Ultra-Fast Noise Parameter Measurements

More than 100x Faster

Enhanced Accuracy

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For a more detailed version of this presentation, go to www.maurymw.com/presentations.htm

Outline

- Motivation
- Basics of Noise Measurements
- Traditional Noise Parameter Measurement
- The New Noise Parameter Measurement
- Results (224x Faster and more Accurate)
- Summary

Noise Parameter Measurement
Motivation for Change

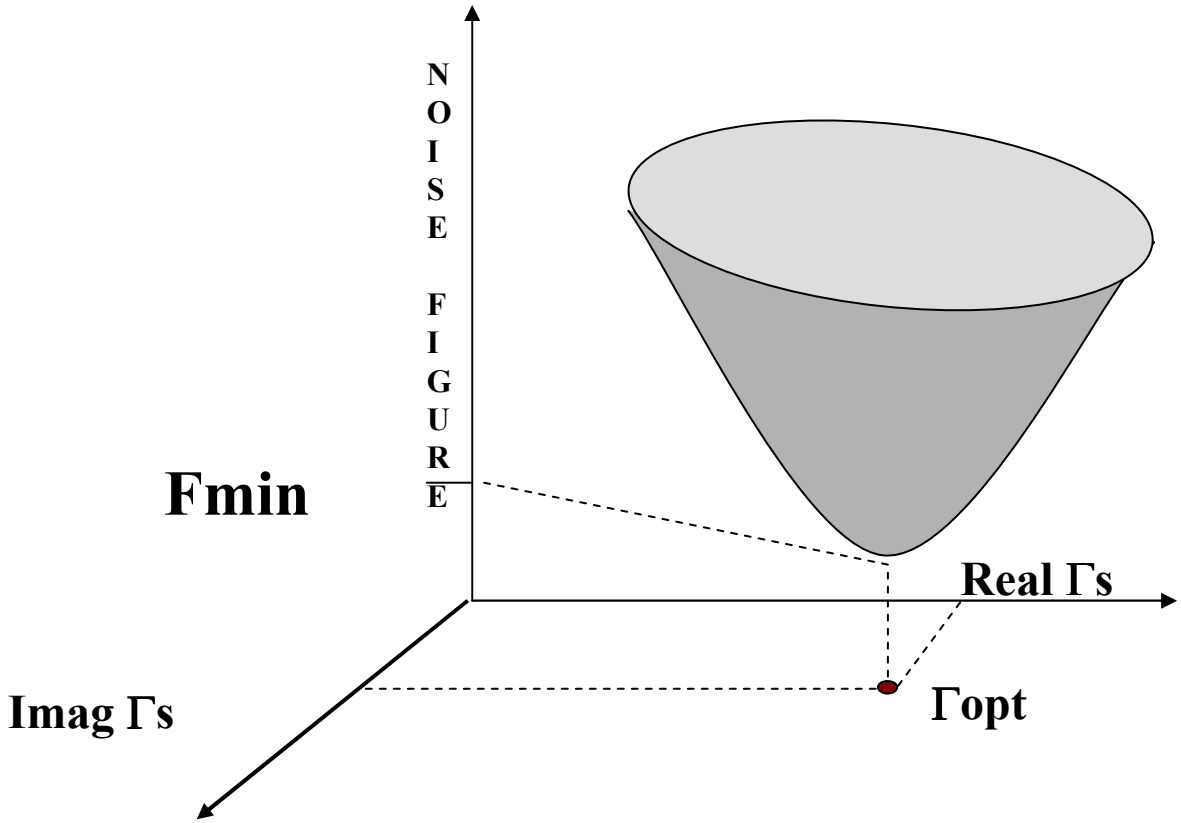
- **Speed Up the Measurement**
  - **Traditionally Slow**
- **Simplify the Measurement**
  - **Traditionally Difficult**

Noise Figure

- Noise Performance at one Impedance
- Example – 50 Ohm Noise Figure

Noise Parameters

Give Noise Figure vs. Impedance



Noise Parameters

Consist of Four Scalar Values

Most Common Set:

