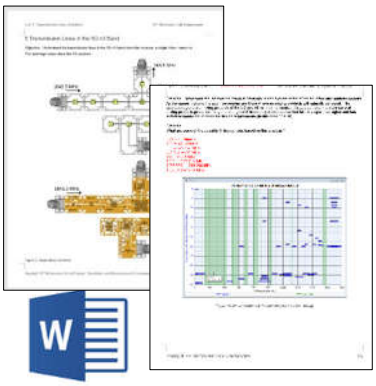
RF Microwave Teaching Solution

RF circuit design, with elements of 5G New Radio n3





Keysight's RF Microwave Teaching Solution focuses on end-to-end RF circuit design flow, and integrates industry-oriented and real-world examples to prepare students for emerging technology trends. The lab courseware comes with a modular prototype kit utilizing a 1.8 GHz receiver module – a 5G New Radio n3 band – as well as lab sheets and assignments that focus on the complete physical design spectrum, from specifications and simulation to prototype building and validation.

The RF Microwave Lab Courseware forms a core component of the Keysight RF Microwave Teaching Solution. In addition to the lab courseware, this comprehensive solution includes Keysight PathWave Advanced Design System (ADS) and SystemVue software, as well as hardware instruments such as network analyzer, RF signal generator and RF spectrum analyzer.

KEYSIGHT

Speed Ahead of the Curve with Comprehensive Teaching Solution

RF Microwave Lab Courseware	Recommended Keysight Instruments	Required Design and Automation Software
U3851A RF Microwave Circuit Design, Simulation and Measurement Courseware, 5G NR n3 	• Signal Generator • Spectrum Analyzer • Network Analyzer • Noise Source • Power Supply • Oscilloscope • Calibration kit Optional: • Signal Generator: N5171B BSA Signal Generator - option 001	• PathWave ADS • PathWave Genesys • PathWave EMPro • PathWave SystemVue • FieldFox Data Link software Optional Software: • PathWave BenchVue

RF and microwave engineering covers the physical layer of wireless communication, and is incorporated into almost everything that transmits or receives a radio wave, such as mobile phones, radios and WLAN. Emerging trends such as 5G and microwave sensing imaging drive rapid innovations in the technology landscape and imposes new requirements on RF components, resulting in design challenges such as increased integration and exponential demands on performance. The increasing complexity brought about by these trends means many companies will need additional expertise to execute the technology in the design of their devices.

To prepare industry-ready students, Keysight's RF Microwave Teaching Solution focuses on the complete RF circuit design flow, from design specifications and simulation to prototype building and validation, operating on the 5G New Radio Band n3 downlink frequency. This gives students a solid foundation in RF microwave fundamentals and paves the way for them to specialize in more advanced wireless applications in areas such as 5G and IoT.

Designed to work hand-in-hand with industry-standard test and measurement instruments and electronic design automation (EDA) software, the RF Microwave Teaching Solution provides students the engineering essentials, practical skills and real-world application knowledge that will make them highly sought after by the industry.

Target university subject	Target year of study	Prerequisite(s)
RF and microwave design	Module 1: 3rd year and final year undergrad	Basic circuits, signals and systems, analog electronics and electromagnetics

By incorporating the RF Microwave Teaching Solution into their curriculum, educators can:

Deepen their students' knowledge base with content that covers the RF circuit design life cycle

- Students not only learn RF and microwave design concepts, the teaching solution is also tailored so they learn how to design and simulate key RF components with EDA software, build prototypes, and measure, characterize and validate RF components and systems with industry-standard test and measurement instruments

Accelerate their students' learning by using the same instruments and design software utilized in the industry, and providing activities that strengthen RF and microwave concept learning.

- Keysight PathWave ADS and SystemVue software are considered the industry-standard for RF and microwave design by many companies. The RF Microwave Teaching Solution introduces design and simulation methods (such as harmonic balance techniques and impedance matching) using these software, allowing students to learn and practice the same practical design skills as they need when they are working in the industry.
- Using the RF Microwave Lab Courseware's modular prototype kit exposes students to real-world RF testing and teaches them about different test parameters and the recommended test setup for each component in an RF communication system. In the process, they learn to handle and configure RF instruments, connectors and other accessories, and how to set up those instruments based on the test objective. The reconfigurable modular hardware kit also allows for rapid prototyping, so students can easily experience real-world measurement effects.
- In the lab sessions, students not only compare the performance of different component specifications and how they affect the overall design result, they also get to correlate the measured performance of the prototype kit with the results simulated by the software.

