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# Adaptive Resonance Control for LANSCE-R

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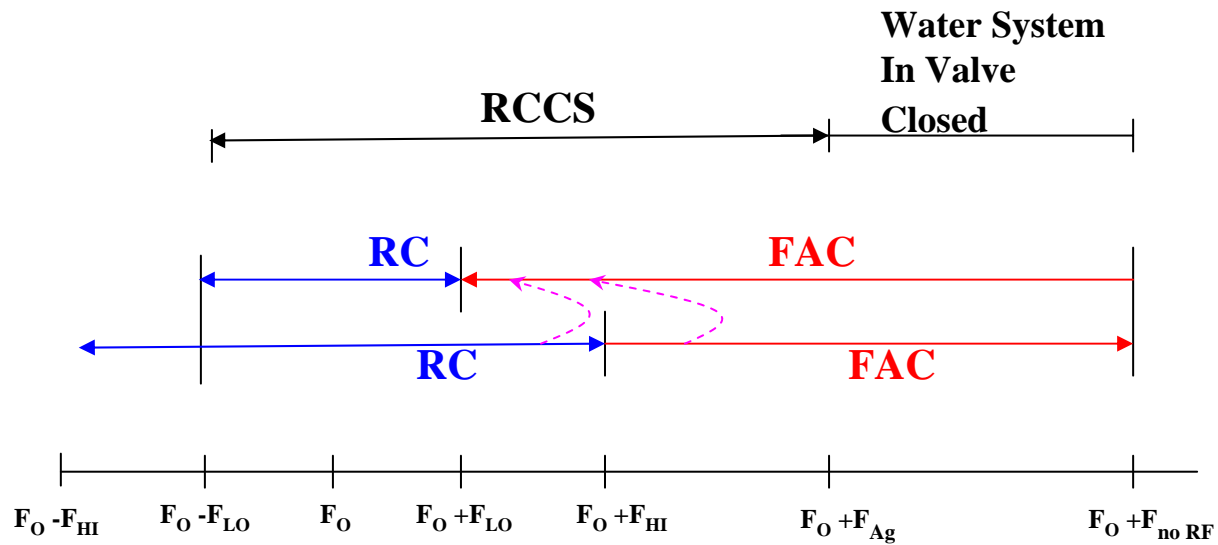


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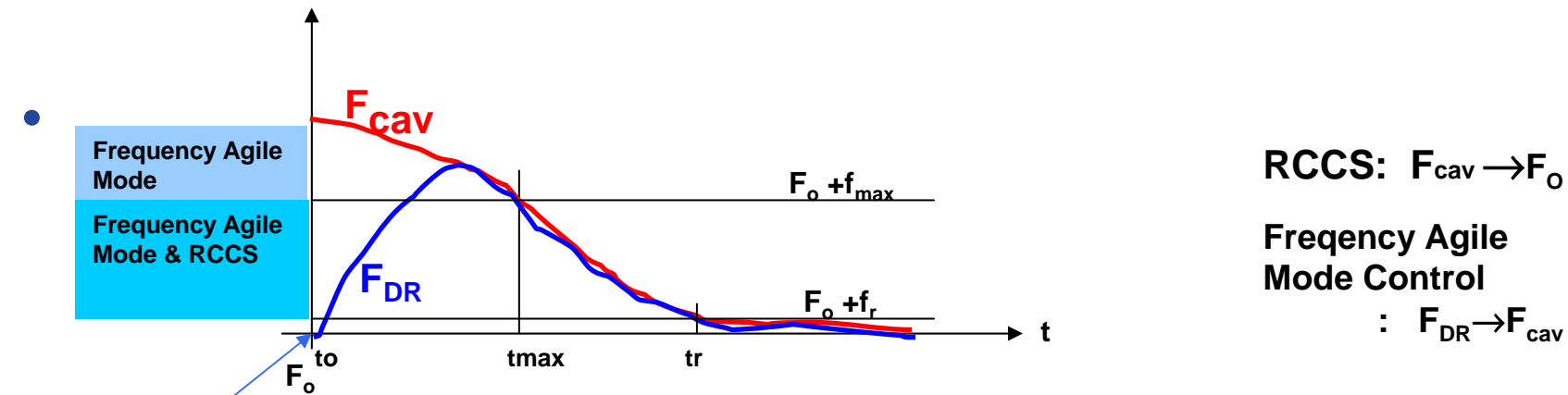


## Resonance Control : Frequency Agile Control and Resonance Control



**FAC** : Frequency Agile Control  
**RC** : Resonance Control  
**RCCS** : Water Cooling Control System

# Resonance Control Scheme



**Frequency Agile Mode**

- 1)  $F_{cav}$  changes due to heating by RF input
- 2)  $F_{DR}$  is controlled by DDS to follow  $F_{cav}$
- 3) Water Resonance Cooling Control System (RCCS) is not activated

