Keysight Technologies

RF and Microwave Industry-Ready Student Certification Program

Introduction

The trend is clear, technology innovations will increase at even faster rates in the future. For industry, these innovations will continue to drive time-to- market pressures and the need for productivity gains. Universities can assist by producing engineers ready to step in and be productive from day one. Universities must produce industry-ready engineers who are knowledgeable of the tools and processes used in the industry today. This allows industry to hire with confidence knowing that the productivity of the new employee is assured from day one. This program provides a collaboration between industry and universities to produce and recognize industry-ready engineers.

Students completing qualification as Keysight Technologies RF and Microwave Industry-Ready Students have demonstrated immediate value to prospective employers and confirm each university's interest in preparing students for future industry contribution.

A key component of this certification program is the use of Keysight's RF and Microwave workflow environment, a comprehensive way to simulate, measure and analyze communications components and systems. The foundations are PathWave Design Software's industry proven design tools and high-performance RF and Microwave measurement instruments. Bringing real-world measurement and test earlier into the design process enables design flaws to be captured early and corrected in a time- and cost-efficient manner, reducing overall development cost and improving design-to-manufacturing cycle time.



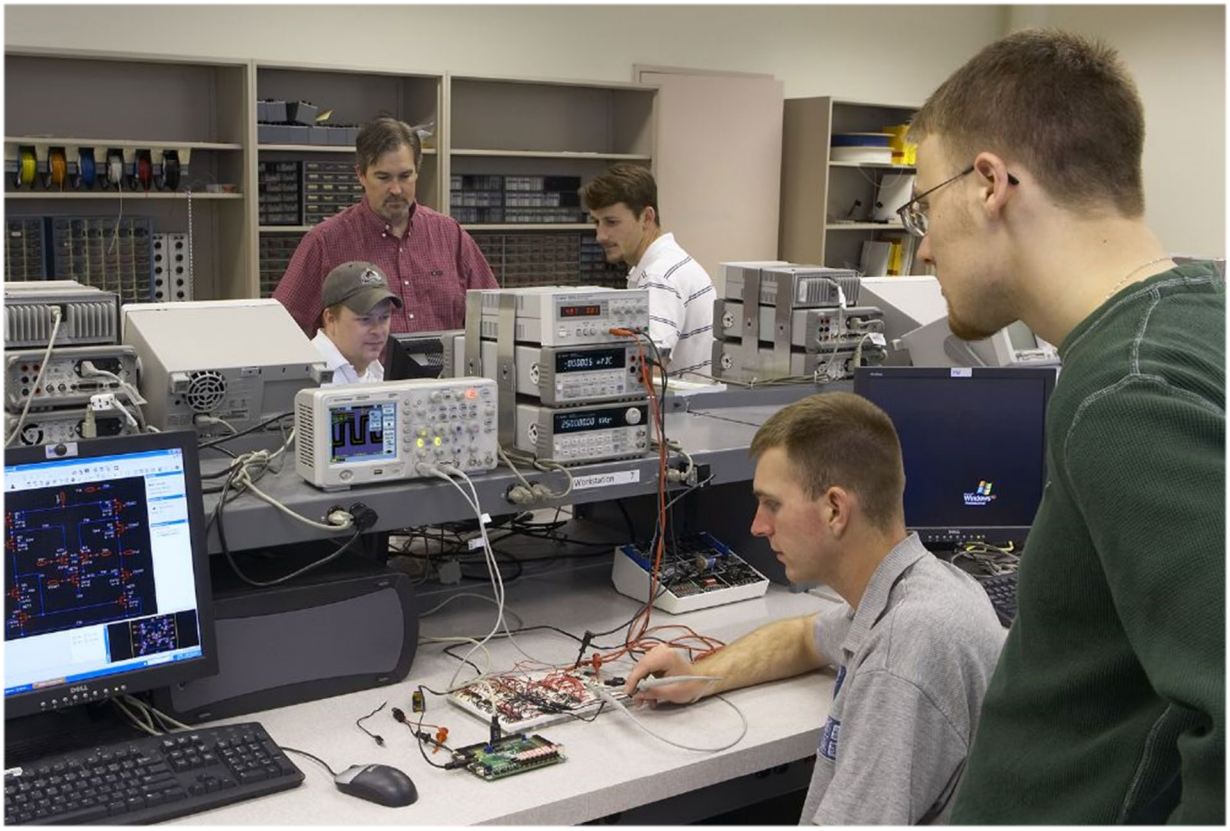
The Keysight RF and Microwave Industry-Ready Student Certification Program confirms the student's technical knowledge, design expertise, and hands-on measurement proficiency in the use of Keysight's design software and instruments.

