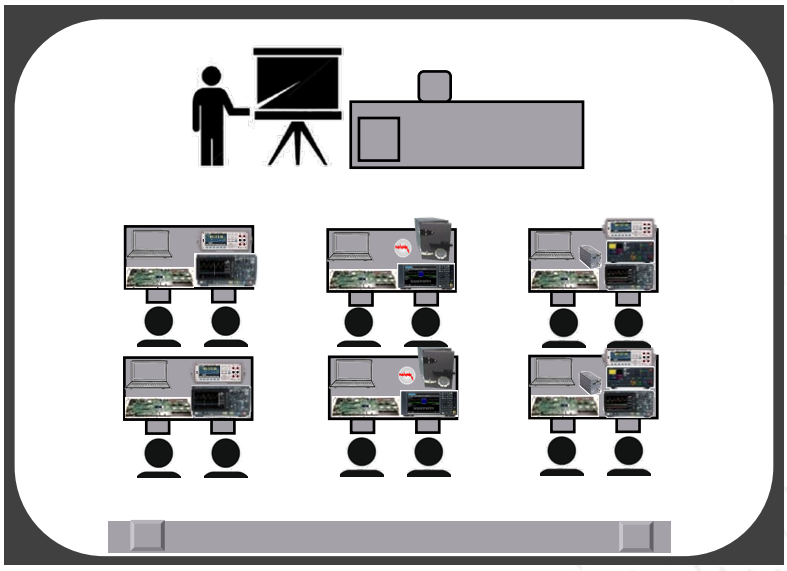
DATA SHEET

Advanced IoT Teaching Lab Solution

Complete IoT ecosystem learning for students, now REMOTE ready



KEYSIGHT TECHNOLOGIES

Overview

Introducing the 5 C's of IoT:

Figure 1. Keysight defined IoT core values

Keysight defined the 5C core values to cover the current IoT areas as showed above. The Connectivity, Compliance, Co-existence, Cybersecurity and the Continuity.

Keysight's ready-to-teach Advanced IoT Teaching Lab Solution is designed to assist educators in quickly setting up new engineering courses on the Internet of Things, with the intention of producing students who will fully understand the challenges and requirements of the IoT system design cycle, from design and validation to deployment in the market. In addition to teaching practical design and test techniques from the fundamentals of system design to wireless communication and power measurement, this courseware will also cover critical design considerations that have emerged with the evolution of the Internet of Things, such as cybersecurity, coexistence, compliance and continuity.

The U3810A courseware series comes with teaching slides and training kit that works with BeagleBone® and includes lab sheets and problem-based assignments for hands-on learning. It is designed to introduce students to Keysight hardware and software used in the industry to form a complete teaching solution.

- Module 1: IoT System Design and Validation Fundamentals

- Module 2: IoT Wireless Communication and Compliance

- Module 3: IoT Precision Power Measurement and MEMS Sensors

Figure 2. Advanced IoT Teaching Lab Solution learning coverage

Keysight Advanced IoT Teaching Lab Solution is covering all the 5C core values in the IoT world and provides a comprehensive IoT Teaching lab learning environment.

With Keysight Remote Advanced IoT Teaching Lab Solution, the IoT teaching can be conducted in a remote environment, to deliver similar learning experience as if the students were at the onsite lab.

Table of Contents

Overview 2

Introduction 5

U3813A/14A IoT System Design and Validation Fundamentals 7

U3813A/14A IoT System Design and Validation Fundamentals Courseware Content 8

U3815A/16A IoT Wireless Communication and Compliance 9

U3815A/16A IoT Wireless Communication and Compliance Courseware Content 10

U3817A/18A: IoT Precision Power Measurement and MEMS Sensors 11

U3817A/18A: IoT Precision Power Measurement and MEMS Sensors Courseware Content 12

Training Kit 13

U3810REM Remote Advanced IoT Teaching Lab Solution 14

IoT Development Kit Characteristics (U3810A) 15

System Requirements 15

Preview IoT Applied Courseware Contents 16

Ordering Information 17

Introduction

The Internet of Things has shifted from personal lifestyle to massive deployments in industries such as the smart home and smart city, connected cars and digital health. Mission-critical applications are driving the IoT revolution, and there are emerging requirements for connectivity, compliance, coexistence, continuity, and cybersecurity that must be addressed so IoT devices will operate as expected in the real world.

