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An introduction to scikit-rf, an Open Source Python Package for Microwave Network Creation, Analysis and Calibration

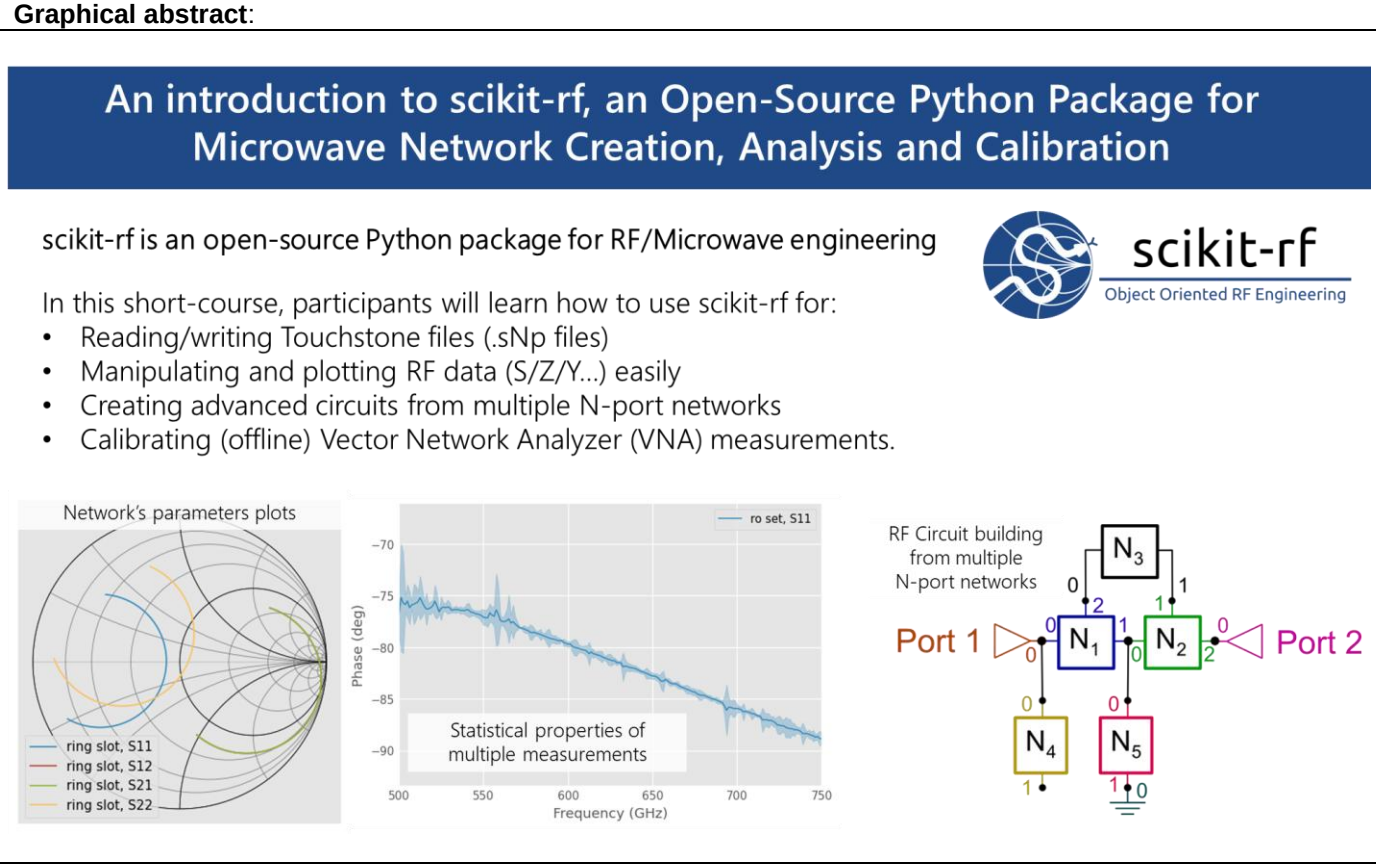
Abstract:

The rapid proliferation of telecommunication and radio-frequency (RF) applications had led to a demand for efficient and convenient tools to design and characterize these devices. scikit-rf is a free and open-source Python package designed to make RF/Microwave engineering both robust and approachable. The package provides a modern library for RF network analysis, circuit building, calibration, and simulation.