- Fmin – Minimum noise figure
- $|\Gamma opt|$ – Optimum Γ magnitude
- $\angle \Gamma opt$ – Optimum Γ phase
- rn - Equivalent noise resistance

$$F = Fmin + 4rn \frac{|\Gamma s - \Gamma opt|^2}{|1 + \Gamma opt|^2 (1 - |\Gamma s|^2)}$$

Noise Parameter Measurement

General Method

- Set 4 Values of Γs
- For Each Γs, Measure F
- Solve 4 Simultaneous Equations for the 4 Values

$$F = F_{min} + 4r_n \frac{|\Gamma s - \Gamma opt|^2}{|1+\Gamma opt|^2 (1 - |\Gamma s|^2)}$$

Noise Parameter Measurement
Practical Method

Use Over-Determined Data:

- Measurement is Sensitive to Small Errors
- Measure at more than 4 Γs Values
- Use Least-Mean-Squares to Reduce Data

Noise Parameter Measurement
Practical Method

Use Noise Power Equation:

- **Rigorous Solution**
- **Account for Γhot and Γcold of Noise Source**
- **Allows Hot/Cold or Cold Only Approaches**

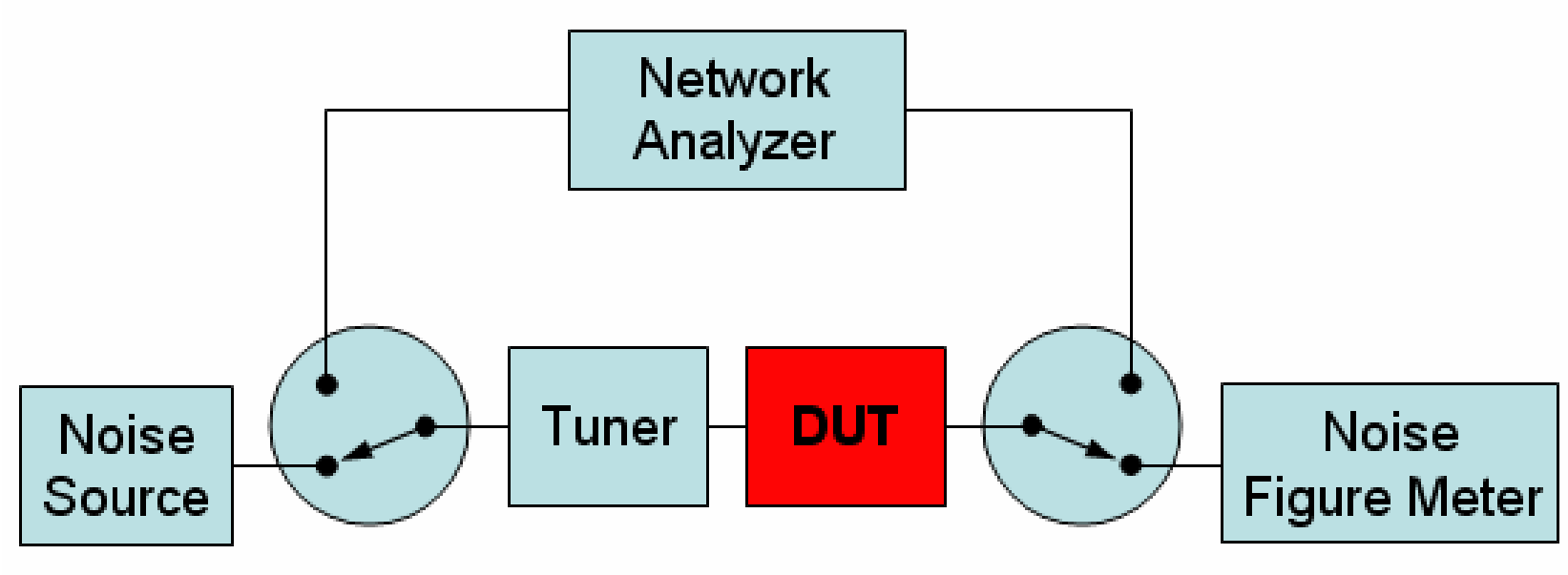
$$P = kB\{[tns + t0(F1-1)]Ga1 + t0(F2-1)\}Gt2$$

