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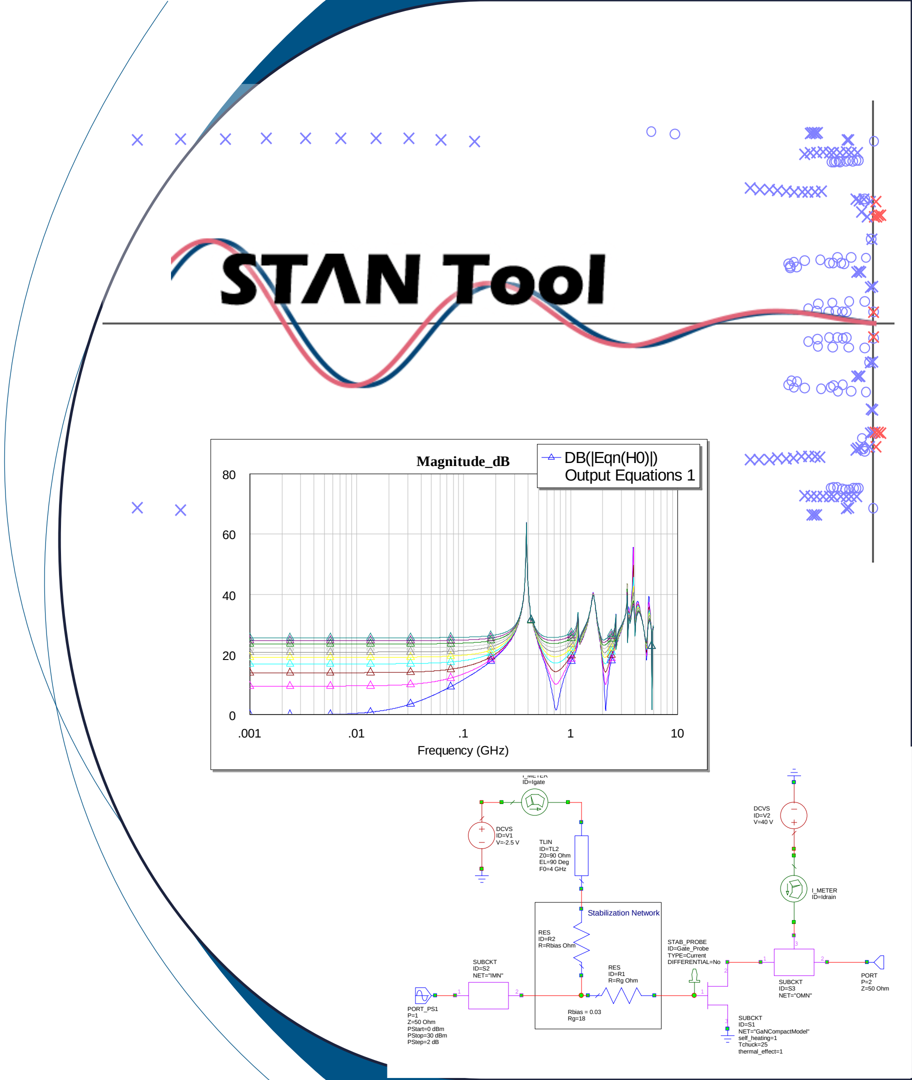
FREQUENTLY ASKED QUESTIONS ABOUT NONLINEAR STABILITY ANALYSIS WHEN USING STAN TOOL WITH MICROWAVE OFFICE

IMS 2024, Washington DC



3DEXPERIENCE

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OUTLINE

Introduction

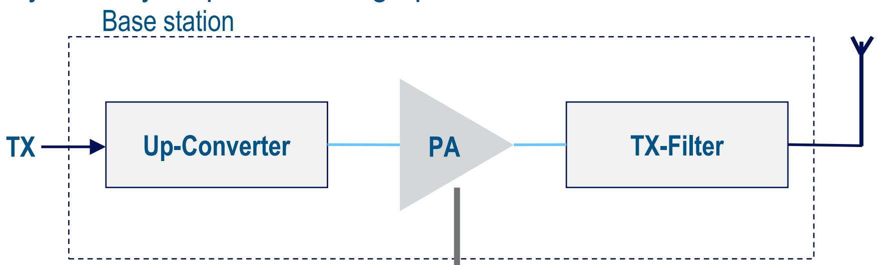
- Context of Stability Analysis in RF & Microwave Circuits
- Existent Methodologies and Limitations
- STAN Tool : Two-step Stability Analysis
  - Extraction of the Frequency Response
  - Pole-Zero Identification