**Frequency Agile Mode & RCCS**

- 1)  $F_{cav}$  is controlled by RCCS to approach  $F_0$
- 2)  $F_{DR}$  is controlled by DSP/DDS to follow  $F_{cav}$

**Frequency Monitoring Mode & RCCS**

- 1)  $F_{cav}$  is controlled by RCCS
- 2)  $F_{DR} = F_0$
- 3)  $\Delta f = F_{DR} - F_{CAV}$  monitored, reported by DSP
- 4) Field Control is activated

# Frequency Error Estimation

Instantaneous Frequency Error Equation :

$$\Delta \omega(k) = K \frac{f_o}{2Q_0} \frac{2(V_{TI}(k)V_{FQ}(k) - V_{FI}(k)V_{TQ}(k))}{V_{TI}^2(k) + V_{TQ}^2(k)}$$

Average Frequency Error Equation :

$$\Delta \bar{\omega}(n) = \frac{\frac{1}{N} \sum_{k=N_0}^{N_0+N-1} V_{TI}(n,k)V_{FQ}(n,k) - V_{TQ}(n,k)V_{FI}(n,k)}{\frac{1}{N} \sum_{k=N_0}^{N_0+N-1} V_{TI}^2(n,k) + V_{TQ}^2(n,k)}$$

$$A(n) = \frac{1}{N} \sum_{k=N_0}^{N_0+N-1} V_{TI}^2(n,k) + V_{TQ}^2(n,k)$$

Gain Adaption :

$$K(n+1) = K(n) + \varepsilon(A(n) - A(n-1)) \|\Delta \bar{\omega}(n)\|$$

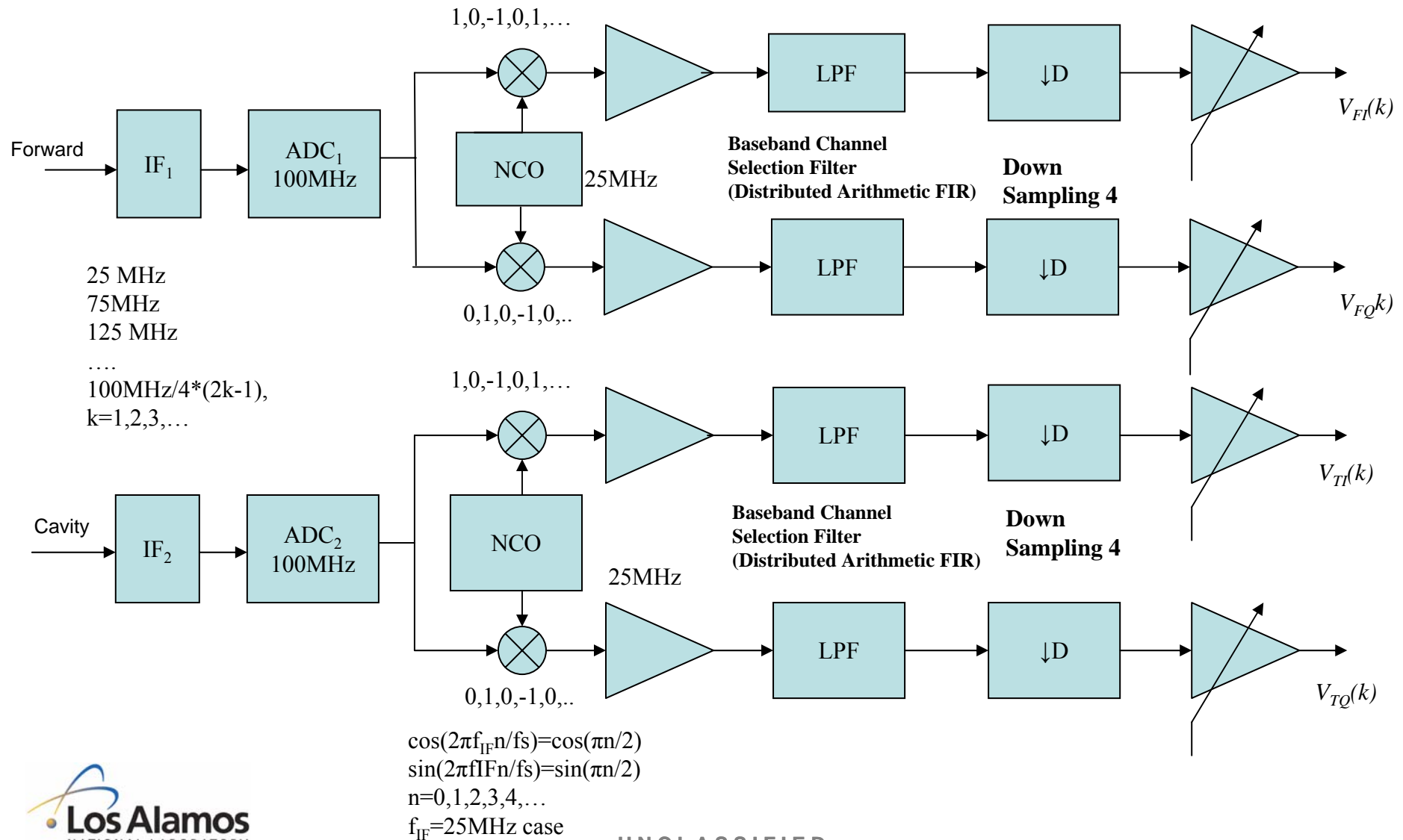
Frequency Error Tracking Filter :

