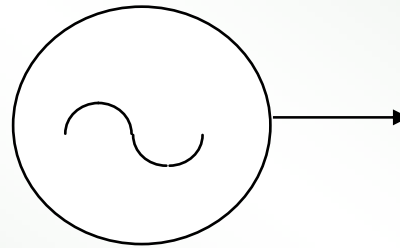


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# A Comparison of Large Signal and Small Signal Design Techniques for Oscillators



Andy Dearn  
Plextek Ltd

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# Introduction/Contents

The design of a 5.8 GHz VCO will be discussed;

- using SMT components
- using Rogers RO4003 substrate
  - Small Signal Design Techniques
  - Large Signal Design Techniques
    - > Output Spectrum
    - > Tuning Range
    - > Phase Noise
  - Comparison with Measured Results



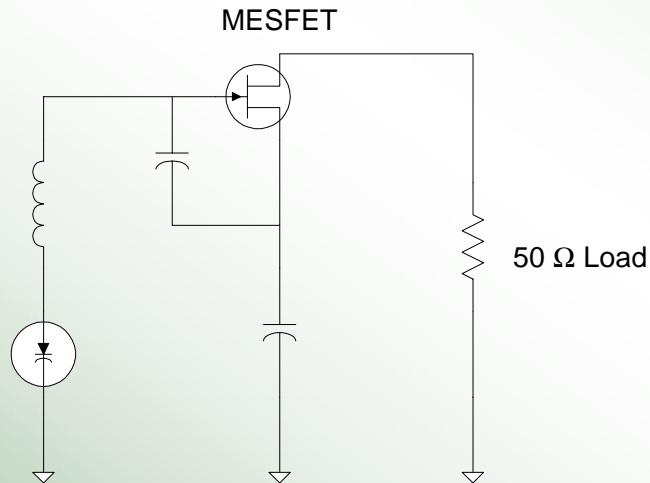
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## Introduction

- Requirement was for a 5.8 GHz fixed frequency LO
  - A VCO was designed with 5.8 GHz at the mid point of the allowed 0 to +6V tuning voltage
- DC bias was applied through quarter-wavelength transmission lines
- Decoupling & DC blocking used 0603 SMT capacitors

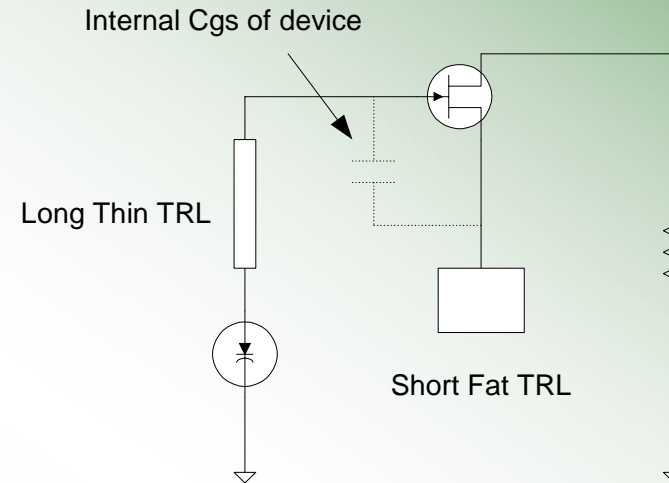


# Simplified Schematic



Colpitt's Capacitive Divider

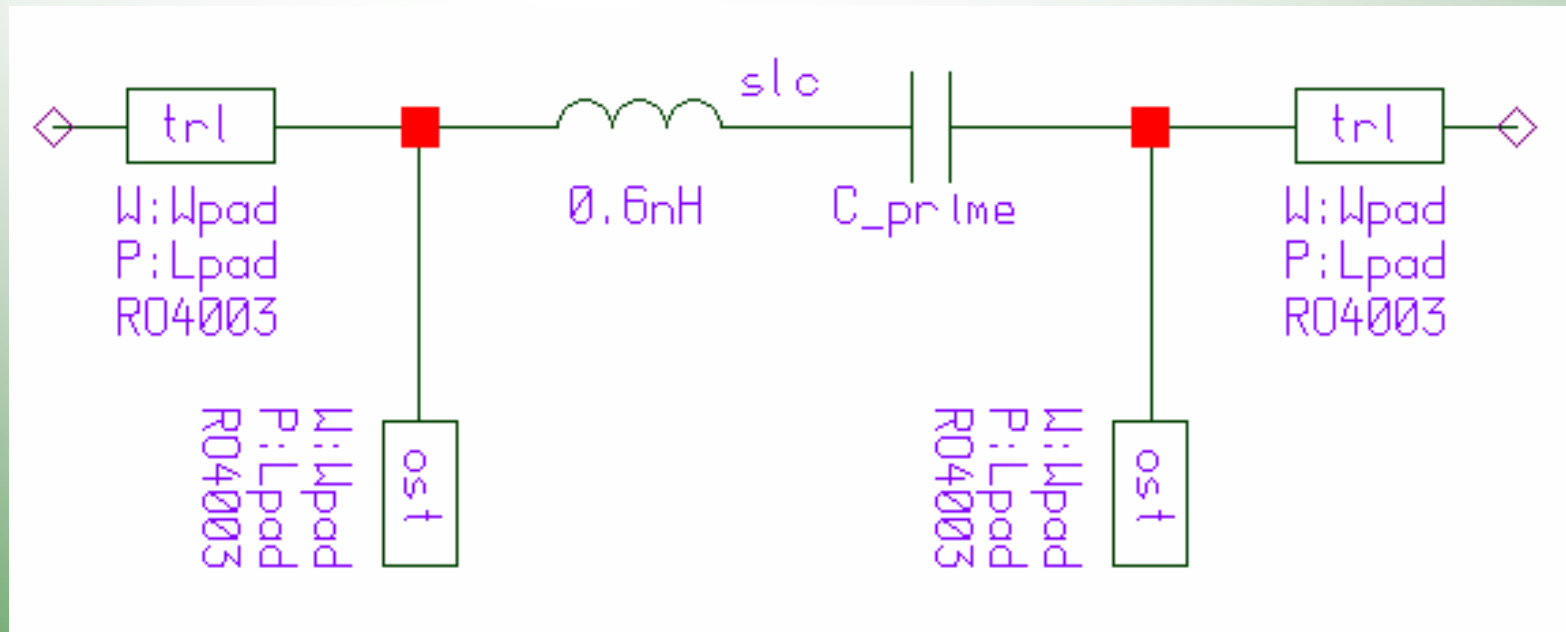
Lumped Element  
Representation of  
Colpitts VCO