The IoT revolution races on, and now educators and students alike can leap ahead with Keysight's ready-to-teach Advanced IoT Teaching Solution. Designed to teach students practical design and test techniques from the fundamentals of system design to wireless communication and power measurement, this solution also covers critical design considerations that are emerging with the evolution of the Internet of Things, such as device and network cybersecurity, radio certification and compliance, and power continuity.

Students need to learn the practical skills and real-world application knowledge to fully understand what it takes to bring an IoT device from design to market. The advanced IoT teaching solution provides editable slides for the classroom, and a training kit with detailed lab procedures that will instruct students on how to use industry standard test and measurement equipment and software so they are industry-ready when they graduate. By incorporating the advanced IoT teaching solution into their curriculum, educators can:

Equip students with IoT engineering knowledge and skills with a complete understanding of the IoT ecosystem.

Students start learning the basics of designing and validating an IoT system, wireless protocols for IoT and battery characterization using the latest industry techniques. The labs then build upon these skills and provide students with an understanding of the entire IoT ecosystem and how these experiences relate to real-world applications.

The complete advanced IoT teaching lab solution consists of three modules:

- IoT system design – Covers IoT's architecture, technologies, standards, wireless protocols, applications, and ecosystems. Also teaches students how to design, develop and evaluate an IoT-enabled embedded system using industry-standard tools
- Wireless communication – How to develop typical IoT applications using various types of wireless connectivity. Students will also learn how to perform quick verification and design validation on these IoT applications
- Power management – Students will characterize the power consumption of IoT devices' onboard controllers, sensors and wireless modules, and learn the principles of power management.

Additionally, students will learn about new design considerations that have emerged with the evolution of IoT mission-critical applications, such as:

- IoT cybersecurity – with billions of devices deployed, it is increasingly important to secure devices and infrastructure against cyber threats. Most cybersecurity solutions today focus on the mass amounts of data processed at the network or cloud level, but there is a lack of awareness of cybersecurity at the device level. The advanced IoT teaching solution covers that gap.
- Pre-compliance – Emerging standards and regulations requires thorough testing and evaluation of IoT devices before selling into global markets. Students will learn how to test for pre-conformance and pre-compliance, why these tests are important, and use mitigation strategies during the design process to optimize and lower compliance test costs.
- Battery life analysis – Battery life is critical IoT device design, especially when the device is deployed in mission-critical situations where failure or disruption can have devastating consequences. Students will learn how to apply optimization techniques during the design process to measure and maximize the battery life of an IoT device.

Accelerate their student's learning with hands-on learning

The advanced IoT courseware training kit has an ergonomic design – with larger and more test pins and built-in sensors and connector wires – for simpler set up and efficient learning. students are exposed to real-world RF testing, and in the process they learn to handle and configure industry-standard test and measurement instruments and their associated software. Students can purchase additional BeagleBone® controllers for their own project development and apply what they learned from the teaching solution.

Increase the employability of students with the Keysight IoT design and validation industry-ready student certification program

This program is a collaboration between the university, industry and Keysight to identify and recognize students who have demonstrated exceptional IoT design knowledge and measurement expertise. Universities that integrate the advanced IoT teaching solution in their curriculum may apply to this program; once a university is certified as meeting the requirements, educators can nominate top students to receive a certificate of acknowledgment from Keysight, a world-leading technology company. Educators gain recognition for their learning institute, students earn recognition of their IoT skills for their resumes, and the industry can easily identify the top industry-ready engineers.

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

It can take a university lecturer up to six months to develop content for a new course, especially when they need to keep pace with rapidly changing technology trends; even more effort is needed to design a training kit for practical lab sessions. The advanced IoT teaching solution is designed for a full semester of teaching and comes with all the critical components needed to accelerate the setup of new IoT-focused courses – teaching slides for classroom lectures, and a training kit with development board and sensors and detailed lab procedures for practical hands-on sessions.

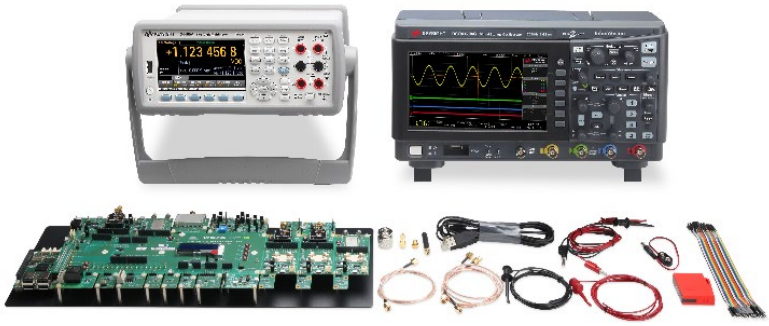
Easily set up lab facilities for IoT teaching

The advanced IoT teaching solution offers a unique bundle that includes the advanced IoT courseware and all the associated test and measurement instruments and Keysight software. This bundle provides teaching institutes with a complete solution to quickly and easily set up new engineering courses with lab facilities to teach the Internet of Things, and ensures students will have access to the same industry-leading equipment that they will use when they are working.