Noise Parameter Measurement Sequence

1. System Cal
2. Receiver Cal
3. DUT Measurement

Noise Parameter Measurement

Traditional Method



Noise Parameter Measurement

Traditional Method

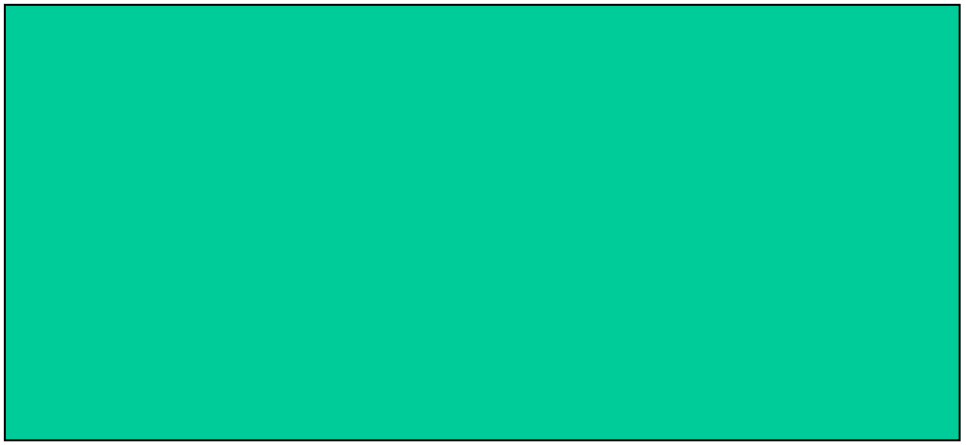
1. System Cal
   - Characterize Tuners Over Entire Chart
   - One Frequency at a Time
2. Receiver Cal and Measurement
   - One Frequency at a Time
   - Allows Ideal Impedance Pattern

Noise Parameter Measurement

Traditional Method

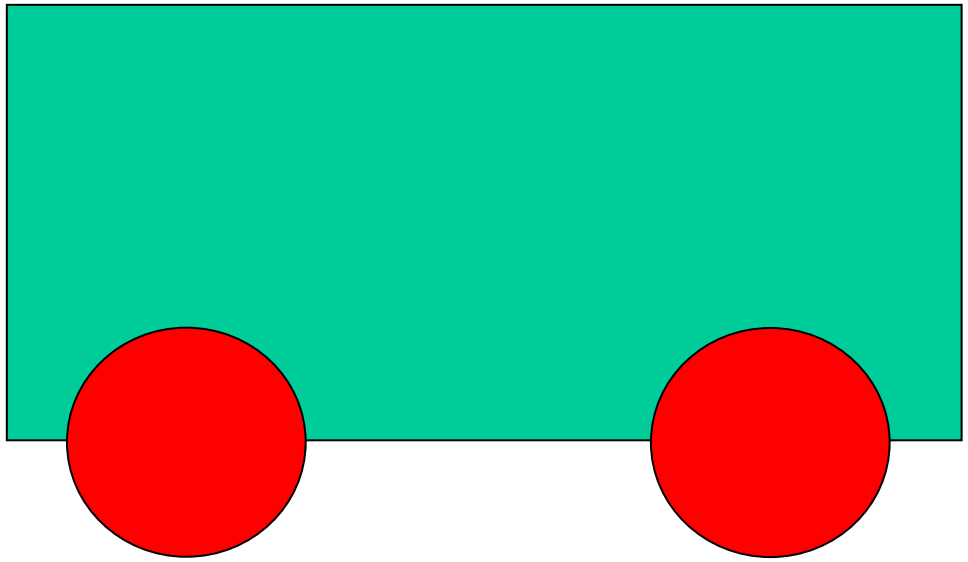
- Time Consuming
  - Can Have Drift Issues
- Use System Cal for Long Time
  - To Save Time
  - Calibrate Parts Separately