Lumped Element/  
Distributed Version of  
Colpitts VCO

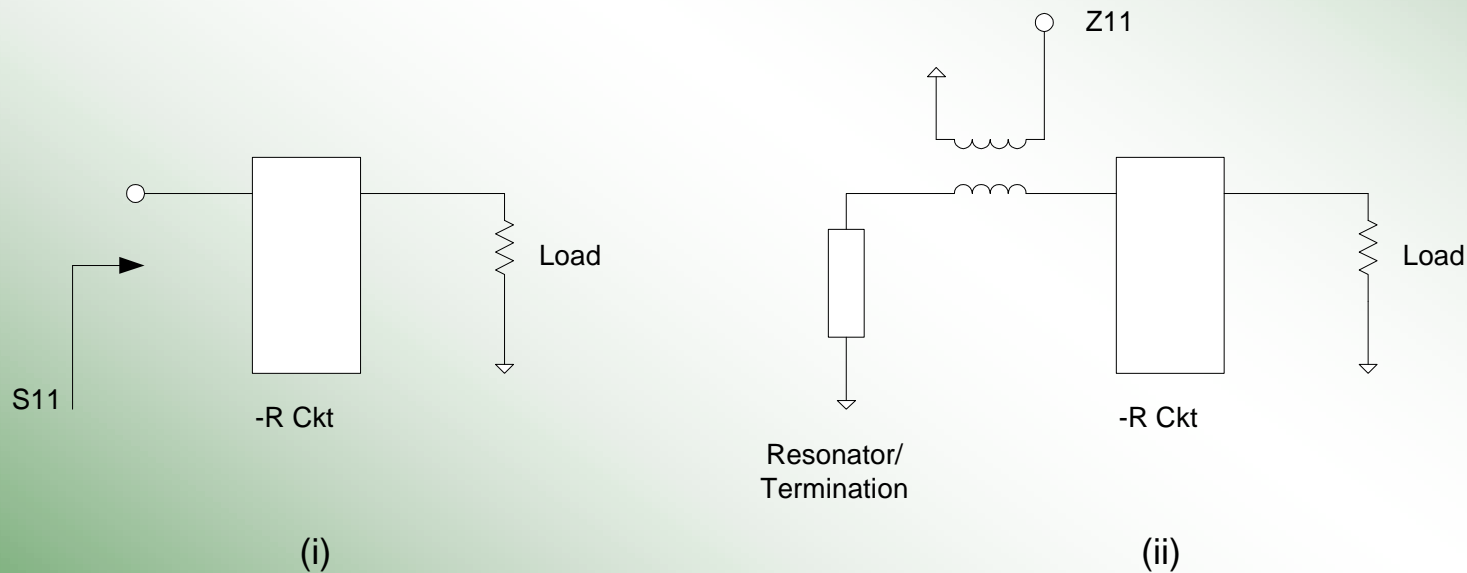
## All strays & parasitics are included ...

For example, the 0603 Capacitor model is ...

