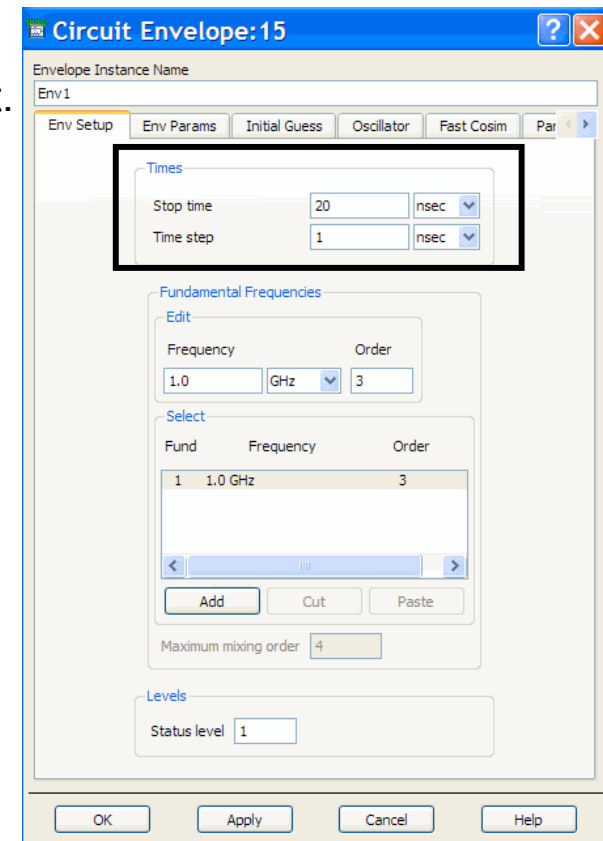
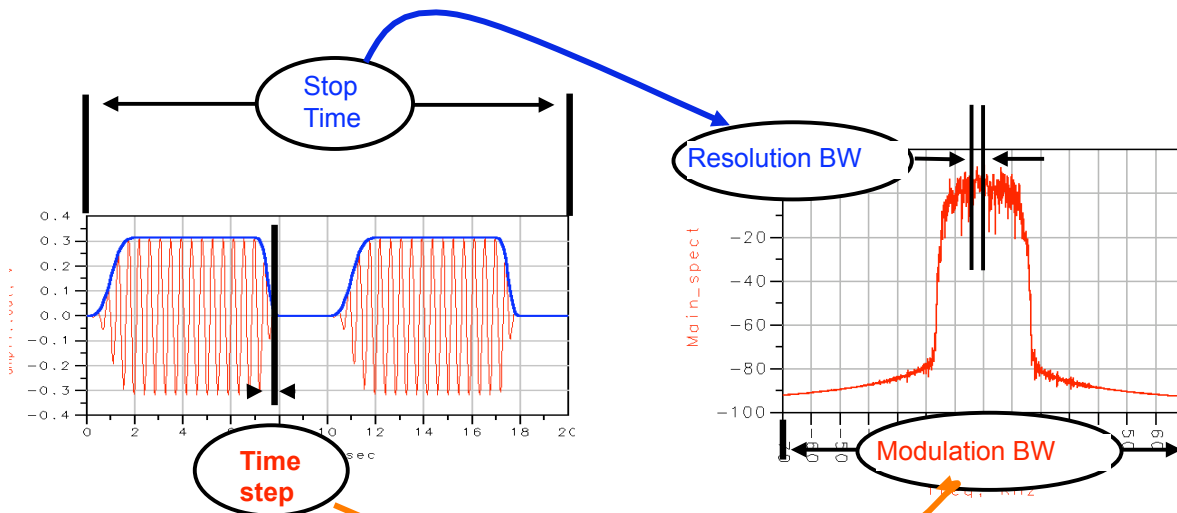
Example setup: one tone with 3 harmonics

## Stop time

- Determines resolution bandwidth of spectrum.
- Large enough to resolve spectral components of interest.