KEYSIGHT TECHNOLOGIES

Level of Experience

Certification insures that the student has completed an RFIC, RF Board, Microwave, or System design class. For PathWave Design Software expertise, students will have basic knowledge of DC simulation, curves, bias, sweeps, models, parameters, libraries, AC simulation, gain, time-domain, noise, use of DesignGuides, Smith charts, S-parameters and matching networks, harmonic balance simulation, plotting data, and writing equations. For measurement expertise, students will have completed basic measurement tasks using Keysight Network Analyzers, Signal Sources, or Signal Analyzers. These tasks will include, but are not limited to: transmission line fundamentals, measurements of cables, group delay filters, attenuators, amplifiers, mixers, and antennas. Included in the measurement experience are error correction techniques and calibration methodology. In addition, as part of the Signal Sources and Analyzers training, the student will have completed labs demonstrating their understanding of swept tuned analysis, power measurement, AM, FM, PM, pulsed, I and Q and other digital modulation basics.

(A full list of criteria is included at the end of this document.)



Keysight Requirements for Universities

- The university must use one or more Keysight's Pathwave Design Software tools in their curriculum (PathWave Advanced Design System (ADS), PathWave RF Synthesis (Genesys), PathWave System Design (SystemVue), PathWave EM Design (EMPro), The PathWave Design Software should be an essential component of the curriculum.
- The university must use Keysight instrumentation for the measurement of their RF and Microwave devices (RF vector network analyzer, sources, receivers, oscilloscopes, etc.). These instruments should be an essential component of the lab exercises.
- The ideal curriculum and lab will involve design, building, measurement, and analysis of RF and Microwave components to help students gain real-world understanding of RF and Microwave design and measurement techniques.



PATHWAVE

Qualification Process for Universities and Students

- University completes and submits Keysight RF and Microwave Industry-Ready Student Certification Program submission form. Additional classroom curriculum and lab material may be required for review by Keysight.
- Keysight certifies that the university course and lab topics meets the program requirements
- Keysight notifies university of acceptance
- Students are notified of certification program by the course professor
- At the end of the course/labs, the Top 15% - 20% of students are eligible for certification
- Class professor provides Keysight with names of students qualifying for certification based on class grade and quality of lab work. A test is required for level 1 proficiency.

Student Recognition

- Keysight provides verification of certification with certificate
- Keysight inserts student name into list on Keysight's website: www.keysight.com/find/eesof-university
- Keysight's PathWave Design Software team will promote industry recognition of this program.
- Certified students will be invited to join the Keysight's PathWave Design Software LinkedIn group.
- Industry recruitment teams will be notified of this group and have access to members.