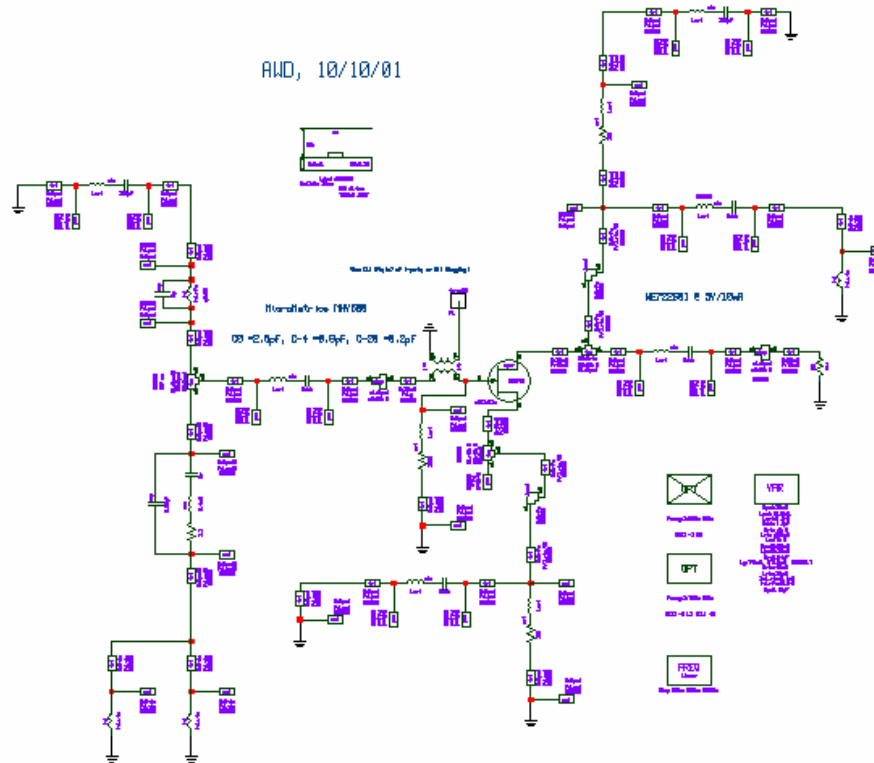


# Small Signal Design Technique

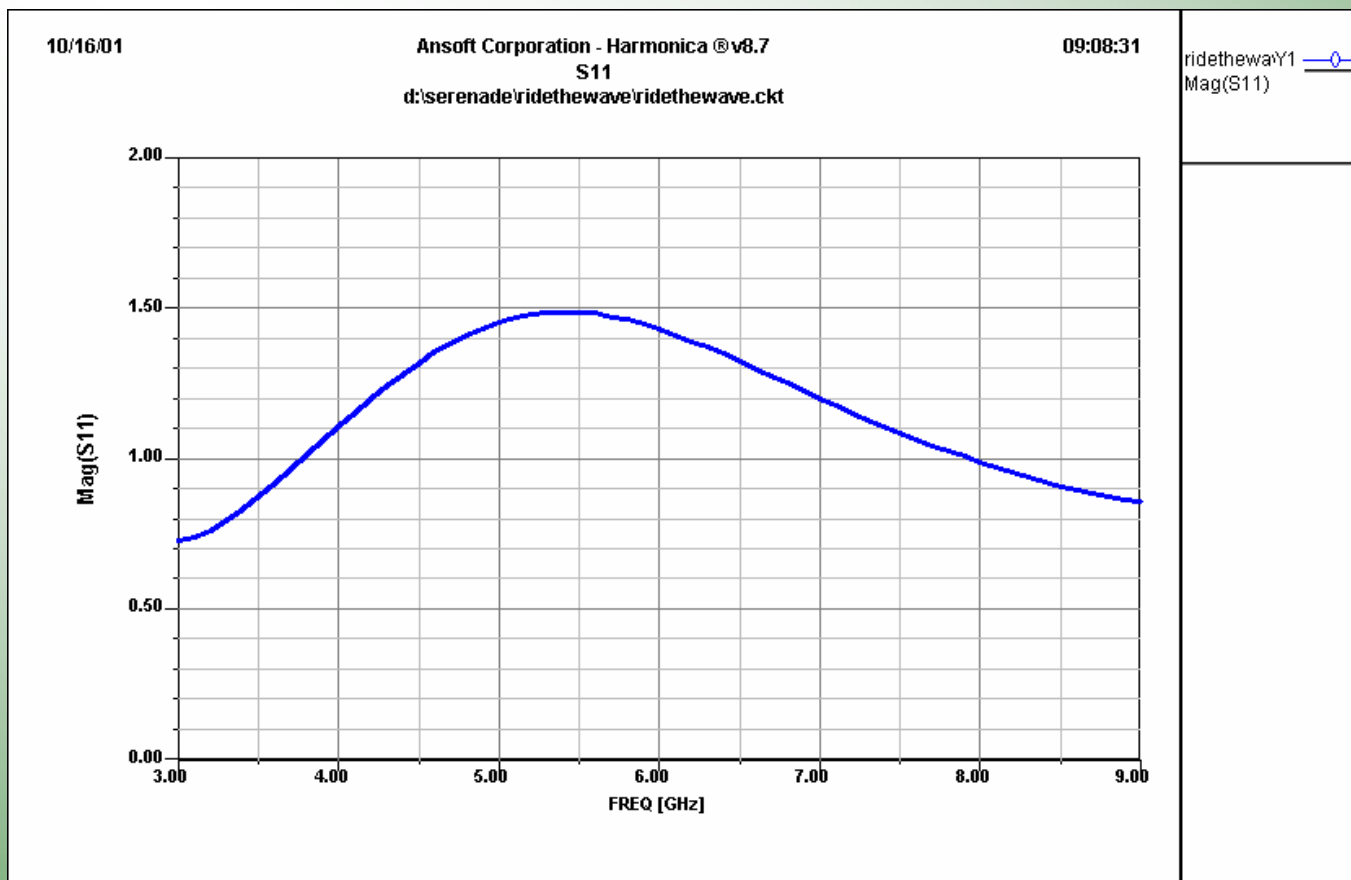
- First analyse the -R circuit to peak (&/or limit the absolute value of) the -R at centre frequency
- Then analyse the closed loop Oscillator (Use Ideal 1:1 Transformer to aid analysis)