## Time step

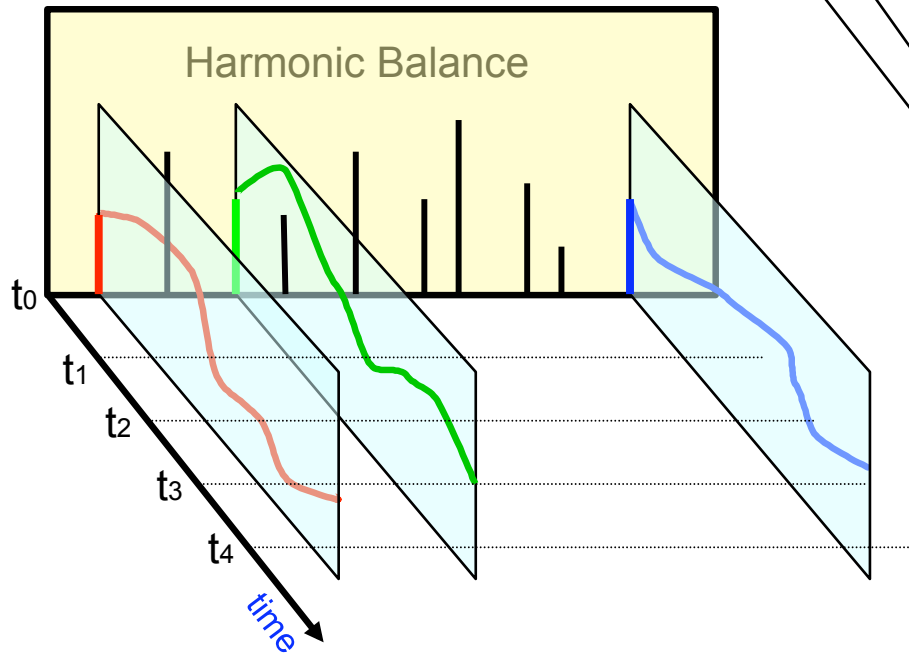
- Determines modulation bandwidth of the spectrum.
- Small enough to capture highest modulation frequency.



# Envelope Setup tab (continued)

Another example: 2 tone analysis

7 Harmonics of Fundamental: Freq [1]  
3 Harmonics of Fundamental: Freq [2]



Same as HB: mixing products  
If 2 or more tones.

Env Setup

**Times**

Stop time: 100 nsec  
Time step: 1 nsec

**Fundamental Frequencies**

Edit

Frequency: 855 MHz Order: 7

Select

Fund	Frequency	Order
1	855 MHz	7
2	900 MHz	3

Add Cut Paste

Maximum mixing order: 10

**Levels**

Status level: 1



# Other CE tabs...

Same as Harmonic Balance except for the bottom button: calculate startup transient instead of waiting for steady state.

**Initial Guess** Same as Harmonic Balance

Transient Assisted Harmonic Balance  
 Auto  On  Off  
 Advanced Transient Settings...

Harmonic Balance Assisted Harmonic Balance  
 Auto  On  Off

Initial Guess  
 Use Initial Guess File   
 Regenerate Initial Guess for ParamSweep (Restart)

Final Solution  
 Write Final Solution

**Env Params**

Integration **Backward Euler**

Sweep offset  **None**

Turn on all noise

Device Fitting

Bandwidth fraction

Relative tolerance

Absolute tolerance

Warn when poor fit  
 Use fit when poor  
 Skip fit at baseband

Env Params – Use for convergence issues.

**Oscillator**

Enable Oscillator Analysis

Method **Use Oscport**

Specify Oscillator Nodes

Node Plus

Node Minus

Fundamental Index

Harmonic Number

Octaves to Search

Steps per Octave

Calculate oscillator startup transient



Same as HB. **Output**

Save by hierarchy:

Maximum Depth

Node Voltages:

Measurement Equations:

Branch Currents:

Pin Currents:

For device types

# Other CE tabs (continued)



**Solver**

Convergence  
Convergence Mode:  Auto (Preferred)  Advanced (Robust)  Basic (Fast)  
Max. Iterations:  Robust  Fast  Custom  
Advanced Continuation Parameters...

Matrix Solver  
Solver Type:  Auto Select  Direct  Krylov  
Matrix Re-use:  Fast  Robust  Custom  
Krylov Restart Length:  Robust  Low Mem  
Advanced Krylov Parameters...

Memory Management  
Matrix Bandwidth (GuardThresh):  Fast  Robust  Custom  
FFT Options:  Minimize memory and runtime  Minimize aliasing  
Waveform Memory Reduction:  
 Use dynamic waveform  NoiseCons  
 Use compact frequency

**Noise**

Select NoiseCons

Select Edit

Add Cut Paste

Nonlinear noise

Noise and Solver are the same as HB.