U3813A/14A IoT System Design and Validation Fundamentals

Overview

The U3813A/14A IoT System Design and Validation Fundamentals lab setup is a ready-to-teach package focused on the fundamentals of the Internet of Things and embedded system design. It introduces students to IoT architecture, technologies, standards, wireless protocols, applications, and ecosystems. It also covers IoT embedded system design that includes device cybersecurity basics.



- University subjects: IoT systems, Embedded System
- Years of study: Second to final year undergraduates
- Prerequisites(s): Basic programming
- Recommended instruments:
  - 34465A Digital Multimeter - Digital multimeter with data logging, digitizing and auto calibration
  - DSOX1204G Oscilloscope - 70/100/200 MHz, 4 Analog Channels, with a built-in Waveform Generator

To add remote connectivity capability, please refer to page 14 for the U3810REM remote accessories kit.

Teaching slides (U3814A only)	Training kit	Learning outcomes
• Editable Microsoft PowerPoint slides • Covers 75+ hours of classroom sessions	• Lab sheets (Microsoft Word) and model answers • Problem-based learning assignments • Covers 50+ hours of lab sessions	Students will: • Demonstrate the understanding of IoT's architecture, technologies, standards, wireless protocols, applications, and ecosystems • Design and develop an IoT-enabled embedded system • Configure IoT systems end to end • Set up WLAN, *Bluetooth*® LE, and Zigbee wireless connectivity • Evaluate I/O signals and perform current drain measurements using industrial-grade test and measurement instruments • Understand some device cybersecurity fundamentals

Note:
U3813A is the training kit with lab sheet
U3814A is the training kit, lab sheet and teaching slides

U3813A/14A IoT System Design and Validation Fundamentals Courseware Content

Teaching Slides (U3814A only)

The teaching slides are editable and cover the following topics:

Chapter	Topic
1	Essential Elements of IoT Systems
2	Enabling Technologies for IoT Systems
3	Fundamentals of Embedded Systems for IoT
4	Connectivity & Power Management for IoT
5	Designing IoT Applications Using Embedded Systems
6	Intro to Cloud Computing
7	IoT Network and Cloud Security Case studies - Smart automation and disaster management applications.

Lab Sheets

Lab Sheet	Topic
1	Setup the U3810A and IoT System Overview
2	Introduction to U3810 Peripherals, GPIO, PWM, SS Relay, LCD, Storage
3	Interfacing to Analog and Digital Devices, I2C, SPI, Relays, Sensors and ADCs
4	Zigbee Communications
5	*Bluetooth*® Low Energy
6	IoT Sensor Node Power
7	Network Security and Cloud
A1	Cloud-based IT Application
A2	Industry 4.0 Automation

U3815A/16A IoT Wireless Communication and Compliance

Overview

The U3815A/16A Wireless Connectivity and Network Security for IoT Frameworks lab setup is a ready-to-teach package started from portion of IoT System Design and Validation Fundamentals. After that move into how to develop typical IoT applications with various types of wireless connectivity and compliance study, it also covers IoT device and network security learning.

- University subjects: IoT systems, Embedded systems, IoT wireless communication, Advance IoT, Pre-conformance and pre-compliance, Network Security
- Years of study: Third to final year undergraduates
- Prerequisites(s): Basic programming, Signals and Systems, Electromagnetics
- Recommended instruments/software for lab setup:
  - N9000B CXA Signal Analyzer - Multi-touch, 9 kHz to 26.5 GHz
  - U3830A Anechoic Chamber - Portable Wireless Anechoic Test Chamber
  - 89600 VSA software – Vector signal analysis tool for demodulation and vector signal analysis.
  - N9077EM0E, N9081EM0E and N6141EM0E - X series measurement application (WLAN, *Bluetooth*®, EMI) - benchtop and modular signal analyzers

To add remote connectivity capability, please refer to page 14 for the U3810REM remote accessories kit.