Levels of Certification

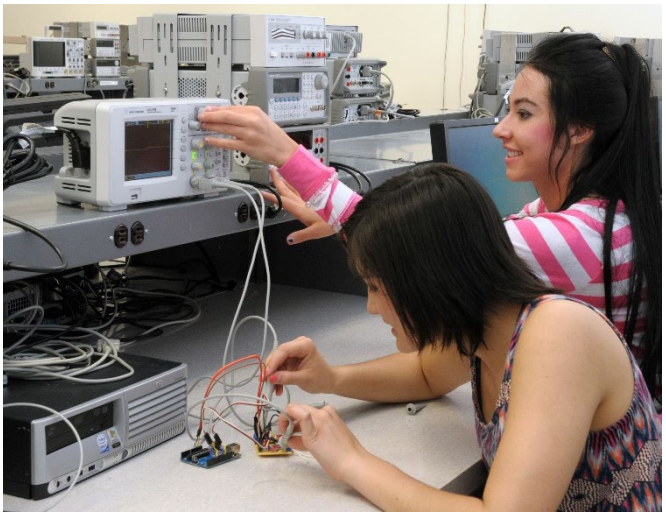
There will be two levels of certification. Both levels require satisfactory course completion of a Keysight certified course and/or lab that demonstrate a minimum coverage of software design and instrument measurement topics. One or more classes or labs may be required to satisfactorily complete the required topics. The first level will also require completion of a hands-on test to demonstrate PathWave Design Software design tool and Keysight instrument measurement capabilities. This test should take no more than 30 minutes and can be administered by a graduate teaching assistant or professor.

Level 1	Example
Basic PathWave Design Software tool knowledge and basic measurement expertise.	PathWave Advanced Design System (ADS) circuit filter design and Network Analyzer S-parameter measurements of filter.
Level 2	**Example**
Additional design analysis with PathWave Design Software (possibly other design tool expertise such as PathWave EM Design (EMPro) or PathWave System Design (SystemVue) along with more involved measurement expertise. No test is required for level 2.	Use of Momentum or PathWave EM Design (EMPro) simulation in PathWave Advanced Design System (ADS) with modulated signal creation and measurements with Signal Sources and Analyzers.

Typical Course Description

RF and Microwave Measurements

This laboratory is designed to introduce the electrical engineering students to the design, building and testing of active electronic networks. Computer Aided Design tools and computer data acquisition strategies are examined in greater detail.



Course Topics

- diode analysis and characterization
- common emitter amplifiers
- common base and common collector amplifiers
- multi-stage BJT amplifiers
- propose/design/build/evaluate
- analyze/design/simulate/present
- Wien bridge oscillator

Wireless Communications

Wireless microwave system design and analysis. RF transmission lines, microwave networks, receiver design, modulation techniques, and mixer characterization and realizations. Noise and distortion, RF oscillators and frequency synthesizers, filter design. Radiating systems and electromagnetic wave propagation, microwave amplifier design.

PathWave Design Software Requirements

At least 16 hours of lab usage of Keysight PathWave Design Software (ADS, Genesys, SystemVue, or EMPro). Demonstrated knowledge and hands–on experience in the following area listed below. The first 3 topics shown are required for level 1 certification. For level 2 certification, 2 of the topics listed as level 2 must be covered in the curriculum or lab. Substitutions can be made with prior written approval from Keysight Technologies. For example, topics 1 and 2 with topic 8 may be substituted for level 1 certification. Level 2 certification may be granted without level 1 certification.

Lab Usage	Level	Typical Lab	Topics
Using the Workspace Understanding the workspace structure, libraries, schematics, simulation setup and tuning. Learn the steps required for using PathWave Advanced Design System (ADS).	1	**Filter Design and Tuning**	• create a workspace and schematic • build a low-pass filter (lumped components) • set up the S-parameter simulation • plot the data • tune the filter parameters • create a symbol • plot two traces on the same graph
Using Linear Simulation Tools DC, AC, S-Parameter simulation and Design Guides.	1	**FET Amplifier Design and Linear Analysis**	• build a simple FET amp • use DC and AC simulation • use a VAR (variable equation) • run a parameter sweep • write a data display equation • measure impedance • list and plot data
Using Non-Linear Simulation Tools Transient and harmonic balance simulation, system components, and Equations.	1	**RF System and Non-Linear Analysis**	• use system components Amp and LPF • set up and run 1-tone HB simulation • plot the spectrum – examine the Mix values • sweep frequency and plot the response • add distortion (compression) to system Amp • sweep input power and plot the response • use your Amp and LPF in the same setup • use a MeasEqn in schematic • plot the response
Harmonic Balance Techniques 2-tone HB analysis, compression, mixer info, IP3 and more.	2	**Harmonic Balance Techniques**	• set up and run HB 1-tone • calculate Zin from HB data • use XDB for compression • sweep power and bias voltage • write equations and use a marker slider • set up and run HB 2-tone with variables
Using Load Pull Analysis FET device testing with Load Pull for power, PAE, and impedance.	2	**Load Pull Design Guide**	• open the Load Pull DesignGuide • replace sample with a DemoKit FET • use a stability network • set up the variables and simulate • examine the data – adjust variables