**Fast Cosim**

Enable fast cosimulation

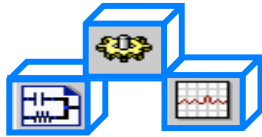
Characterization  
 Build model  
 Use previous data (select only if the circuit remains unchanged between simulations)  
Set Characterization Parameters...

Model simulation  
 Apply frequency compensation (filter)  
Place filter at Input  
 Add delay  
Delay 0.0 sec

Verification  
Stop time 0.0 sec  
Accept tolerance 1e-3

Node names  
Active input  
IQ pair

**Cosim** is for use with Ptolemy co-simulations. It builds a behavioral model (Automatic Verification Modeling) for single input/output RF circuits which runs faster than co-simulating with the device model.

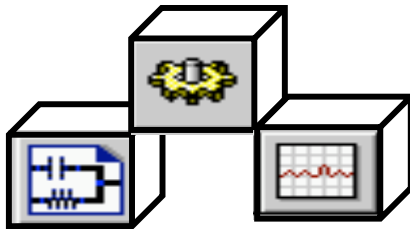


What the lab is about ...

Lab 8:

# Circuit Envelope Simulations

# Steps in the Design Process



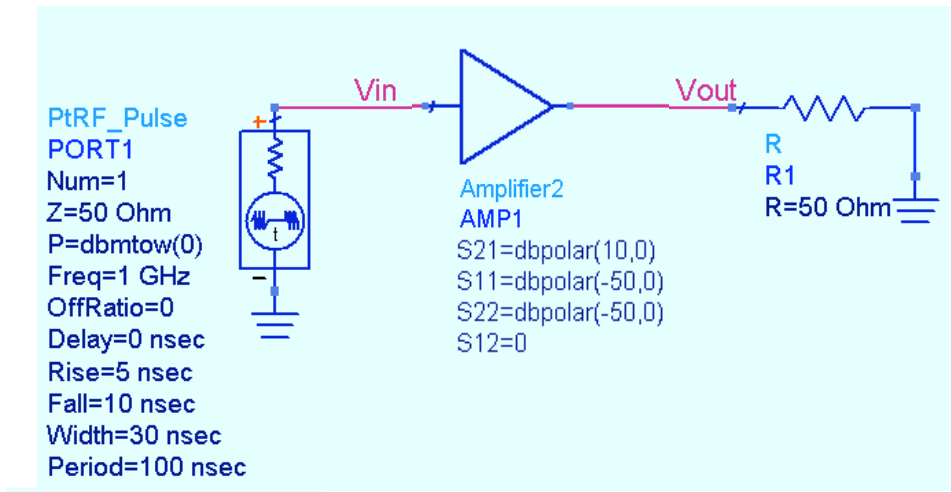
You are here:



- 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 amp noise contributions – tune parameters
- 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

# First, simulate using an RF pulse

Behavioral amp and different time steps:



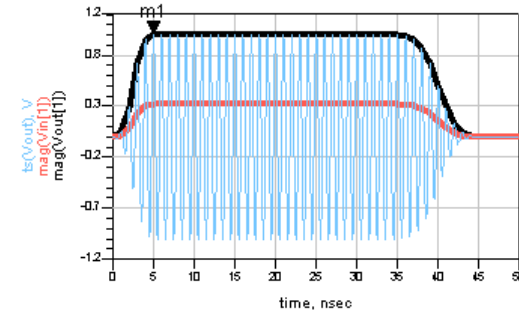
**ENVELOPE**

Envelope  
 Env1  
 Freq[1]=1 GHz  
 Order[1]=5  
 Stop=50 nsec  
 Step=1 nsec

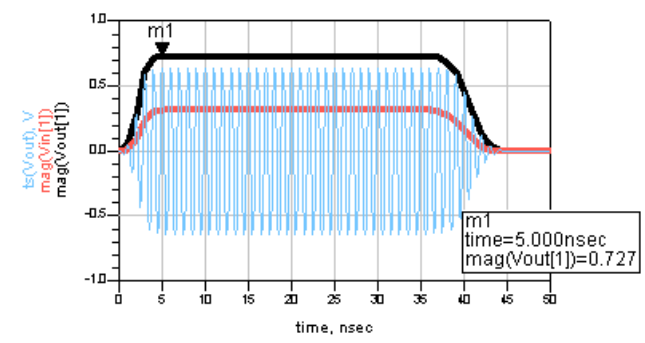
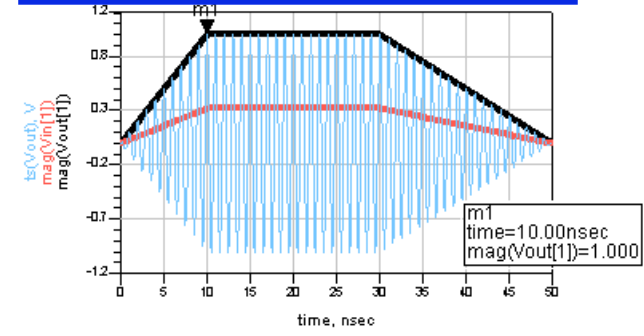
Vary step time.