Besides offering standard microwave network operations, such as reading/writing Touchstone files (.sNp files), connecting or de-embedding N-port networks, frequency/port slicing, concatenation or interpolations, it is also capable of advanced operations such as Vector Network Analyzer (VNA) offline calibrations, time-gating, vector fitting, interpolating between an individual set of networks, deriving network statistical properties and support of Virtual Instruments for direct communication to VNAs. The package also allows straightforward plotting of rectangular plots (dB, magnitude, phase, group delay, etc.), Smith Charts or automated uncertainty bounds.

During this short course, some of the capabilities of scikit-rf will be live-demonstrated, such as N-port networks manipulations and plotting, advanced RF circuit simulations and offline calibrations.

Graphical abstract:



Recommended prerequisites for attendees (if any):

- The course requires basic knowledge of the Python language and RF network theory (S-parameters)

Learning objectives:

After the course, the participant will be able to use the open-source Python package scikit-rf to:

- Read/write Touchstone files (.sNp files)
- Represent RF data in various ways: S/Z/Y parameters, magnitude/dB/angle, Smith charts, statistical properties…
- Manipulate easily N-port Networks and their associated data: connecting, de-embedding, frequency/port slicing, concatenation, interpolations…
- Work with a set of similar N-port networks to extract statistics or produce interpolations
- Perform Vector Network Analyzer (VNA) offline calibrations and time-gating
- Create advanced RF circuits such as passive circuits and filters from the combination of various N-port networks (lumped elements or N-port measurements)

Course outline:

The programme of the course is the following:

- Installation of the scikit-rf package
- Introduction to the scikit-rf package.
- The Network representation of N-port RF networks
  - Reading/writing data from measurements (.sNp files)
  - Plotting Network's parameters (S, Z, Y…)
  - Manipulation of Networks (connecting, port/frequency slicing, interpolations, etc.)
- Working with a set of networks. Dealing with errors.
- Offline calibrations techniques and time-gating
- Building and simulating RF Circuits

If participants want to follow the live demonstration on their laptop, internet connexion and a working Python distribution (such as the Anaconda Python distribution, https://www.anaconda.com) are required.

Julien Hillairet received a Ph.D in Electromagnetics from the University of Toulouse in 2007. He is an expert in the design and manufacturing of high-power RF Heating Systems for fusion experiments at CEA, France. He is also a specialist in RF antenna/plasma coupling modelling and co-developer of scikit-rf and other open-source codes. He was involved in the design and the tests of High-Power RF systems for other fusion laboratories in Europe, China, the US, India and Korea. He is teaching RF and microwave techniques for fusion applications at a master level in France and different summer schools in Europe and Asia.

Alex Arsenovic received a B.S and Ph.D in Electrical Engineering from the University of Virginia in 2007 and 2012, respectively. Alex has worked as an independent consultant in Central Virginia for several years, with clients such as Virginia Diodes Inc, Nuvotronics, and Plotly. He continues to work closely with the University of Virginia, and has authored and co-authored over 15 technical papers in the field of microwave metrology and geometric algebra. In 2016, he created Eight Ten Labs LLC to continue providing services for microwave metrology, software development, and applied mathematics. His chief interest is in modernizing the theoretical and computation tools used by electrical engineers and scientists.

Key bibliography:

- The scikit-rf project: http://scikit-rf.org/
- Arsenovic, J. Hillairet, J. Anderson et al., *scikit-rf: An Open Source Python Package for Microwave Network Creation, Analysis and Calibration*, IEEE Microwave Magazine, January 2022 (accepted).