Detecting Low-Frequency Critical Resonances in Power Amplifiers Using the Periodicity of Floquet Exponents

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STATUS QUO

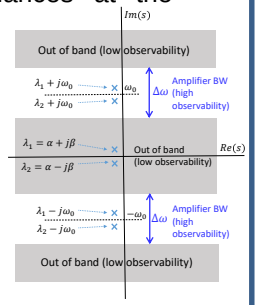
Detection of LF critical resonances in power amplifiers in large signal operation

- × Critical resonances negatively impact amplifier performance and are potentially risky (can lead to oscillation)
- ➢ Mainly two techniques to measure the critical poles responsible for these resonances:
  - ➢ Reflection measurements in VNA
  - ➢ Noise measurements in SA, with broadband noise injection
- × These techniques might be of little application for LF resonances if LF dynamics is efficiently decoupled from RF ports

NEW INSIGHTS

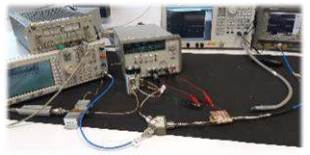
Using Floquet exponents

- ✓ We use periodicity of Floquet exponents to measure LF critical resonances at the amplifier RF bandwidth
- ➢ Linearization of steady state of amplifier with large signal at f_0 → PLTV system with dynamics ruled by Floquet exponents λ_j
  - ➢ Repeated in imaginary axis with f_0
  - ➢ Agree with system poles

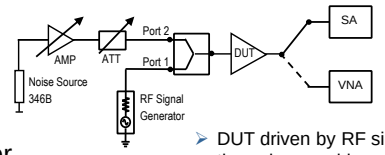


- ✓ Even if LF dynamics is completely decoupled from RF ports we have opportunity to observe its effect analyzing poles repeated around f_0

DESCRIPTION



Measurement setup

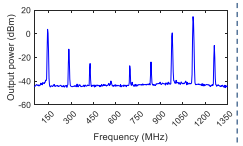


- ➢ We use a combined setup for reflection/noise measurements
- ➢ DUT driven by RF signal through a combiner
- ➢ Output to VNA or SA

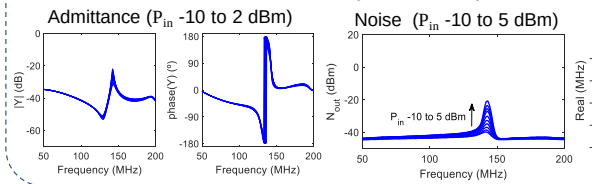
- ➢ Output admittance with VNA:
  - ➢ Noise switched off (50 Ω)
  - ➢ Measure Γ_{out} → obtain: $Y(f) = (1 - \Gamma_{out})/100$
- ➢ Noise at DUT output with SA:
  - ➢ Broadband noise injected (flat noise source + variable gain)
  - ➢ Scalar measurement

Reference DUT: PA with parametric LF oscillation

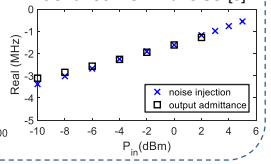
- ➢ GaAs FET medium power amplifier
- ➢ Biased in AB class, RF at f_0=1.12 GHz → Parametric oscillation at 140 MHz for P_{in} 8 dBm
- ✓ Good LF observability → Good verification DUT



Measurements at LF (50-200 MHz)

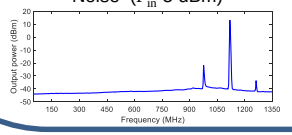


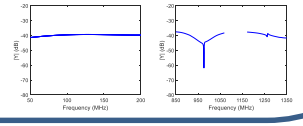
Real part of critical poles identified from Y/noise [3]



DUT with LF decoupled: PA + filter

- ➢ High-pass filter added
- × No LF observability
- ✓ Resonances detected around f_0

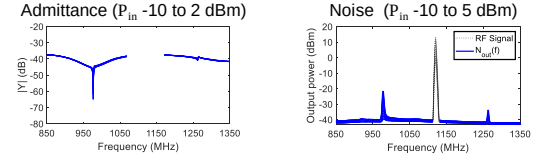




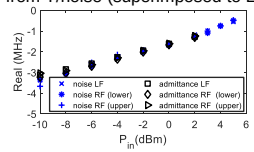
QUANTITATIVE IMPACT

DUT with LF decoupled: PA + filter

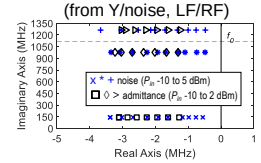
Measurements around RF (850-1350 MHz)



Real part of critical poles identified from Y/noise (superimposed to LF)



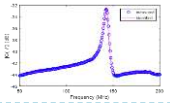
Evolution of poles (from Y/noise, LF/RF)



- ✓ Very good agreement with LF measurements

- ✓ Poles identified from noise (scalar measurements, no phase)

example: identification of LF noise (P_{in}=-2 dBm)



[3] N. Otegi, J. M. Collantes, I. Lizarraga, "Characterization Technique to Reveal Critical Resonances in Nonlinear RF Circuits," IEEE Trans. Instrum. Meas., vol. 71, pp. 1-11, 2022, Art no. 8003211, doi: 10.1109/TIM.2022.3170883

PROPOSED CONCEPT GOALS

- ➢ LF critical resonances can be characterized using periodicity of Floquet exponents with frequency even if not observable at LF
- ➢ The low-damping poles responsible for the resonances can also be obtained
- ➢ Noise injection and reflection measurement techniques can be used
- ➢ SA allows for easier high power handling, without receiver overload