Frequently Asked Questions

- SISO or DACWIN
- Observability, ρ factor
- Phase Tolerance Impact
- Physical or Numerical
- STAN probe place
- Current or Voltage probe
- Frequency sweep

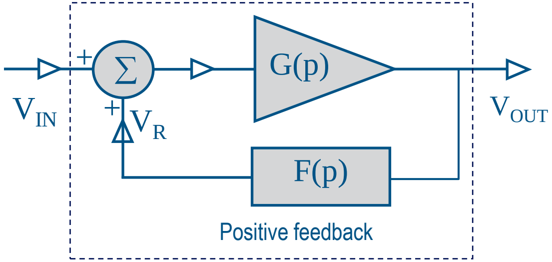
INTRODUCTION : CONTEXT OF STABILITY ANALYSIS IN RF & MICROWAVE CIRCUITS

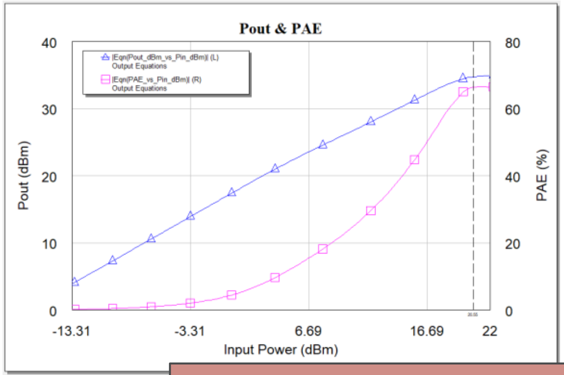
The stability is a key step in the design process of RF & microwave circuit



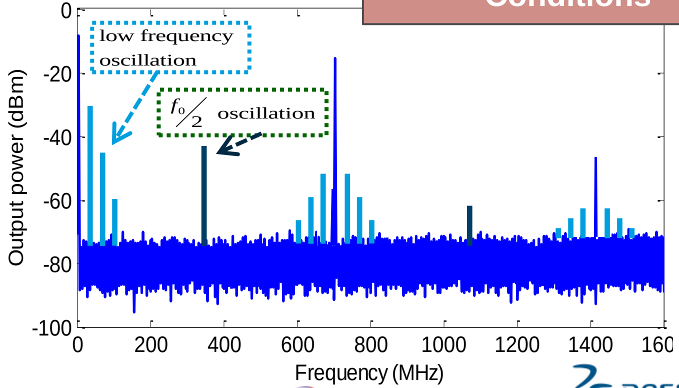
Feedback loops:

- Low-frequency oscillations
- Oscillations @ $f_0/2$
- Hysteresis





Instabilities in Linear and Nonlinear Conditions



[1] A. Suárez and R. Quere, Stability Analysis of Nonlinear Microwave Circuits. Norwood, MA, USA: Artech House, Inc., 2 ed., 2003.

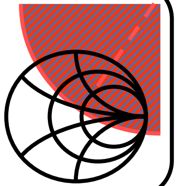
INTRODUCTION : EXISTENT METHODOLOGIES AND LIMITATIONS

- Linear
  - Rollett factor
  - μ factor
  - Normalized Determinant Function (NDF)

K > 1 & IΔI < 1 Unconditionaly Stable

K < 1 Conditionaly Stable

Stability circles



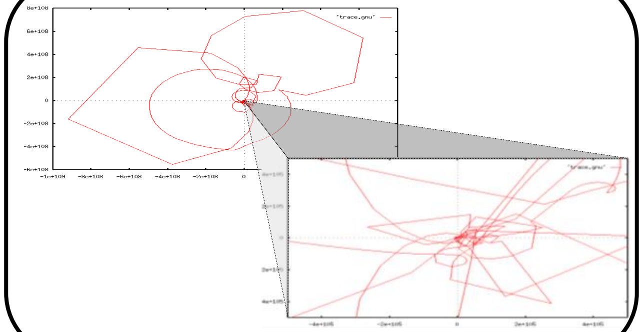
Limitations of small-signal analyses:

Valid for a linear two-port network, intrinsically stable

Not suitable for complex multistage Pas

Need of an open model of active(s) device(s)

- Nonlinear
  - Applying Nyquist criterion to the characteristic determinant of a perturbed system
  - NDF extension to large-signal



Limitations of large-signal methodologies:

Arduous and tiresome implementation

Most CAD Tools do not give access to the characteristic determinant

Need of an open model of active(s) device(s)

Require external tool for data processing

[2] J.M. Rollett, "Stability and Power-Gain Invariants of Linear Two ports", *IRE Transactions on Circuit Theory*, vol. 9, No. 1, pp. 29-32, March 1962

[3] D. Woods, "Reappraisal of the Unconditional Stability Criteria for Active 2-Port Networks in Terms of S Parameters", *IEEE Transactions on Circuits and Systems*, vol. 23, No. 2, pp. 73-81, February 1976

[4] M. Ohtomo, "Stability analysis and numerical simulation of multidevice amplifiers," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 41, no. 6, pp. 983-991, June-July 1993.

[5] V. Rizzoli and A. Lipparini, "General Stability Analysis of Periodic Steady-State Regimes in Nonlinear Microwave Circuits," in IEEE Transactions on Microwave Theory and Techniques, vol. 33, no. 1, pp. 30-37, Jan. 1985

INTRODUCTION : STAN TOOL

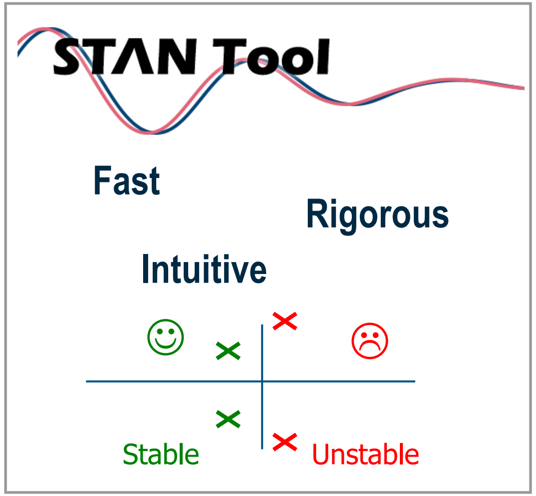
Why STAN Tool?

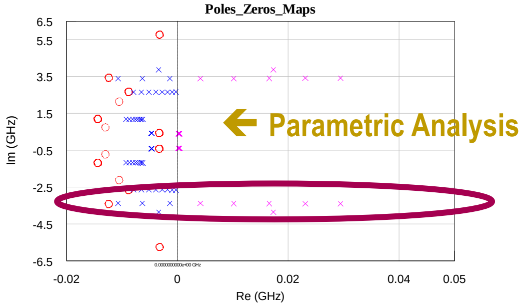
STAN Tool proposes a much more efficient approach to the stability analysis:

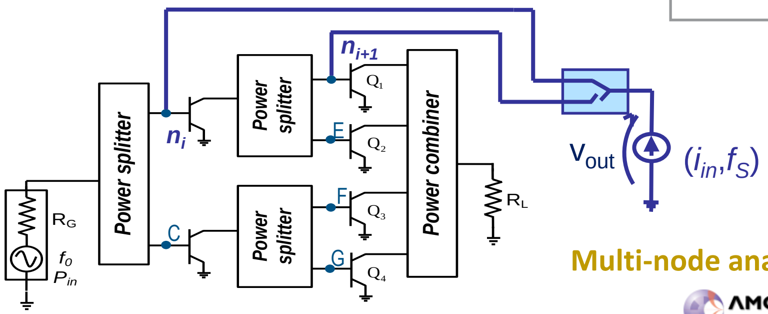
- Stability analysis in both **linear** and **nonlinear** conditions
- Easy to use and compatible with commercial CAD Tools
- Very easy to analyze results