Increase the employability of their students.

- Keysight is a world-leading technology company that delivers breakthrough solutions and trusted insight in electronic design, test, manufacturing and optimization. By partnering with Keysight, educators can be assured that their courses contain up-to-date and industry-relevant content, giving students the engineering knowledge and skills most sought after by the industry.

Save time and resources, allowing them to focus on other aspects of teaching.

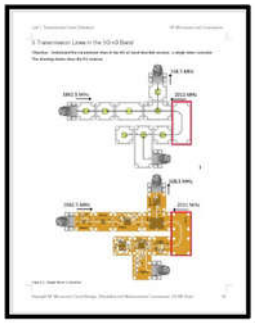
- It can take a university lecturer up to six months to develop content for a new course – content that may not be industry-oriented – and additional effort to design a training kit for practical lab sessions. Keysight's RF Microwave Lab Courseware comes with a dedicated modular prototype kit, and offers lab sheets and assignments that focus on the complete industry design flow and covers real-world applications such as designing receiver system at the 5G New Radio band.

Easily integrate the lab courseware into their current curriculum.

- No matter how a university's current RF and microwave engineering track is set up, the Keysight RF Microwave Teaching Solution allows educators to obtain just what they need. The complete teaching solution – which comes with the lab courseware, hardware instruments and Keysight design and automation software – is ideal for learning institutes that wish to set up a new RF course and lab space. For universities that wish to upgrade their existing RF and microwave courses, the Keysight RF Microwave Lab Courseware can be combined with their current courses to provide hands-on learning experience with real-world application content.

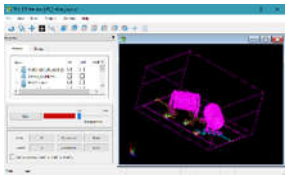
Learning Outcomes: Industrial Experience

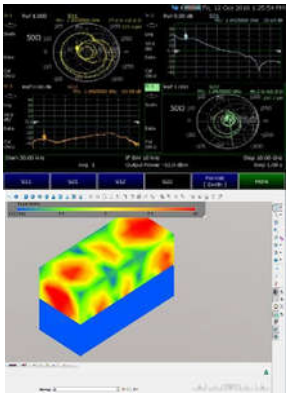
Design Specifications | **Design and Simulation** | **Prototype Building** | **Design Verification**



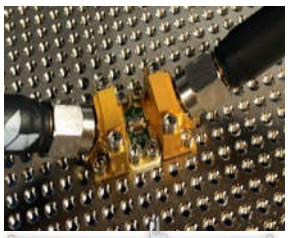


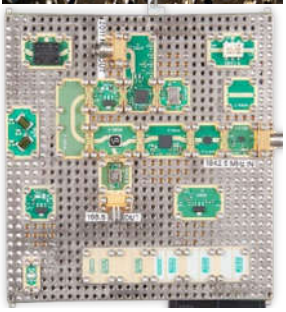
Learn and understand the fundamentals of the transmission specification, which is crucial for component design





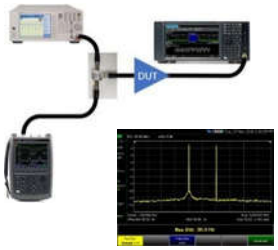
Design and simulate using industrial design and automation software such as PathWave ADS, PathWave Genesys, PathWave EMPro, PathWave SystemVue and FieldFox Data Link software





Experience the prototype building of RF receiver system at the 5G New Radio band





Evaluate system design and validate the 5G receiver design module with Keysight instruments

U3851A RF Microwave Circuit Design, Simulation and Measurement Courseware, 5G NR n3

Microwave concepts and components

- RF fundamentals and concepts
- Passive and active devices design principles
- Filters, amplifiers, mixers, oscillators, and more
- Measurements and RF parameters
- Software based design and simulation in ADS

Courseware contents

- Training kit
  - RF education hardware kit
  - Kit controller
  - RF adapters and splitter
  - Cables (RF, power, LAN, BNC)
  - Power adapter (Not all countries, please refer to training kit section for more detail)
  - Carry case

- Editable lab sheets and model answers
  - Problem-based assignments
  - Covers 50 hours of lab sessions

Training kit



Figure 1.
RF Microwave Lab Kit

Training Kit includes:

- Prototype plate with accessories
- Controller using Raspberry Pi 3 model B and Schroff casing
- Power adaptor 13 W and power cable for Raspberry Pi 3*
- Hard carrying case to keep the U3851A training kit and accessories.