Set behavioral Amp parameters into compression: distortion generates odd harmonics out-of-phase.

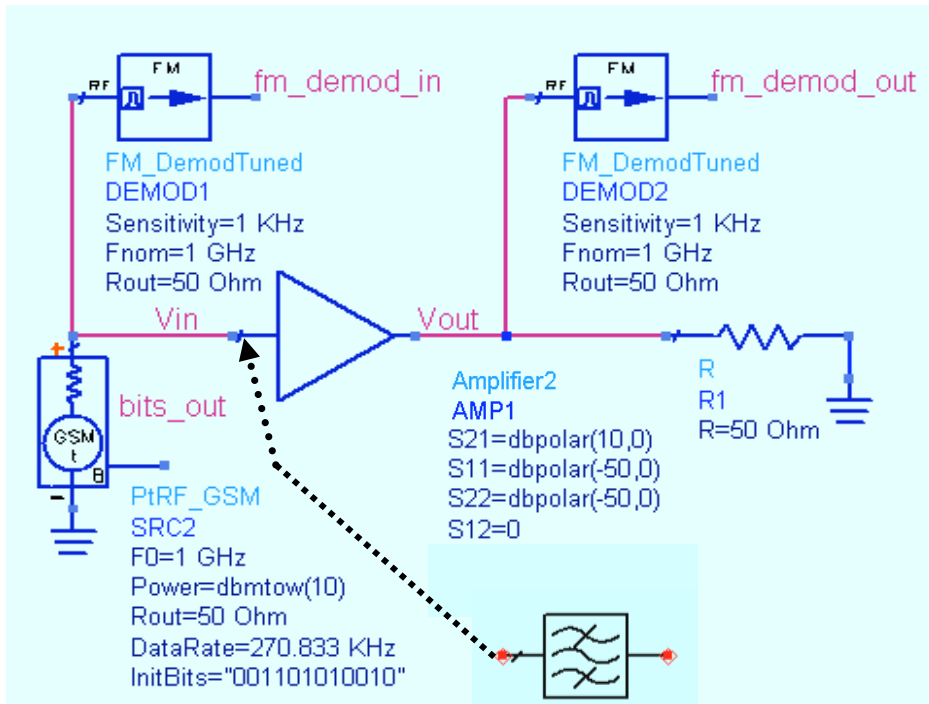
S21=dbpolar(10,0)  
 S11=dbpolar(-50,0)  
 S22=dbpolar(-50,0)  
 S12=0.  
**GainCompPower=5**  
**GainComp=1 dB**