History



Heavy Objects are Hard to Move

Innovation



Once Seen, Wheels are Obvious

Noise Parameter Measurement
New Method*

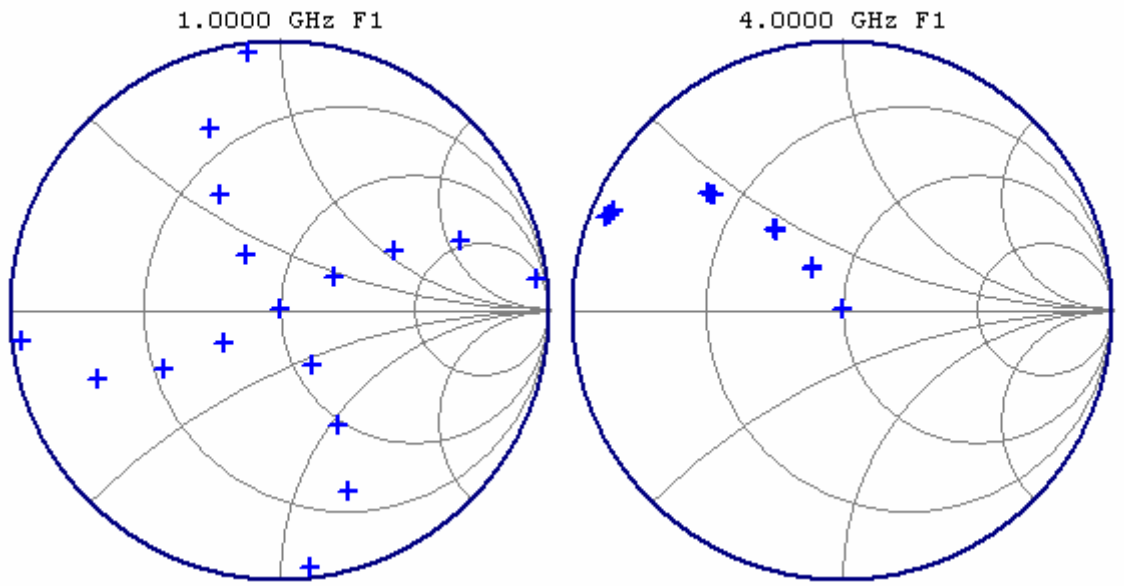
Main Idea:

- Characterize One Set Of Tuner States
- Sweep Frequency at Each State
- Take Advantage of Fast Sweep of Modern Instruments