Lab Usage	Level	Typical Lab	Topics
Optimization and Matching Optimization with goals, yield, MC, and using the Impedance Matching tool.	2	**Optimization and Matching**	• create biased FET with a simulation template • simulate Gain and Stability • setup the Optimization and Goals • enable the variables to be adjusted • use the Optimization cockpit • use the Impedance matching Tool • simulate the final results
Circuit Envelope and Modulated Sources Basics of Circuit Envelope, using GSM and CDMA sources, CE data handling.	2	**Circuit Envelope and Modulated Sources**	• set up and run CE with a pulsed source • vary the CE time settings • use a GSM source & system amp • plot the spectrum and bit comparison • use a CDMA source with the FET Amp • copy an example Data Display • view the CDMA spectrum, ACPR, etc.
Layout Basics Library technology, layer information, layout tools and features.	2	**Basics on PathWave Advanced Design System (ADS) Layout**	• create a workspace and schematic • examine technology and preferences • set up Hot Keys • generate a layout from schematic • draw and edit shapes and components
EM Basics EM user interface setup, basic substrate setup, layer and via mapping, material definitions, and simulation.	2	**Basics of EM Simulation**	• define materials in the Technology file • draw two lines with via to connect them • add a new substrate and map layers • setup the EM simulation • define the ports and other settings • view the simulation data • optional: basic current visualization
SystemVue Overview of PathWave System Design (SystemVue) and Workspace Structure, RF Architecture and data flow templates, basic data flow analysis and sinks, bit generators, coding and mapping components, PRBS sources and continuous. data plots.	2		• envelope analysis and MathLang, BER, EVM measurements • datasets and equations using MathLang • FM modulation • envelope parameters • receiver and transmitter design • BER and EVM setup and results • path/channel models and IQ impairments
EMPro Overview of PathWave EM Design (EMPro) geometric modeling, constraint-based modeling,material specifications, ports and waveforms, boundary conditions, gridding and meshing, sensors and post processing.	2		• microstrip line • microstrip low pass filter • coaxial tee • pyramidal horn antenna • importing/exporting CAD files • PathWave EM Design (EMPro) links to PathWave Advanced Design System (ADS) • Python scripting • advanced solid modeling

Keysight Instrument Measurement Requirements

Demonstrated knowledge and hands-on measurement experience on the following topics.

Completed (7) lab experiments specifically using instrumentation to reinforce the topics below using instrumentation independently and in addition at least (3) lab experiments that utilize both the Keysight PathWave Design Software and instrumentation tools as part of the lab.