$$\Delta f(n+1) = \alpha \Delta f(n) + K(n) \Delta \bar{\omega}(n)$$

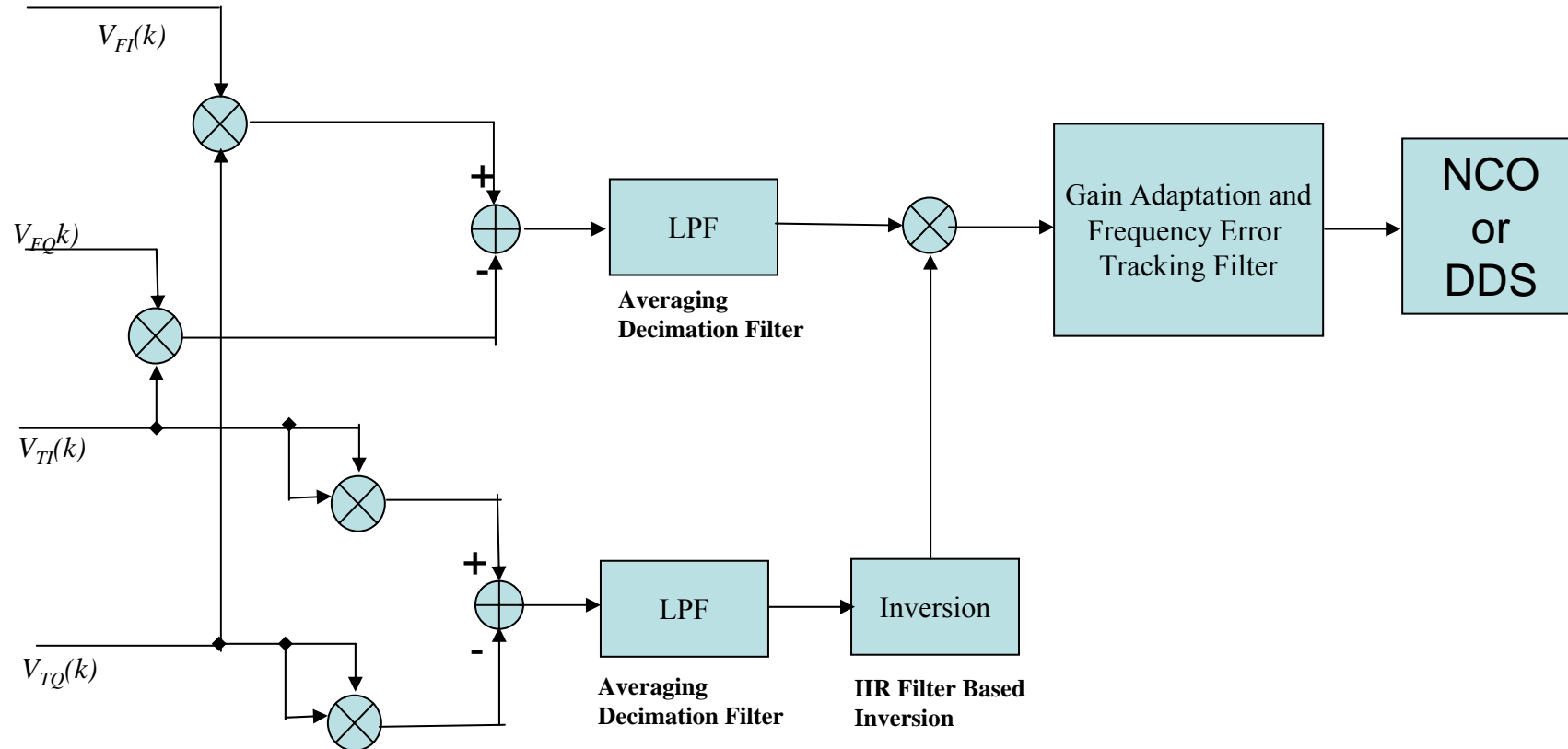
$$f(n+1) = f(n) + \Delta f(n)$$