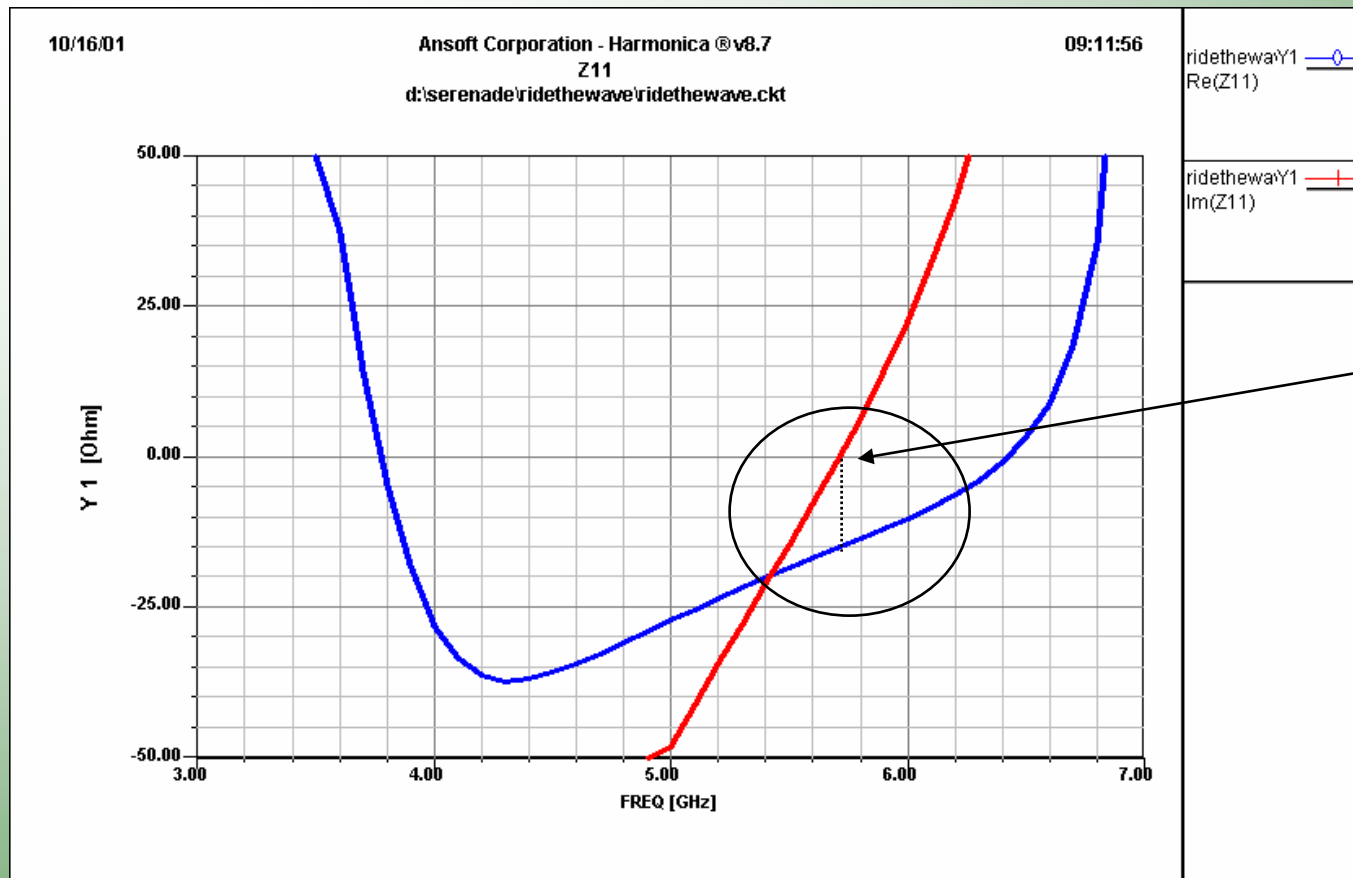
# Small Signal Serenade Schematic



# Input Reflection Coefficient of -R Ckt

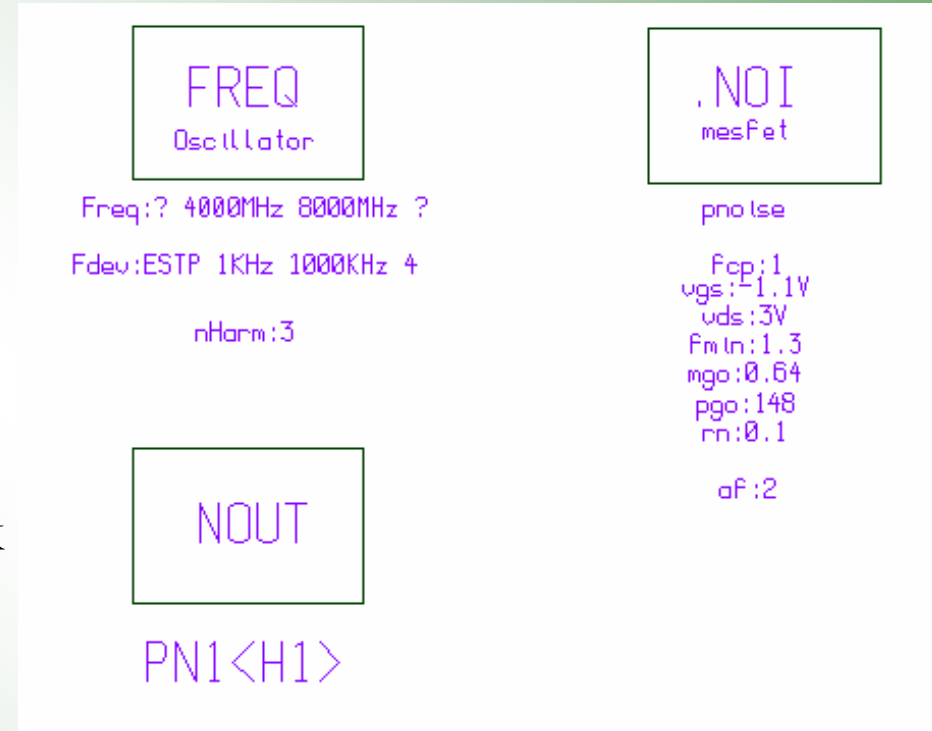


# Small Signal Simulation - Varactor set to 3V



# Large Signal Design Technique

- Remove the transformer
- Replace small signal models with large signal ones
  - add noise models, if required
- Add Oscillator Freq Control Block
  - if phase noise is required add Nout Block
- Use Oscillator Design (Ctrl-F10) as a check
  - (Equivalent to small signal design)
- Perform Oscillator Analysis (Shift-F10)
  - (Full non-linear, harmonic balance design)