- **Parametric** analysis
- **Multi-node** analysis
- **Monte Carlo** analysis

Stabilization techniques:
Component value VS circuit performance





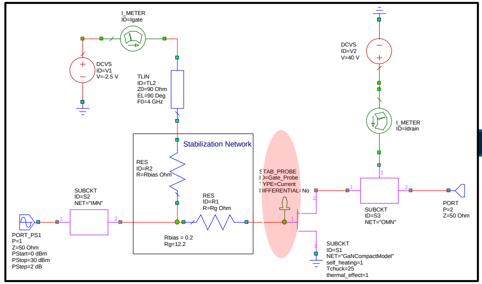


Multi-node analysis

INTRODUCTION : STAN TOOL

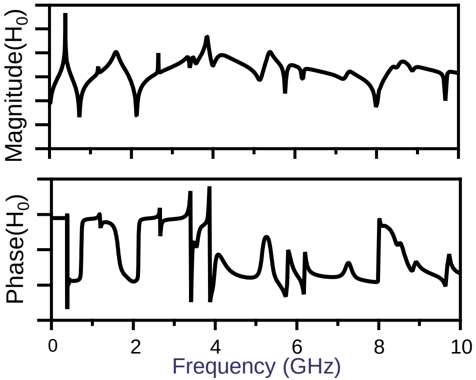
STAN Tool: two-steps stability analysis

1. Extraction of the frequency response: **Commercial CAD Tools**



AC simulation
or
Mixer-like HB
simulation

$$H_0(j\omega_s) = \frac{v_{out}(\omega_s)}{i_{in}(\omega_s)}$$



2. Pole-zero identification: **STAN Tool**

$$H_0(s)$$

$$H_n(s) = \sum_{k=1}^{N} \frac{r_{n,k}}{s - p_k} + D_n$$

$$H_0(s) = \frac{\prod_{i=1}^{N_Z}(s - z_i)}{\prod_{i=1}^{N_\lambda}(s - p_k)}$$

Identification Techniques in the Frequency Domain

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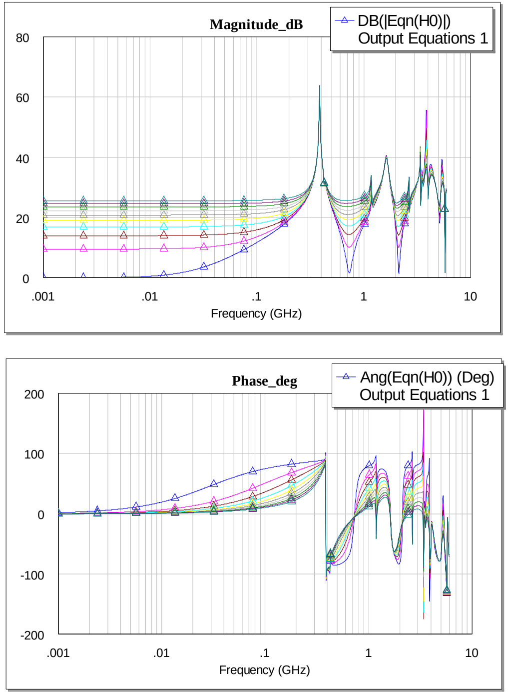
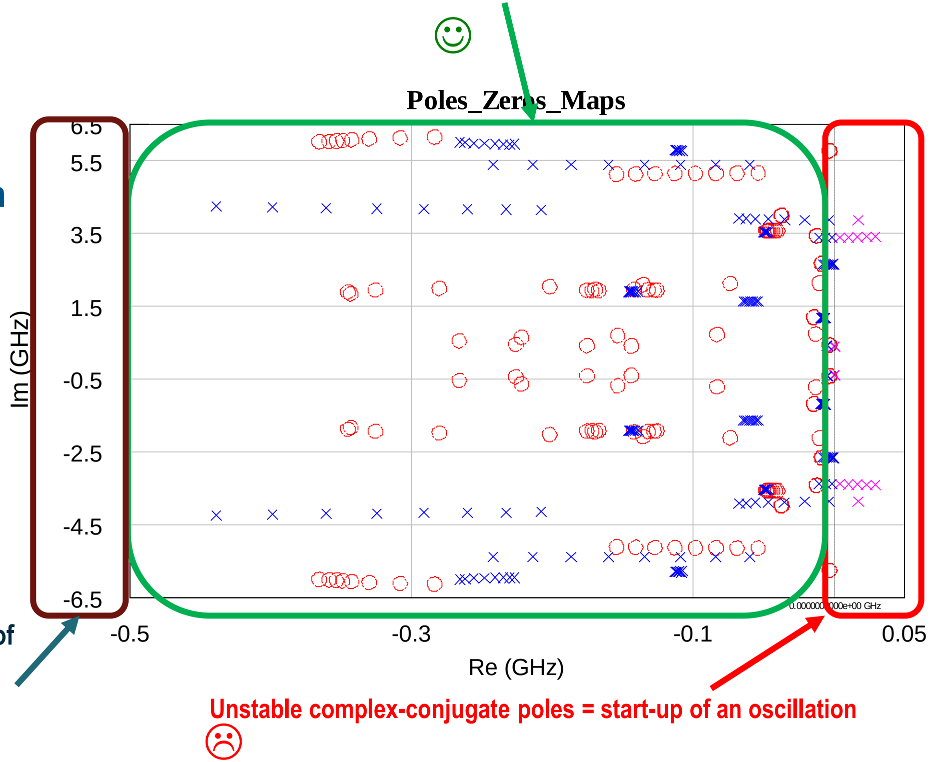
INTRODUCTION : STAN TOOL