Time Step: 1 nsec vs 10 ns



# Next, use a GSM source and demodulators

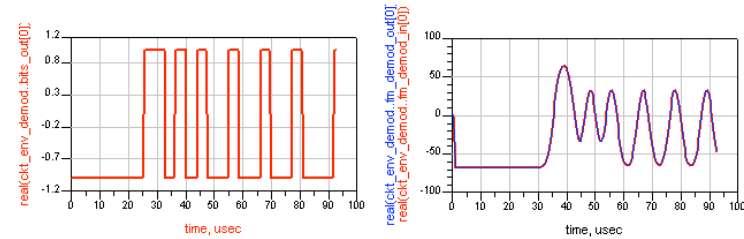


## ENVELOPE

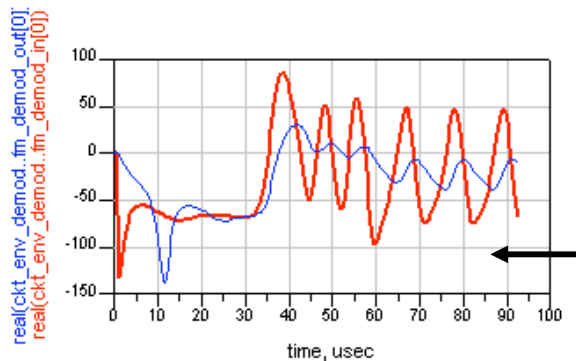
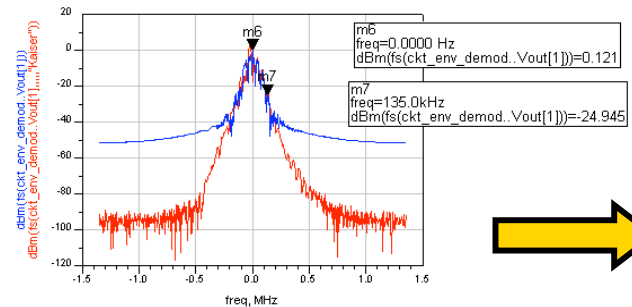
Envelope  
 Envx1  
 Freq[1]=1 GHz  
 Order[1]=10  
 Stop=t\_stop  
 Step=t\_step

Var	Eqn
VAR	
VAR2	t_stop=25 / (270e3)
	t_step=1 / (10*270e3)