*Patent Pending

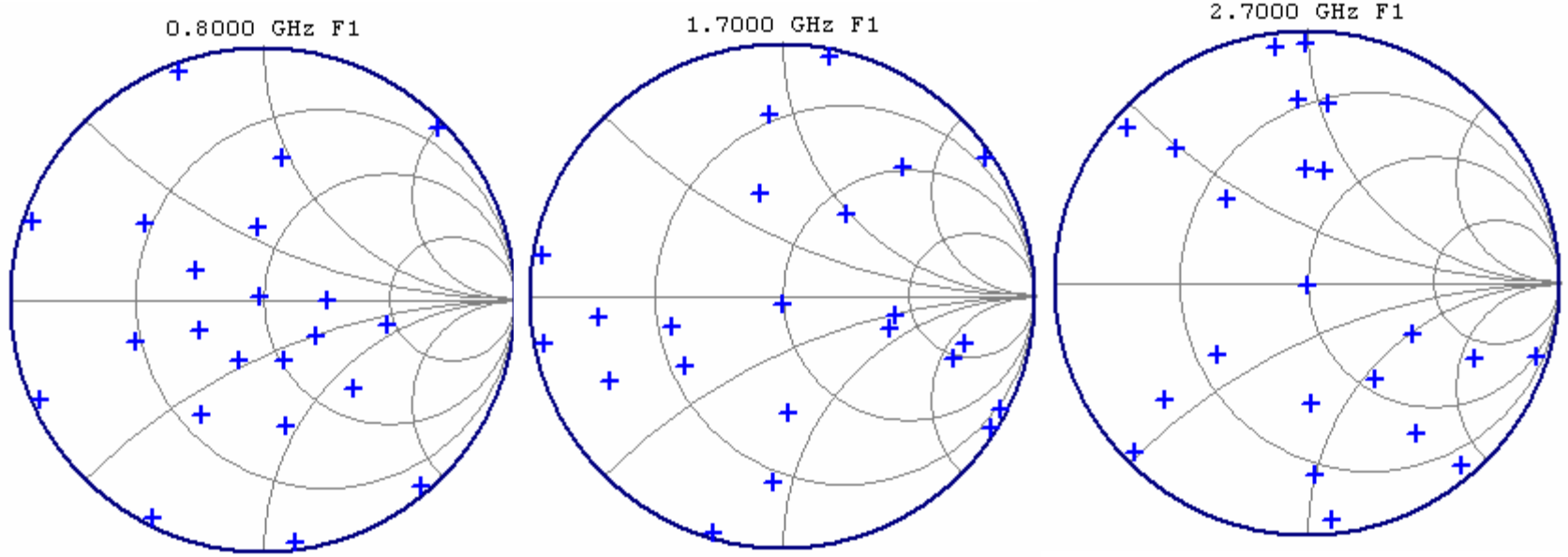
Noise Parameter Measurement
New Method

Problem: Impedance Patterns at All Frequencies



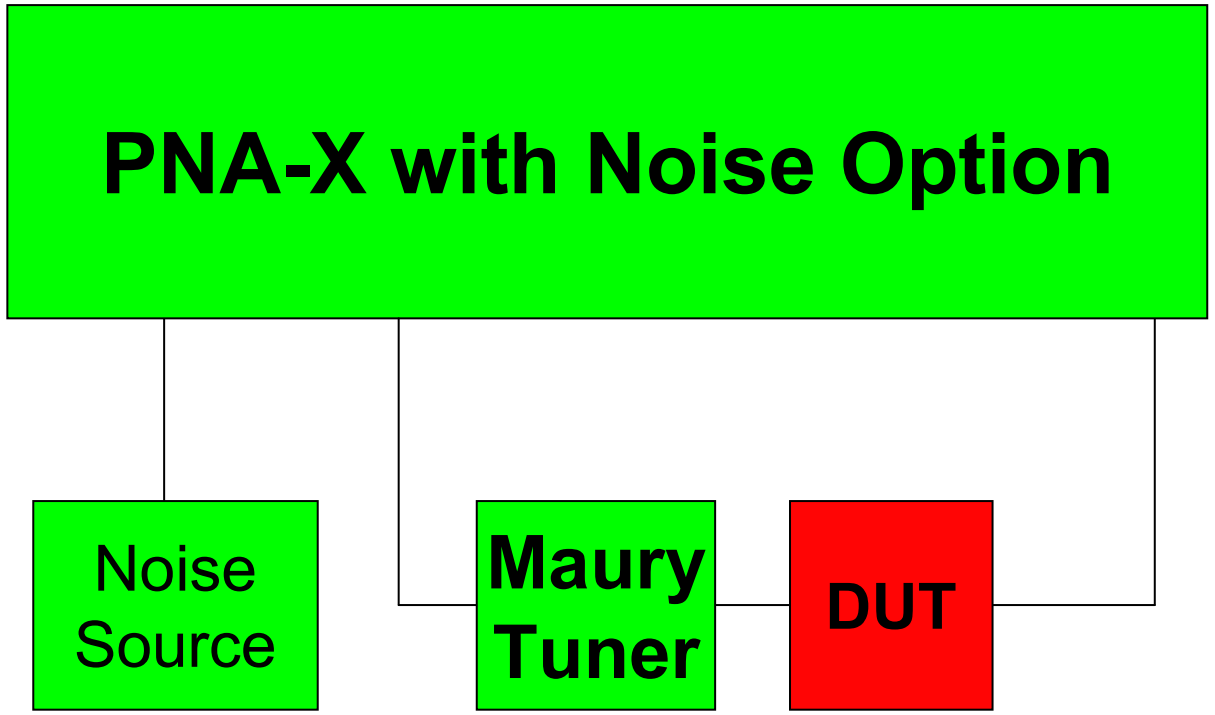
Noise Parameter Measurement
New Method

Solution: Non-Uniform Phase Spacing



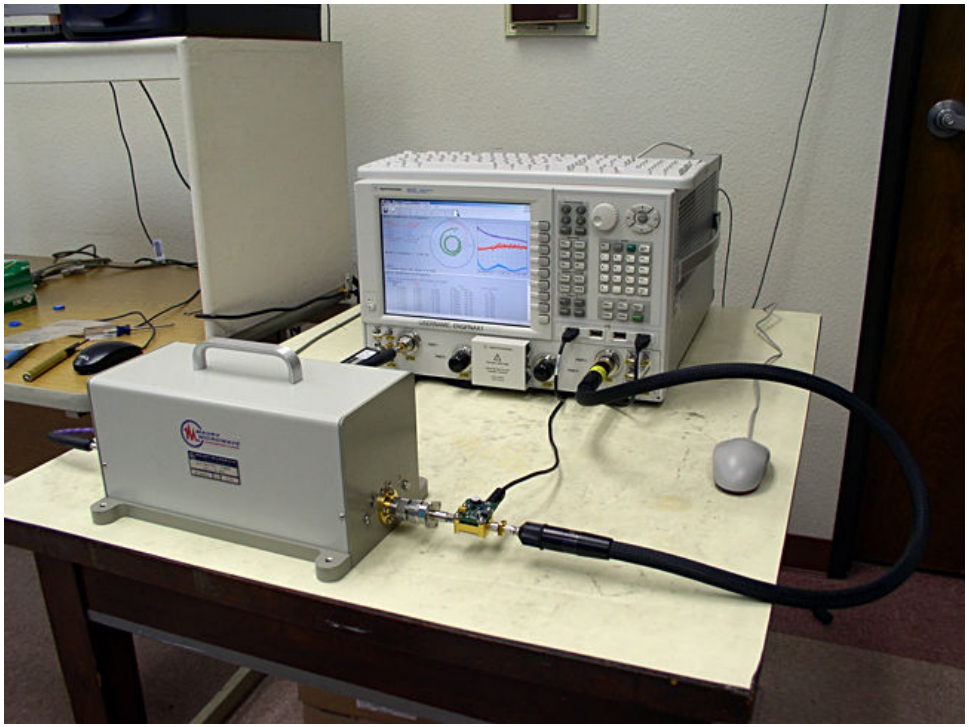
Noise Parameter Measurement

New Method



Noise Parameter Measurement

New Method



Noise Parameter Steps
New Method

1. System Cal
   - 2-Port S-Parameter Cal at DUT Plane
   - 1-Port S-Parameter Cal at Noise Source Plane
   - Tuner Cal (~3-4 Minutes, 73 Freqs)
2. Noise Receiver Cal (< 2 Minutes, 73 Freqs)
3. DUT Measurement (< 2 Minutes, 73 Freqs)