$n$ : RF Pulse Number,  $k$ : sample number

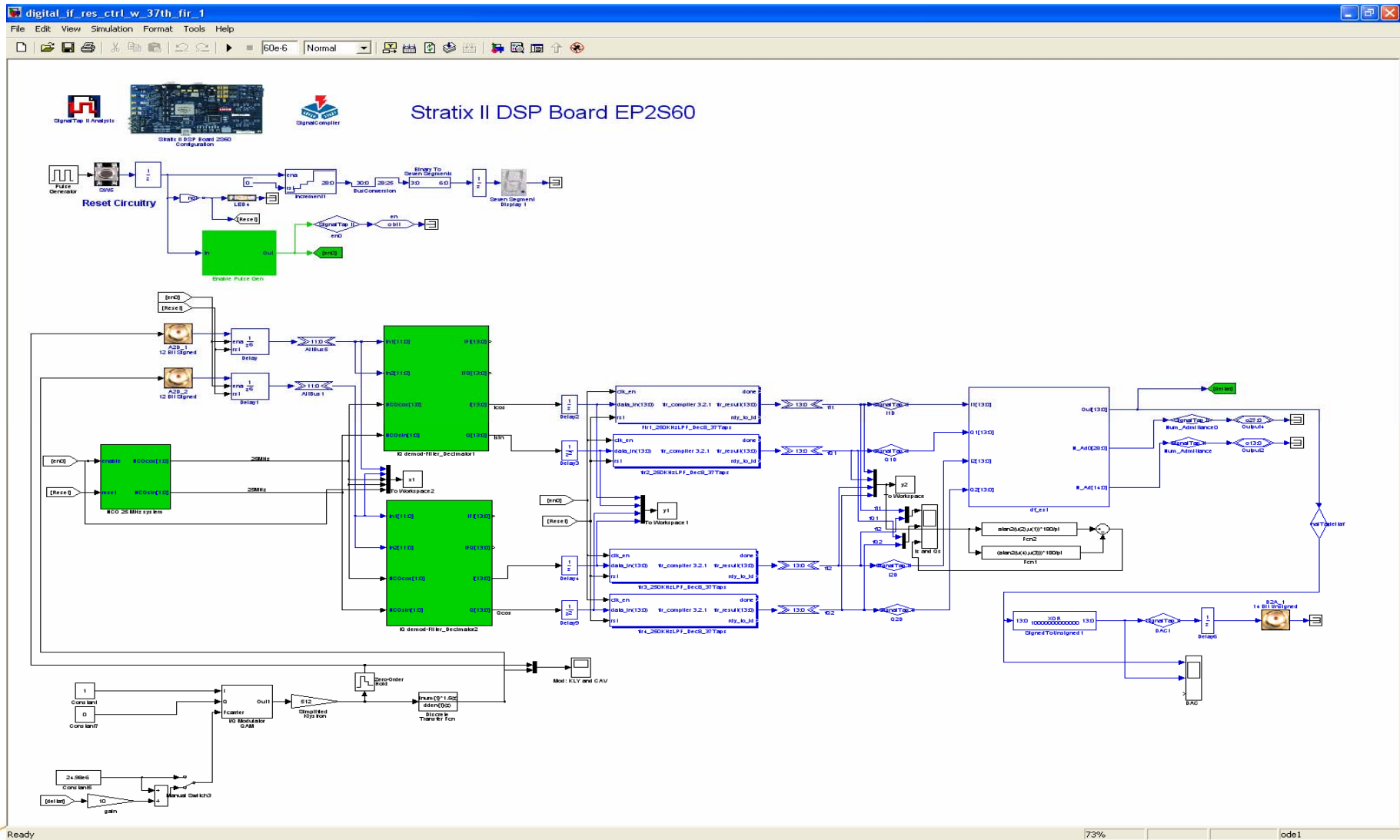
# Direct Conversion Receiver Architecture