RF Vector Network Analyzer Basic Concepts	
Transmission line fundamental concepts (basic waves and propagation, types of transmission lines)	
Complex Impedance plane and its relation to RF devices and wave propagation	
Why are 75 Ω and 50 Ω common impedances for RF components and transmission lines	
Concept of Gain and loss of a RF devices	
Concept of Electrical Delay	
Concept of Electrical Length	
Understanding Phase	
S-parameters	
Smith Chart	
What is VSWR	
Basic Block Diagram of a network analyzer	• directional coupler • source • receiver
(Optional / Advanced Topic) Baluns and transformers	
RF Vector Network Analyzer Operation Basics	
Systematic error correction on a network analyzer 1 1 Port Calibrations	• open/Short Response Calibration • 1-port reflection calibrations • sliding load Calibration • 1 port error model
2 Port Calibrations	• thru Response calibration • enhanced Response calibration • full 2-Port SOLT • TRL calibration • 2 port error model
Equal	
Power calibration	
Adapter removal	
Basic cable measurement	
Group delay measurements	• definition • deviation from linear phase • aperture
Basic Filter measurements	
Basic Attenuator measurements	
Basic Amplifier measurements	
Basic Mixer measurements	• conversion loss • reflection measurements • phase measurements
Basic Antenna measurements	• antenna SWR • free space path loss

RF Vector Network Analyzer Operation Basics, continued	
Non-insertable devices	• calibration methods (Swap Equal Adapters, Adapter Removal) • (Optional / Advanced Topic) On-Wafer measurements
Waveguide measurements	• calibration • (Optional / Advanced Topic) Basic Device Measurements
Data storage and display	• how to get data out of the analyzer • marker usage • traces, Channels, and Windows
Setting measurement parameters	• IFBW • stimulus settings • averaging
(Optional / Advanced Topic) Differential devices and measurements	
(Optional / Advanced Topic) Non-linear, X-parameters	
Signal Analyzers	
Understand the different components of a swept-tuned SA	• attenuator, Mixer, IF Gain, LO, RBW, Sweep Generator, Envelope Detector, Video Filter • understand parameter effects (RBW > sweep time, DANL, resolving signals; IF Filter > DANL, sensitivity)
Be able to interpret key parameters on a typical SA screen	• amplitude, start/stop/center frequency, span, reference level
Understand safe habits when using RF instruments	• static discharge, no DC, nothing higher than max input level
Be familiar with the different areas of accuracy that affect a measurement	• frequency, amplitude
Be able to explain the power measurements that are commonly used today	• OBW, Channel Power, ACP, SEM
Explain the difference between Swept tuned vs. FFT Analysis	• How are they different in their measurement algorithm? • What are the advantages and disadvantages of both? • What parameters are important in each?
Know both Analog and Digital Modulation	• Analog: AM, FM, PM, how do they impact how a signal might look in frequency and time domain? • Digital: Concept of phase and magnitude. Draw and I/Q diagram. Define QAM, PSK, FSK. • Comparison of both Analog and digital, what are the pros and cons of both? are they different in their measurement algorithm?
Know the different stages of a signal	• baseband, IF, RF, etc.
Frequency thresholds of different cables/connectors	• BNC, N-type, SMA, etc. • How does using a lower-rated connector/cable impact the measurement?

Signal Sources	
Understand a CW Signal	• How does it look in time and frequency domain?
Frequency range, accuracy, resolution, output power, phase noise	• frequency range, accuracy, resolution, output power, phase noise
Know the different ways a CW signal can be analog modulated	• I.E.: AM/FM/PM/Pulse • within each, what parameters are important? (deviation, duty cycle, pulse width, etc) • swept measurements (Ramp, List, Step)
How the methodology of how a vector/digital/composite signal is modulated	• draw an IQ modulator block diagram. (IE carrier input, 90-degree shift, summation) • understand important parameters. (Sample clock, bandwidth, filter types, symbol rates)
Understand the difference between Arb vs. Real-time waveform playback	• Benefits/drawbacks for each?

Acknowledgement

- Top student identification
- Confirmation of their technical expertise
- LinkedIn and PathWave Design Software university webpage identification

Added Value

- Employment opportunity increases
- Separation from other students
- Identification with their school

Industry Access

- Valuable item for their resume
- One stop shopping for industry on LinkedIn
- Demonstrated value for industry

Learn more at: www.keysight.com

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