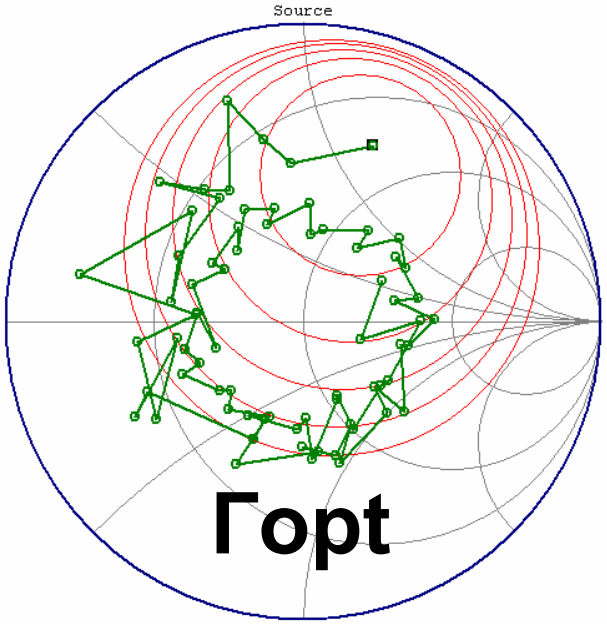
Noise Parameter Results

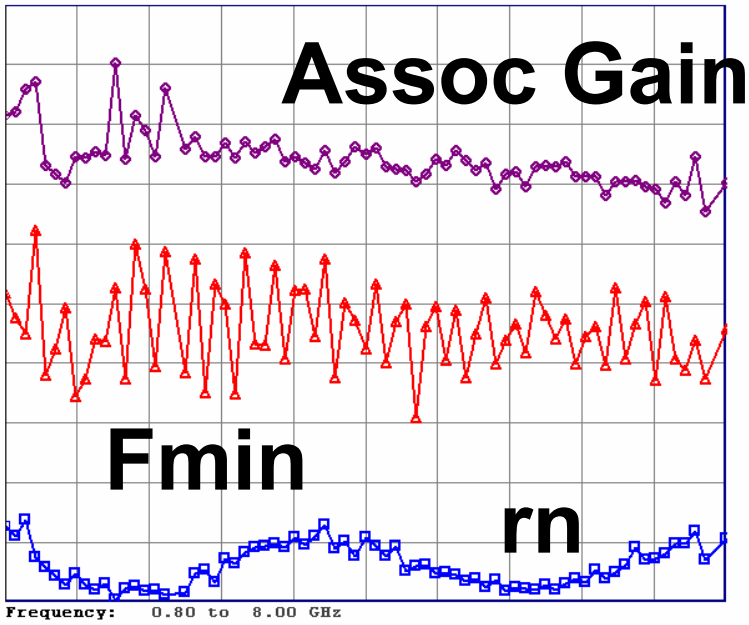
Old Method

Noise Parameters vs Frequency

△ Fmin: 1.04 dB
0.00 to 2.00 dB
□ rn: 0.32
0.00 to 2.50
◇ Γopt: 0.6336 < 68.25
◇ Assoc_gain: 20.40 dB
0.00 to 25.00 dB

Marker: Frequency = 0.80 GHz





Label:
Coax DUT with traditional method 9-7-2008

73 Frequencies

Noise Parameter Results

Old Method

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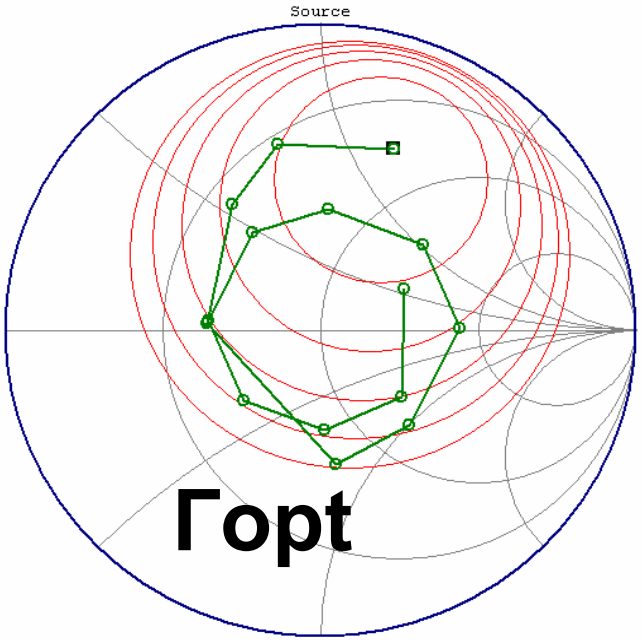
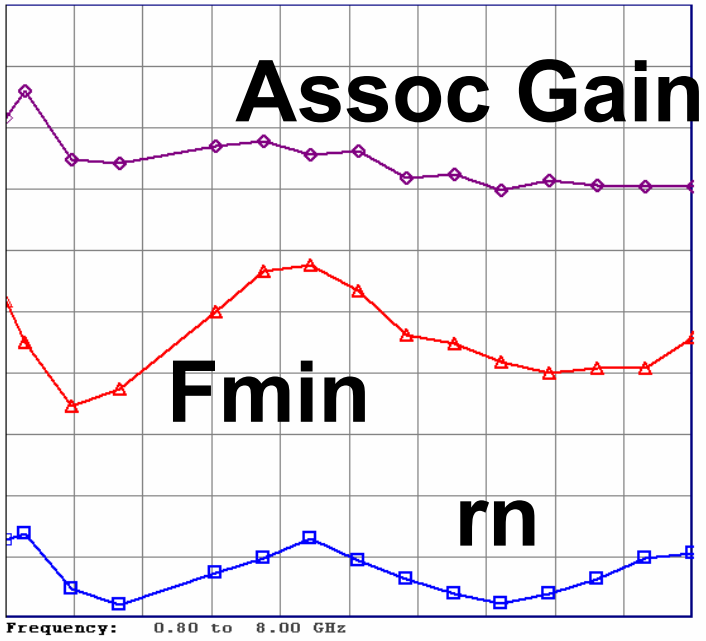