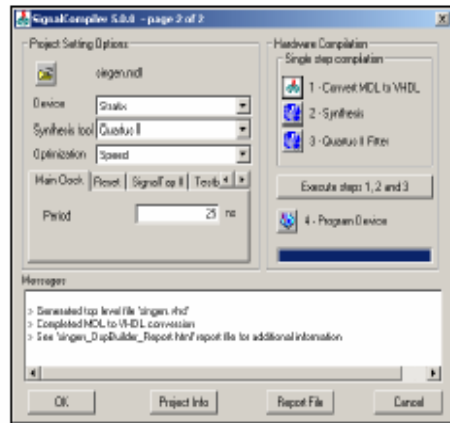
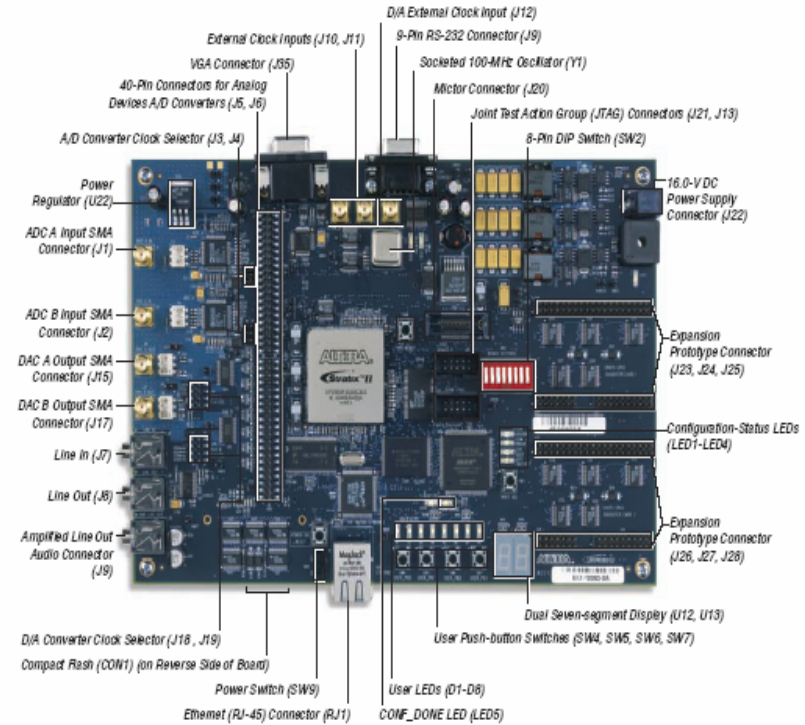
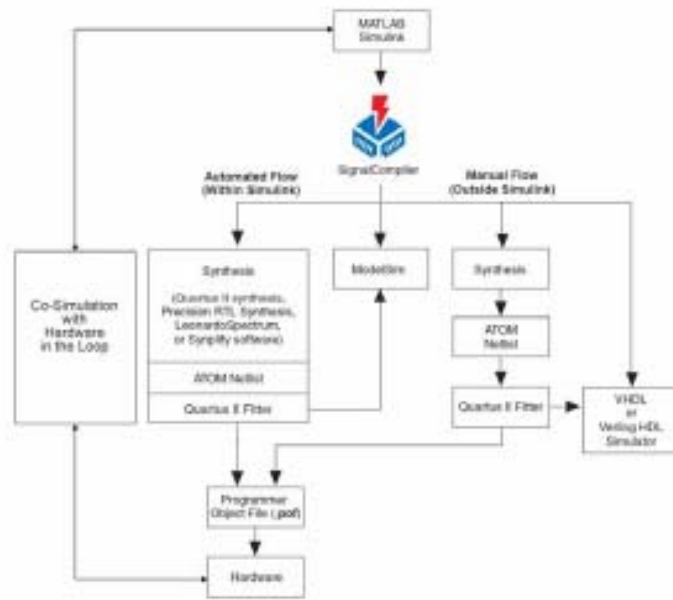
# Frequency Error Tracking