### Plot: bits\_out and fm\_demod

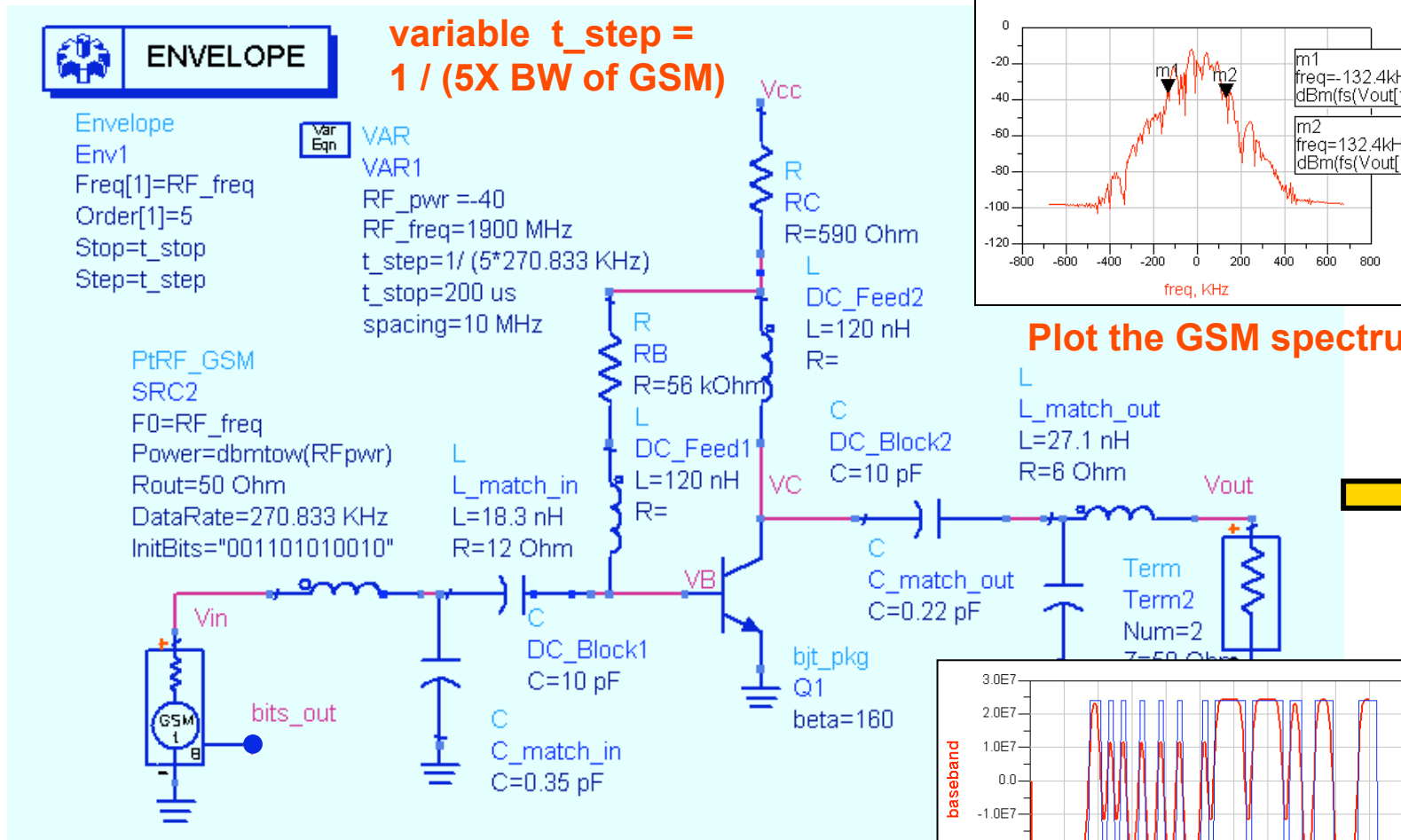


### Plot the GSM BW spectrum with with and without windowing.



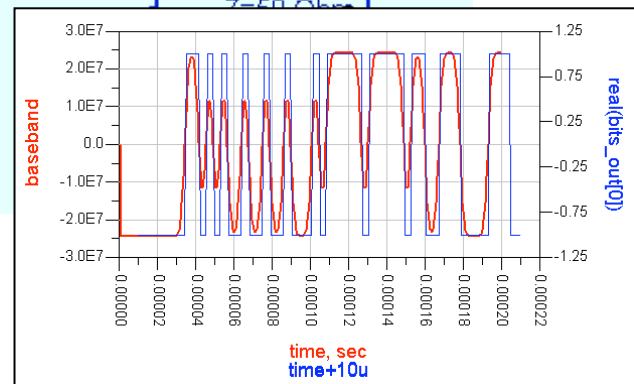
Also, insert a filter at **Vin** to alter the phase. See the difference at fm\_demods.

# Finally, use AMP\_1900 with the GSM source



Verify baseband integrity using an equation to demodulate the signal and compare bits.

$$\text{Eqn baseband} = \text{diff}(\text{unwrap}(\text{phase}(\text{Vout}[1]))) / 360$$



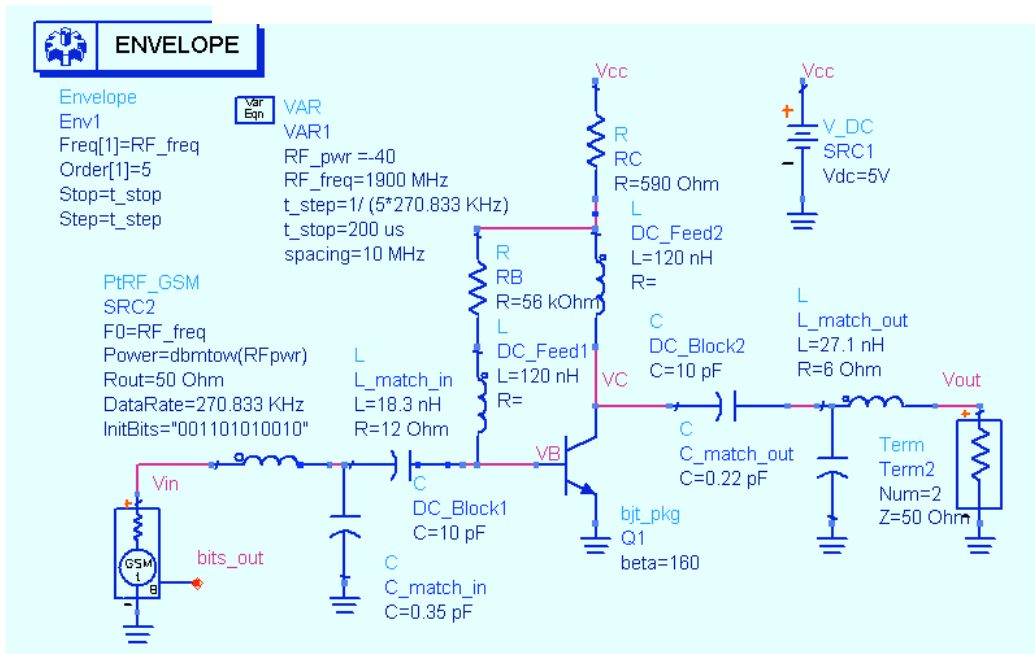
# Optional - channel power calculation

On a new page in DDS, write two equations:

**Limits:** defines the bandwidth and  
**channel\_pwr:** calculates power in the channel.

**Eqn** limits= {-(270KHz / 2), (270KHz / 2)}

**Eqn** channel\_pwr=10\*log(channel\_power\_vr ( Vout[1], 50, limits, "Kaiser"))+30



No need to resimulate, use Vout[1] which is 1900 MHz!

channel_pwr
-4.886