* Important Note: Shipments to Mexico, Argentina, Russia, Taiwan, and Singapore do not include the 13W Raspberry Pi 3 power supply due to regional regulatory concerns. A 5.1V 2.5A power supply with USB micro-B must be purchased separately. Visit https://www.raspberrypi.org/documentation/faqs/ for more information.

Customers are recommended to purchase the adaptor from one of the suppliers below:

- RS Stock No. 103-4302 https://my.rs-online.com/web/p/ac-dc-adapters/1034302/
- Digi key Part number: 1690-1022-ND https://www.digikey.com/product-detail/en/raspberry-pi/T5989DV/1690-1022-ND/6674285

Lab sheets

Lab Sheets	Topics	Description
1	Transmission Lines	Design, simulate and measure microstrip and coplanar waveguide transmission lines
2	Filter	Design RF and IF filters for a 5G Band 3 downlink; measure the performance and compare to the data sheet or design.
3	Low Noise Amplifiers	Simulate and evaluate two LNAs, and select one for the front end
4	Driver and Power Amplifiers	5G PA (or wideband DA/PA) MMIC with external tuning circuit.
5	Oscillator and Synthesizers	Synthesizer design trade offs
6	Mixers	Single diode, single balanced, double balanced, and triple balanced mixers
7	5G Receiver Design, Simulation and Measurement	Simplified 5G receiver model

Recommended Instruments and Software

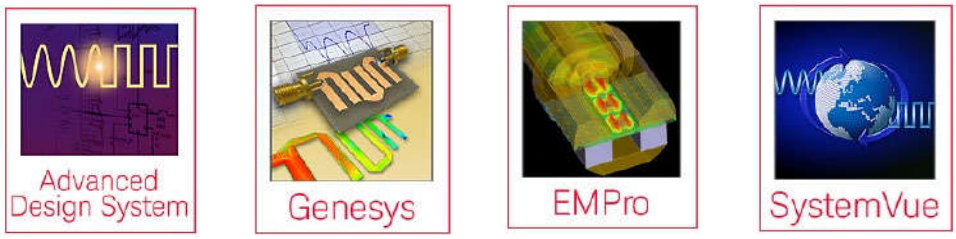


Figure 2. Reference lab solution photo

Required Keysight instruments

- Signal Generator: N5171B EXG Signal Generator – 503, UNM
- Spectrum Analyzer: N9000B CXA Analyzer – 507, N9068C
- Network Analyzer: N9917A FieldFox VNA – 210, 211, 010, 233, 235 option.
- Noise Source: 346B Noise Source - 100
- Power Supply: E36312A – STD option
- Oscilloscope: DSOX1102G – DSOX1B7T102
- 85521A Calibration kit, 4-in-1 open, short, load and through, DC to 26.5 GHz, 3.5mm(f) – STD option.

Required Keysight Design and Automation software with Keysight Instruments



License required and available for download at:

- PathWave ADS www.keysight.com/find/PathWave-ads
- PathWave Genesys http://www.keysight.com/find/PathWave-genesys
- PathWave EMPro http://www.keysight.com/find/PathWave-empro
- PathWave SystemVue http://www.keysight.com/find/PathWave-systemvue

Free download from Keysight web:

- FieldFox Data Link Software http://www.keysight.com/find/fieldfoxdatalink

Training Kit Characteristics



Figure 3. Controller – Raspberry Pi 3

Controller - Raspberry Pi 3	
Dimensions	89.5 mm (w) x 65.5 mm (d) x 32 mm (h)
Computer module	Raspberry Pi 3B Processor: Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.2GHz
RAM and flash storage	1GB LPDDR2 SDRAM, 16 GB microSD card
Connectivity	LAN Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps) 4 × USB 2.0 ports Extended 40-pin GPIO header (40 to 28 pin ribbon cable) 1 × full size HDMI
Supply	Micro USB port < 2.5A
PC Operating system	Windows 7 and 10
Warranty	1 year