# Fixed Point SIMULINK MODEL-DSP BUILDER/SIMULINK BLOCKs

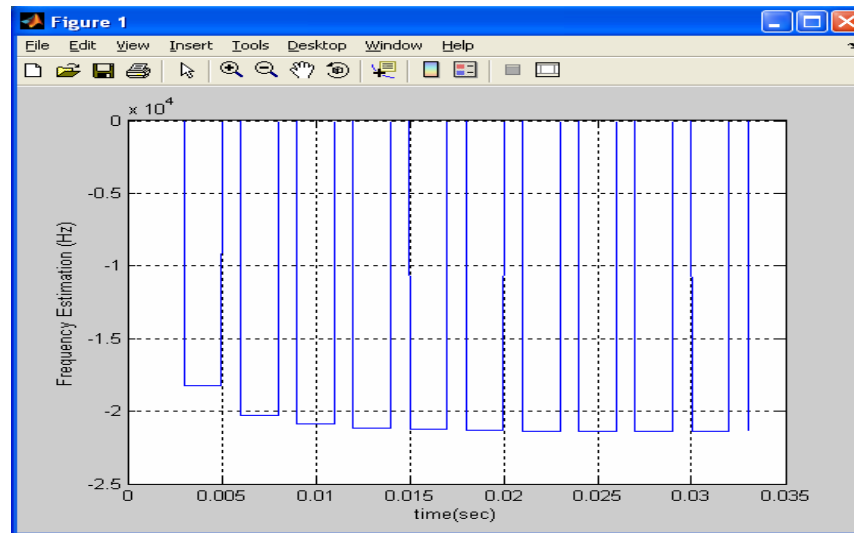
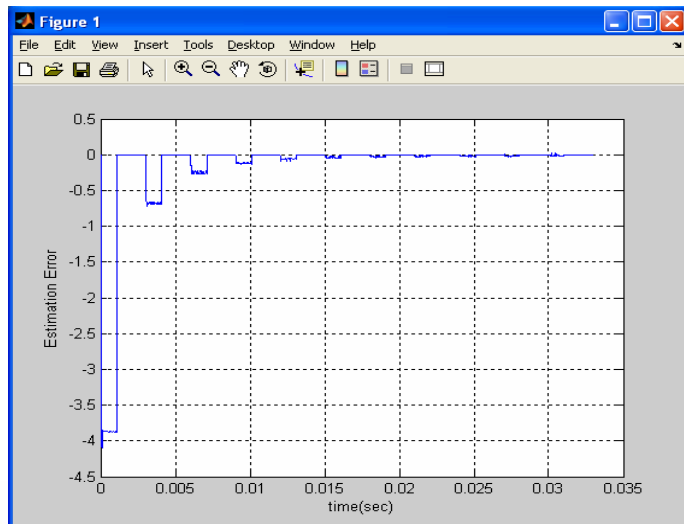
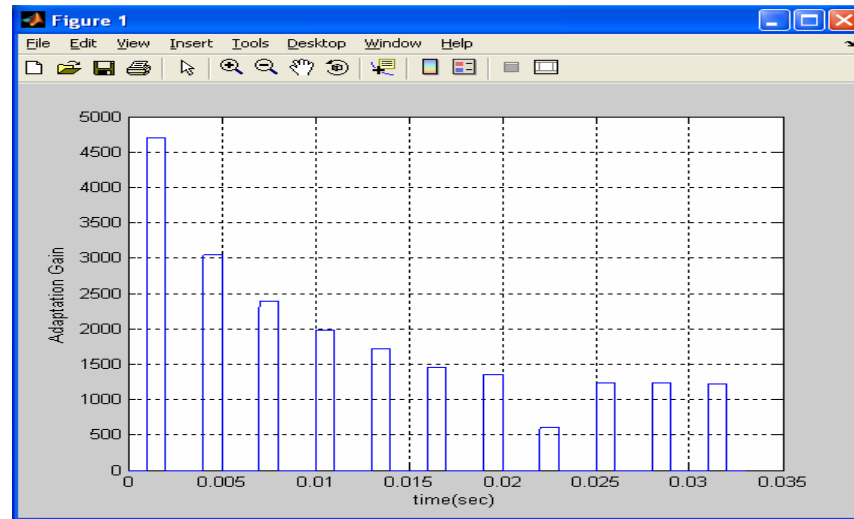
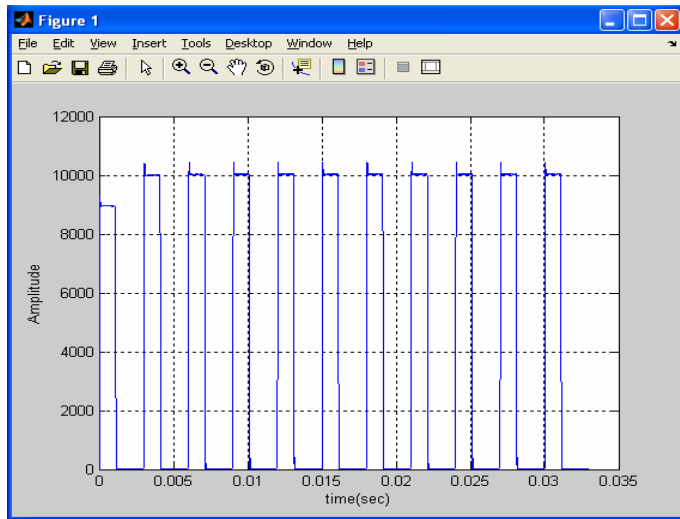