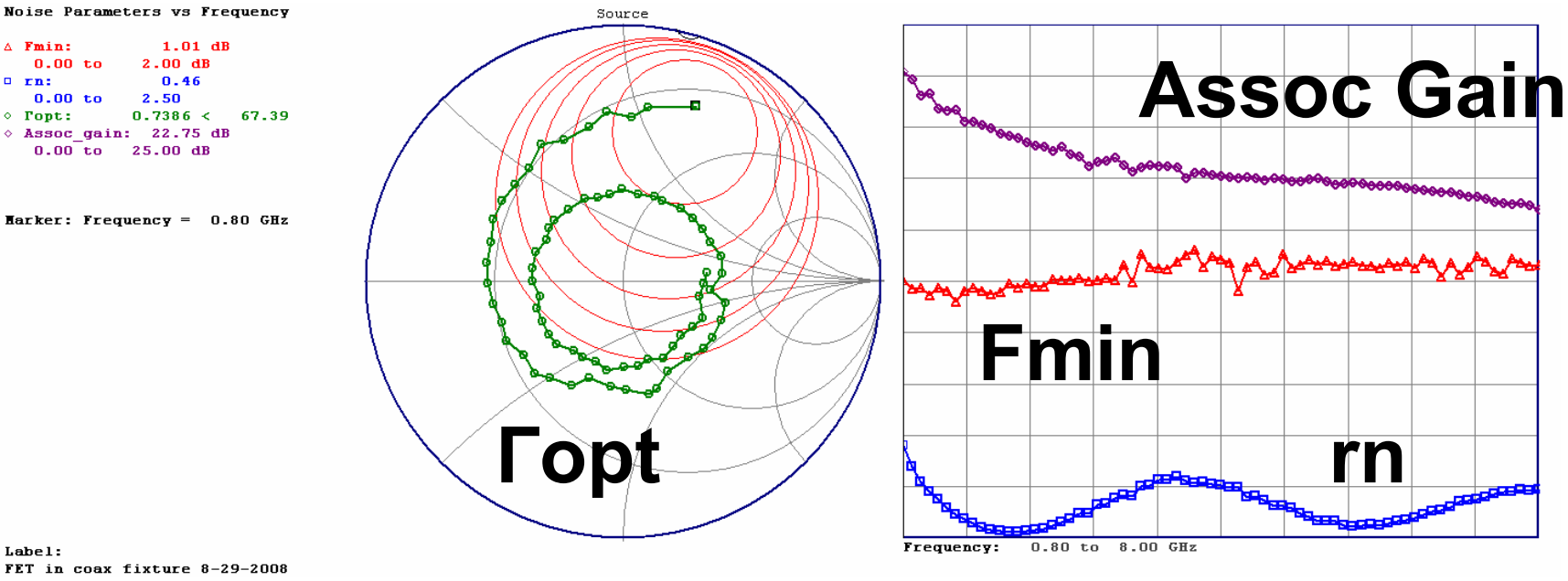


Label:
Coax DUT with traditional method 9-7-2008

Same Data, 0.5 GHz Steps

Noise Parameter Results

New Method



73 Freqs, 224x Faster

Accomplishment

Success for Motivation:

- Two Orders of Magnitude Faster!
- Setup and Measurement Is Much Simpler!

In Addition:

- Results are More Accurate

Why Better Accuracy?
New Method

- Simpler Setup
  - Fewer Cables and Connections
- Always Do Full In-Situ Cal
  - Removes Accumulated Errors of Multiple S-Parameter Cals
  - Removes Connection Errors
- No Drift
- Always Use Dense Frequency Selection

Summary

- **New Ultra-Fast Noise Parameter Measurement**
  - Industry Breakthrough (224x Faster)
- **Simpler Setup and Measurement**
- **Better Accuracy**

Reference

G. Simpson, D. Ballo, J. Dunsmore, A. Ganwani," A New Noise Parameter Measurement Method Results in More than 100x Speed Improvement and Enhanced Measurement Accuracy", 72nd ARFTG Conference, Dec 9-12, 2008.