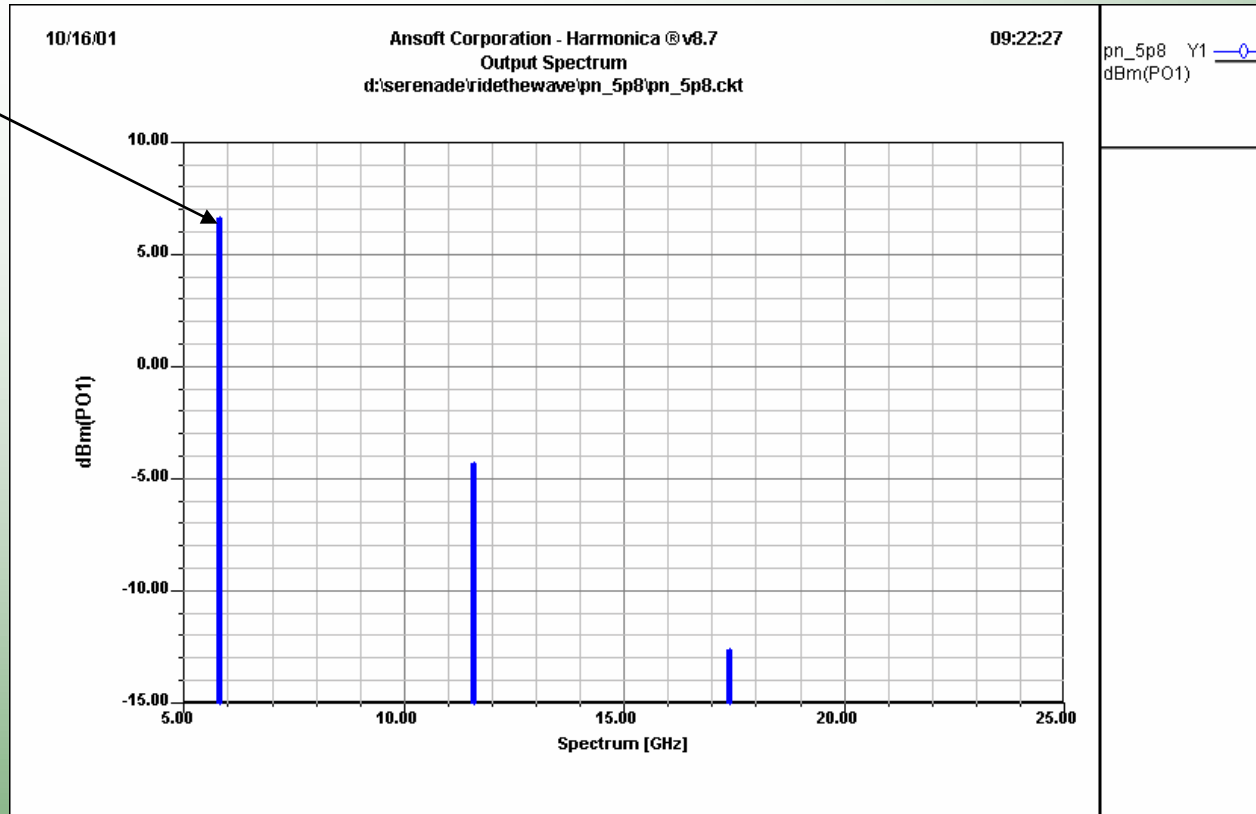




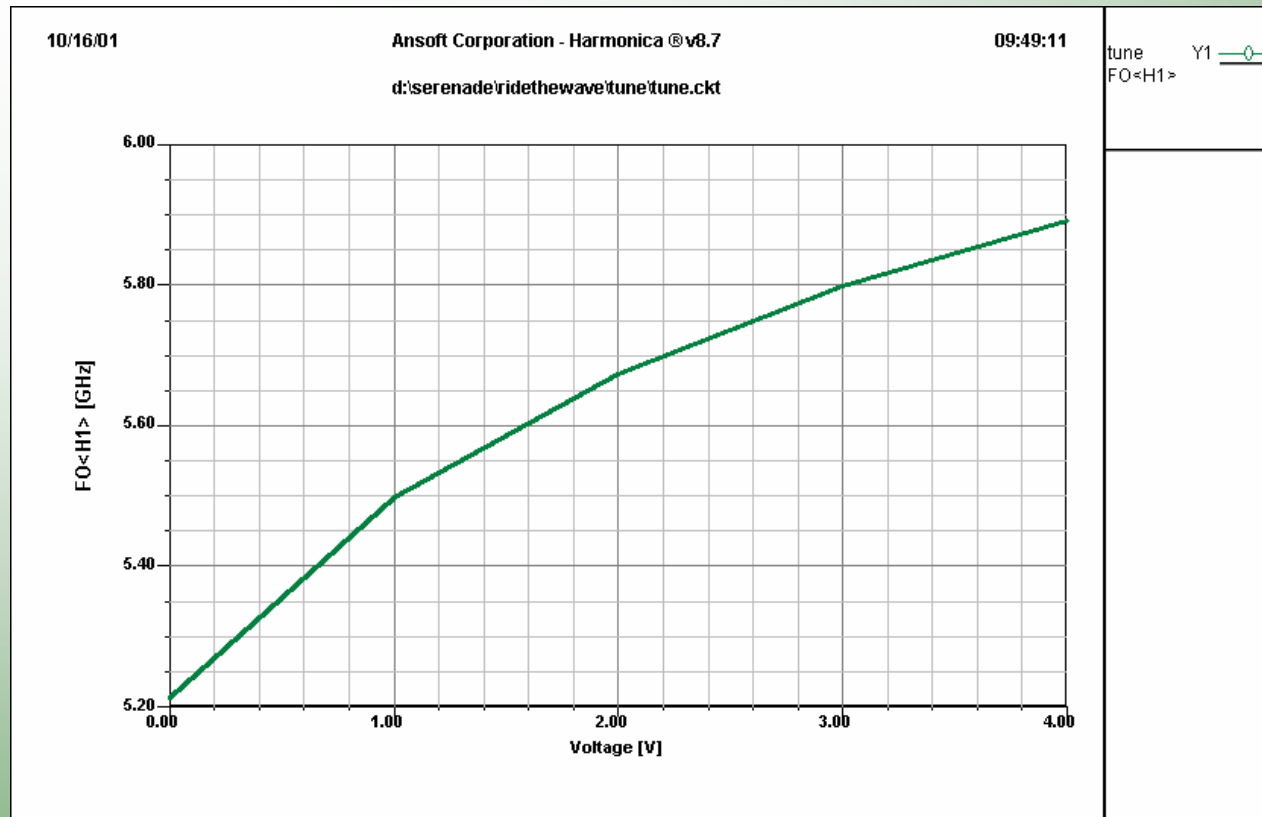
# Large Signal Simulation - Varactor set to 3V