# DSP Builder Compiler/DSP Development Board for Stratix II FPGA EP2S60

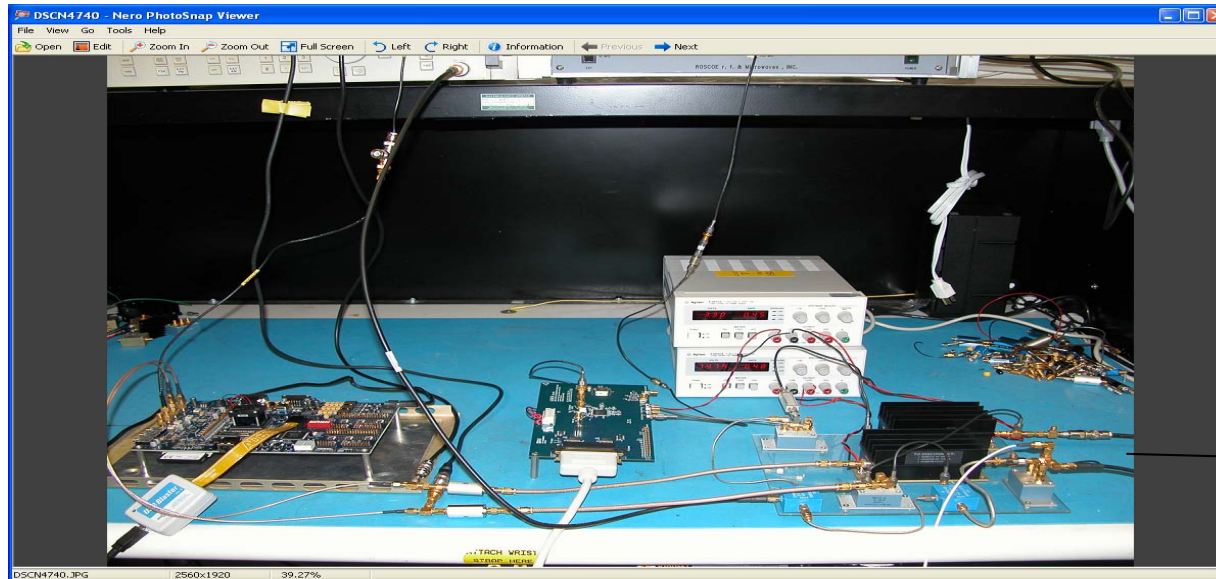
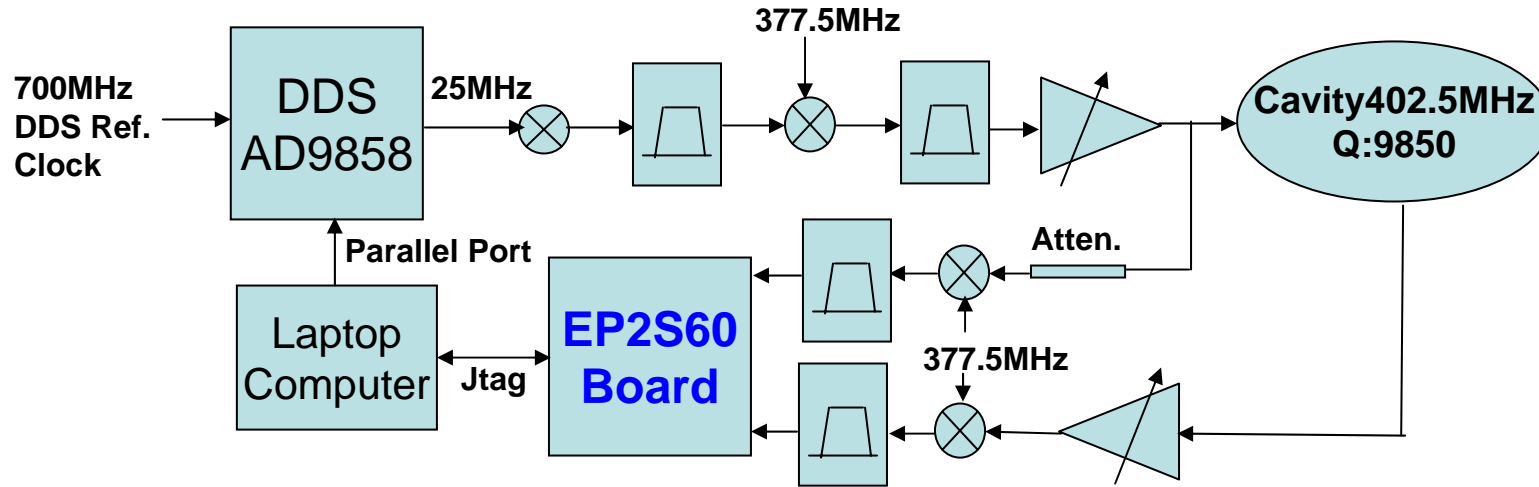