$H_0(s)$



Identification Techniques



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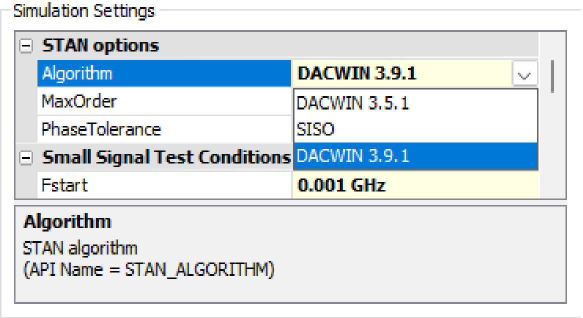
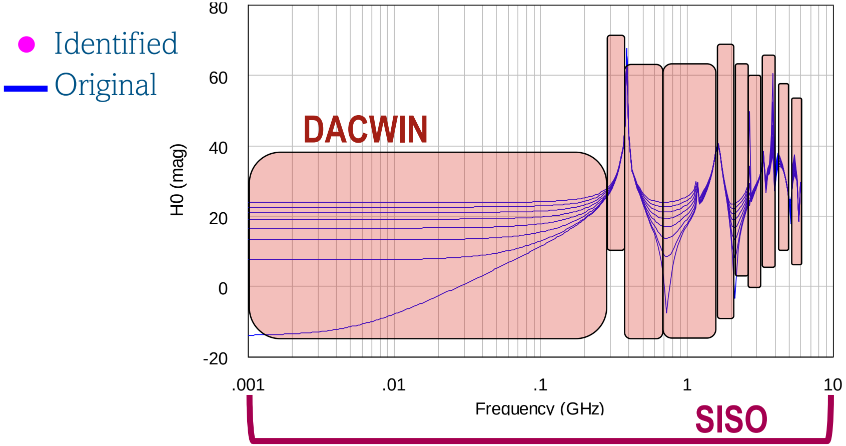
IDENTIFICATION ALGORITHM : SISO AND DACWIN

SISO *(Single Input Single Output)* or DACWIN *(Divide And Conquer With Noise)* ?





DACWIN works with frequencie's subbands and is faster for complex frequency responses

SISO is powerful and solve complex problem without subband division, but take more time

Each algorithm increase the identification order until fit the frequency response

Each algorithm identify the number of slope change, for subband division or identification initial order

SISO by default for entire frequency band and rho factor analysis

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