## Output Spectrum

5.8 GHz  
+6.6 dBm



# Large Signal Simulation - Tuning Range

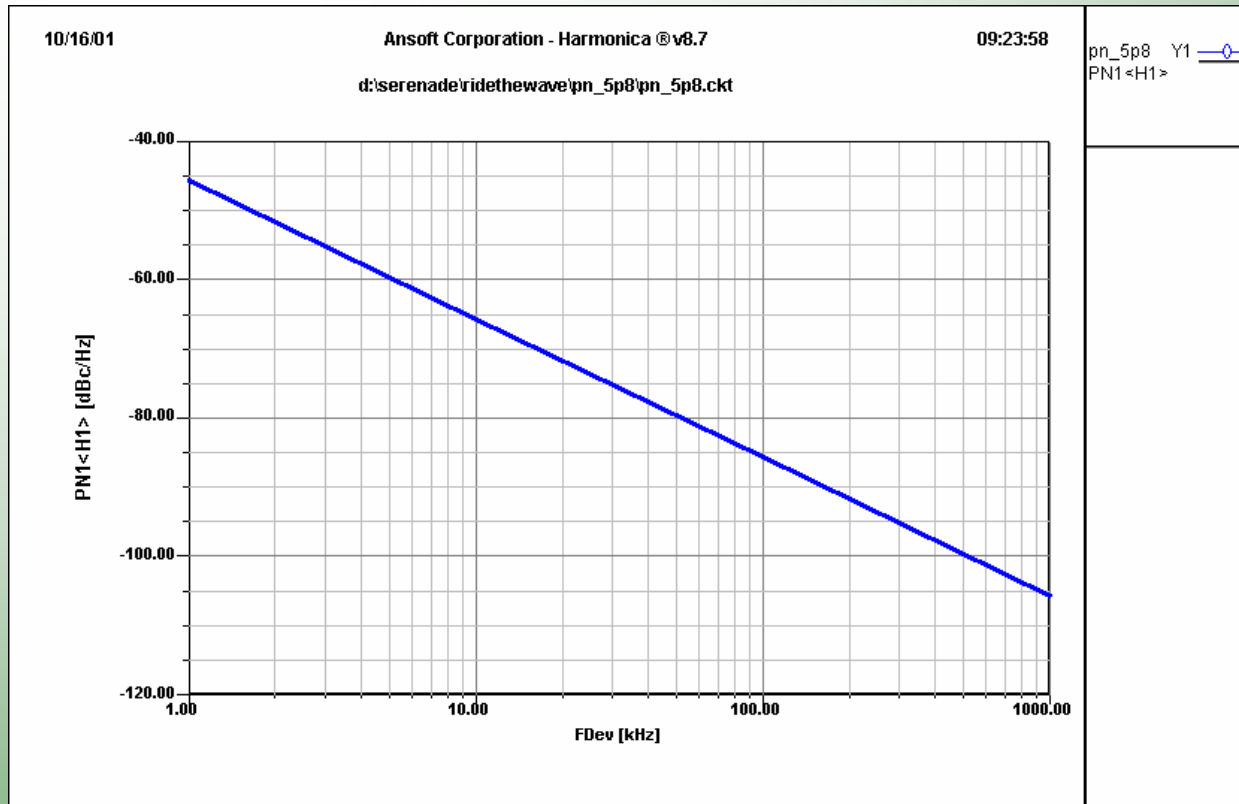


5.2 to 5.9 GHz  
(~ 14%)



