Introduction

We report the experimental and numerical study on the nonlinear dynamics of an electronic time-delayed feedback circuit [1]. It operates at ultra-high frequency and can generate high-dimensional chaotic oscillations with ultra-wide bandwidth. We introduce an improved model of the transistor based nonlinearity and use the synchronization based data assimilation technique [2] to optimize the parameters. The optimized model agrees quantitatively with the experimental observations.

Experiment

The circuit is comprised of a transistor-based nonlinearity, commercial amplifiers and a transmission-line connected in a time-delayed feedback loop.

Numerical Model

Piecewise Linear Model

Schematics

Experimental Setup

Transistor Nonlinearity

BJT Model

Nonlinear & voltage dependent frequency response of the transistor:

$$I_C = BS \cdot \exp(V_{BE} \cdot VTF)$$

$$C_{BE} = C_{BE} \cdot A \cdot \exp(V_{BE} \cdot VTF)$$

Transistor Nonlinearity

Synchronization Based Parameter Optimization [2]

- Sync numerical model to experiment
- Optimize parameters to minimize sync error
- Multivariable optimization

BJT Model & Experiment

Conclusion

We built a detailed BJT model for the UHF chaotic oscillator and optimized the parameters using synchronization based multivariable optimization. The numerical model agrees with experiment quantitatively.