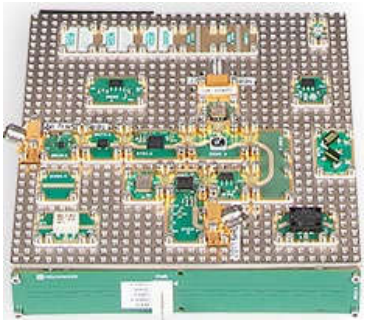


Figure 4. Prototype plate

Prototype plate	
Dimensions	115 mm (w) x 131 mm (d) x 35 mm (h)
Interface	28 pin Raspberry Pi Ribbon Cable
Supply voltage	2 separate 6.0 V Supplies each <1 A (5 pin to Banana Cable)
Warranty	Three months include accessories

Preview Lab Courseware Contents

Visit http://www.keysight.com/find/rfuw for more information about the contents of the Keysight's RF Microwave lab courseware and to view samples of the lab sheets.

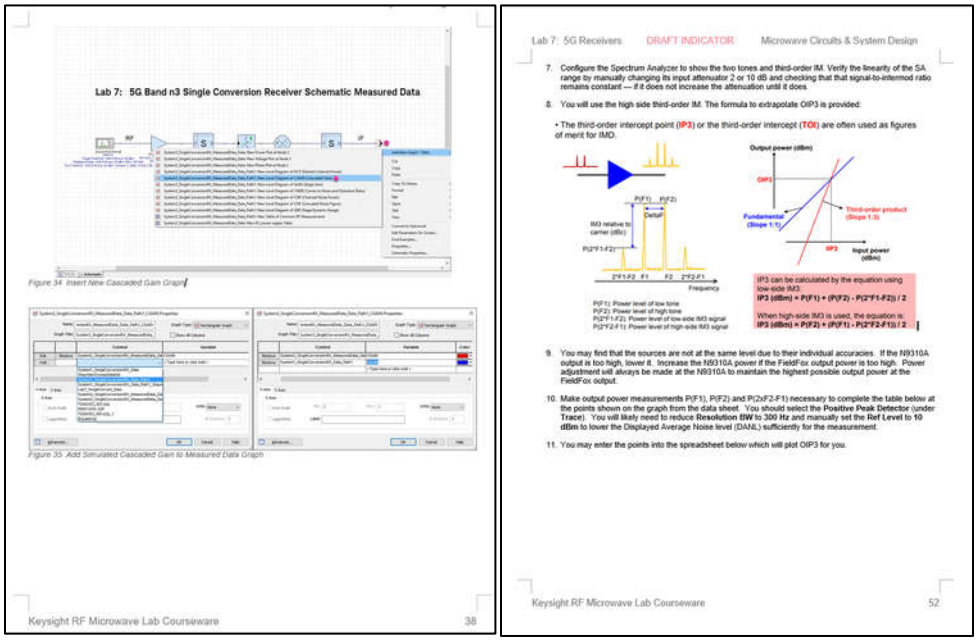


Figure 5. Sample of lab sheet

Ordering Information

Product number	Description
U3851A	RF Microwave Circuit Design, Simulation and Measurement Courseware, 5G NR n3 Including: • Training Kit and accessories • Editable lab sheets and model answers • Problem-based assignments
Recommended instruments	• Signal Generator: N5171B BSA Signal Generator • Spectrum Analyzer: N9000B CXA Analyzer - 507, N9068C • Network Analyzer: N9917A FieldFox VNA - 210,211,010,233, 235 option • Noise Source: 346B Noise Source -100 • Power Supply: E36312A -STD option • Oscilloscope: DSOX1102G - DSOX1B7T102 • 85521A Calibration kit, 4-in-1 open, short, load and through, DC to 26.5 GHz, 3.5 mm(f) - STD option Note: The Network Analyzer, N9915A may be used for the lab courseware for up to 4th harmonic and limited filter response analysis
Software License	Please contact https://www.keysight.com/us/en/contact.html for more information and to acquire the licenses below: • PathWave ADS www.keysight.com/find/PathWave-ads • Genesys http://www.keysight.com/find/PathWave-genesys • EMPro http://www.keysight.com/find/PathWave-empro • SystemVue http://www.keysight.com/find/PathWave-systemvue

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.

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