# Large Signal Simulation - Varactor set to 3V

## Phase Noise



-100 dBc/Hz  
@ 500 KHz  
offset

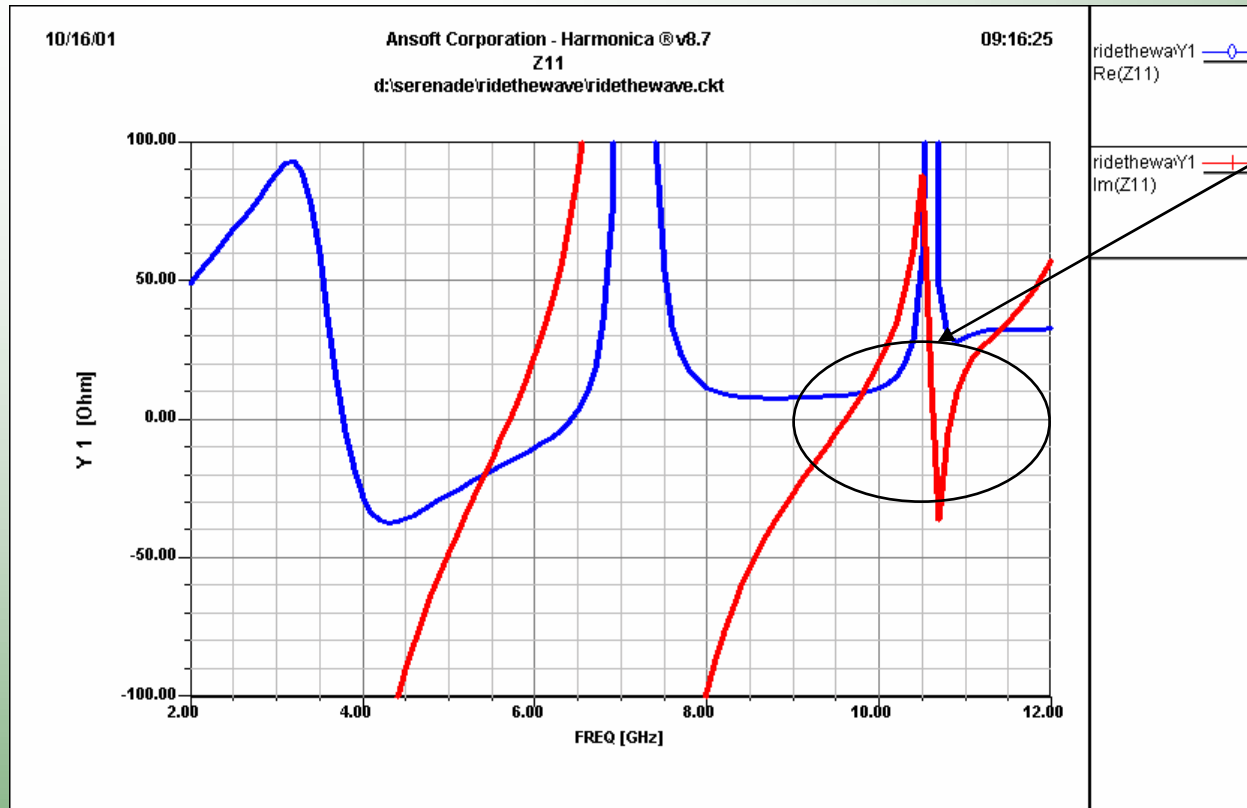


## Why bother with the Small Signal approach ?

- Large signal analysis give true steady-state frequency plus Power/Phase Noise/Harmonic Content/Efficiency etc.
- Small signal analysis can indicate the potential for oscillation at unwanted frequencies
  - & it indicates whether the wanted oscillation is “strong enough” to cope with any unforeseen stray or parasitic resistances



# Small Signal Simulation (Wideband) Varactor set to 3V

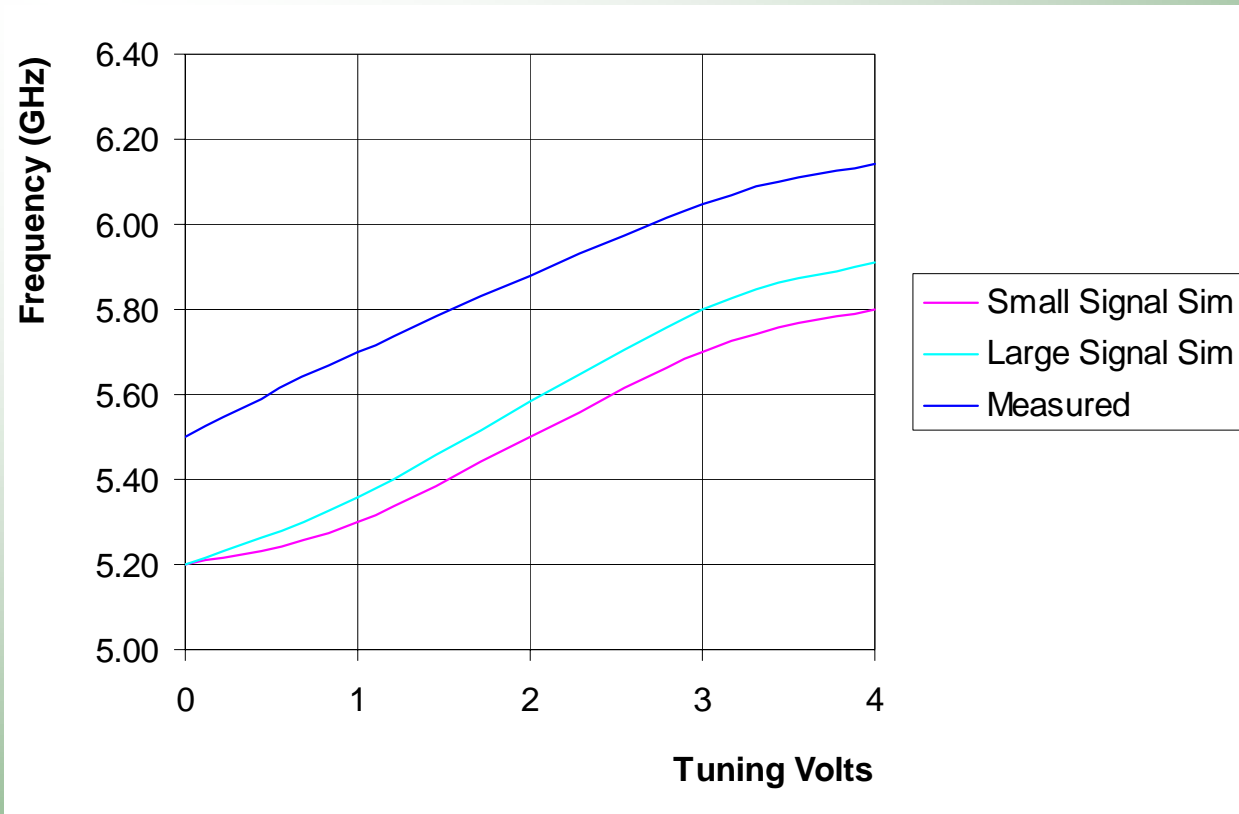


Potential unwanted frequencies -

In this case there is no -R



# Simulated Frequency vs. Measured



## Power & Phase Noise

- Power

Vtune (V)	Power (dBm)	Power (dBm)
	<i>Predicted</i>	<i>Measured</i>
0	5.6	7.0
1	5.9	6.9
3	6.6	7.2
4	6.8	7.8

- Phase Noise at 500 KHz offset

- Predicted: -100 dBc/Hz
- Measured: -105 dBc/Hz



## Conclusions

- Small signal, large signal & measured frequencies agreed to within  $\sim 5\%$
- Predicted & measured powers agreed to within  $\sim 1$  dB
- Although large signal simulation yields lots of additional information, the small signal simulation gives very useful information on the possibilities of multiple-frequency oscillations etc.