# SIMULINK MODEL Simulation: -21.5 KHz Frequency tuned case



# System Setup

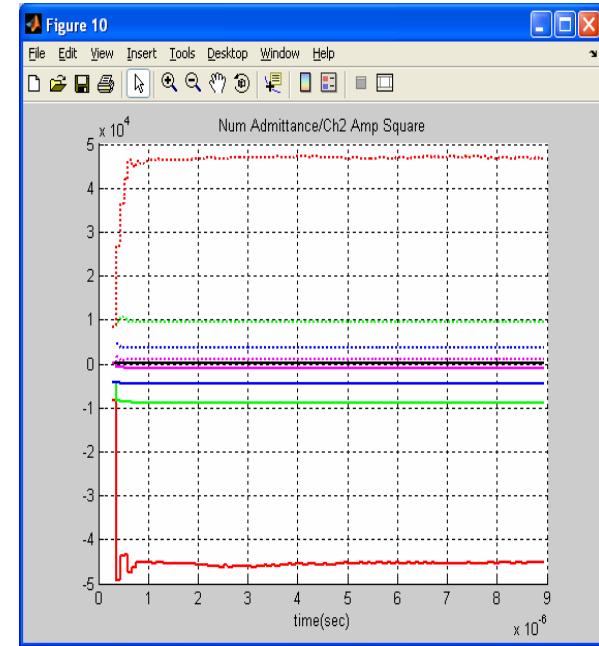
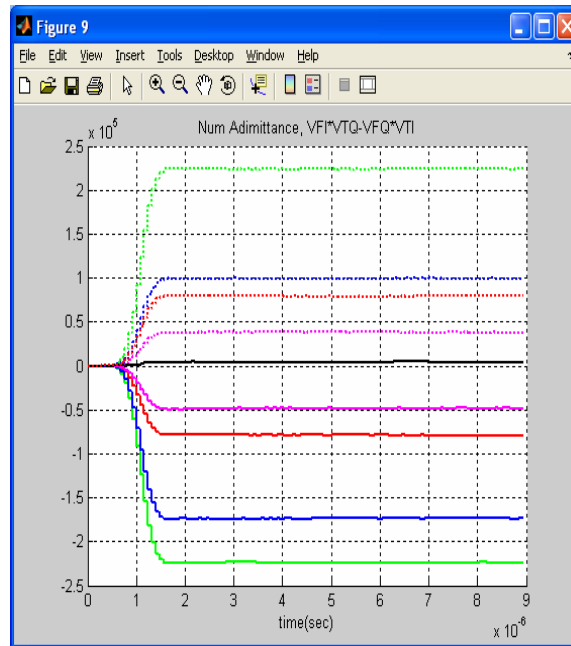
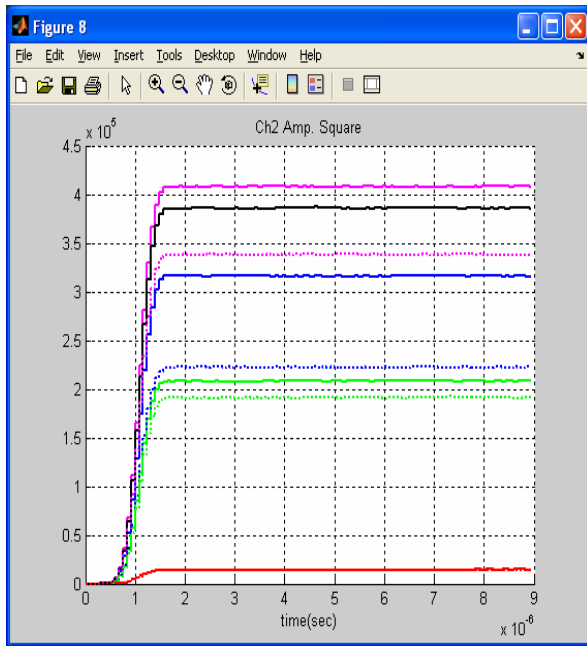


→ To/From Cavity  
Cavity not shown

# EP2S60 Development Board Test- Signal Tap Analyzer used

.Cavity operating freq: 402.5 MHz  
 .Q:9850  
 .f3dB=21.5 KHz (single-sided)  
 .Cavity is -21.5 kHz OFF

- : -5f3dB Frequency Error
- : -f3dB Frequency Error
- : -0.5f3dB Frequency Error
- : - 0.1f3dB Frequency Error
- : 0
- ... : 0.1f3dB Frequency Error
- ... : 0.5f3dB Frequency Error
- ... : f3dB Frequency Error
- ... : 5f3dB Frequency Error



Y value is Scaled by  $2^{13}$

## Analysis and Future Work

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- Limitation of the Current Hardware
  - No External interface circuitry
  - Single RF pulse
  
- Future Work
  - Timing Control Circuitry
  - External DDS Interface
  - External Host Interface