Teaching slides (U3816A only)	Training kit	Learning outcomes
• Editable Microsoft PowerPoint slides • Covers 90+ hours of classroom sessions	• IoT development kit • IoT sensor devices • XBee Zigbee kit • Lab sheets (Microsoft Word) and model answers • Problem-based learning assignments	Students will: • Learn basic of IoT System Design and Validation Fundamentals • Understand the modulation and protocols of the BLE, Zigbee, WLAN and LoRa physical layers • Understand conformance and compliance testing requirements and methods • Learn how to use design validation, pre-conformance and pre-compliance testing to identify and mitigate potential problems • Understand cybersecurity fundamentals in radio communication at device/network level • Learn how to protect an IoT device and network using advanced topics in device cybersecurity Note: the LoRa and Zigbee setup will be in wired mode.

Note:
U3815A is the training kit with lab sheet
U3816A is the training kit, lab sheet and teaching slides

U3815A/16A IoT Wireless Communication and Compliance Courseware Content

Teaching slides (U3816A only)

The teaching slides are editable and cover the following topics:

Chapter	Topic
1	Overview of IoT Connectivity
2	Principles of Wireless Communications
3	Wireless Standards for IoT
4	Wireless Networking
5	Test and Measurement for Wireless Connectivity
6	IoT Device Security Case studies - Public safety (LTE/ Wireless Local Area Network (WLAN)), Smart home (WLAN), Energy Management (Zigbee), Healthcare (*Bluetooth*®), Smart City (6LoWPAN)

Lab sheets

Lab sheet	Topic
1	Setup the U3810 and a 3-Node Zigbee Network
2	BLE Design, Validation, Pre-Conformance and Pre-Compliance Testing
3	Zigbee Design, Validation, Pre-Conformance and Pre-Compliance Testing
4	WLAN Design, Validation, Pre-Conformance and Pre-Compliance Testing
5	LoRa Design, Validation, Pre-Conformance and Pre-Compliance Testing (Wired mode LoRa setup)
6	Advanced Modulation Analysis for BLE and ZigBee, and Coexistence Testing
7	Advanced IoT Network and Device Security
8	IoT Device Protocol Request Response Cycle and Network Security
A1	LoRa Remote Sensor Node
A2	Securing a ZigBee Sensor Network

U3817A/18A: IoT Precision Power Measurement and MEMS Sensors

Overview

The U3817A/18A Precision Power Measurement and MEMS sensors lab setup is a ready-to-teach package started from portion of IoT System Design and Validation Fundamentals. Then move into topic of how to characterize the power consumption of IoT devices onboard controllers, sensors and wireless modules, eventually covers sophisticated battery optimization learning involve RF event detector and analysis software.

- University subjects: IoT systems, Embedded systems, IoT device management, IoT sensors technologies, Advanced IoT
- Years of study: Second to final year undergraduates
- Prerequisites(s): Basic programming, Electronic Circuits, Digital Circuits
- Recommended instruments/software for lab setup:
  - 34465A Digital Multimeter – Digital multimeter with 2M memory, digitizing and auto calibration
  - DSOX1204G Oscilloscope - 70/100/200 MHz, 4 Analog Channels, with a built-in Waveform Generator
  - N6705C DC Power Analyzer - Modular System Based on DC Power Supply or Electronic Load Outputs
  - N6781A 2-Quadrant source - Source/Measure Units (SMUs) Modules
  - X8712AD Event detector X8712AS – IoT and analysis software

To add remote connectivity capability, please refer to page 14 for the U3810REM remote accessories kit.

Teaching slides (U3818A only)	Training kit	Learning outcomes
• Editable Microsoft PowerPoint slides • Covers 90+ hours of classroom sessions	• IoT development kit • IoT sensor devices • XBee Zigbee kit • Lab sheets (Microsoft Word) and model answers • Problem-based learning assignments • Covers 75+ hours of lab sessions	Students will: • Learn basic of IoT System Design and Validation Fundamentals • Understand sensor selection • Evaluate the performance of commonly used sensor modules • Understand the design considerations in IoT applications (power management) • Characterize the power consumption of IoT devices and sub-circuits using industrial-grade test and measurement instruments • Learn about the use of solar energy harvesting and battery charging • Perform battery life analysis with battery drain and analysis software

Note:
U3817A is the training kit with lab sheet
U3818A is the training kit, lab sheet and teaching slides

U3817A/18A: IoT Precision Power Measurement and MEMS Sensors Courseware Content

Teaching slides (U3818A only)

The teaching slides are editable and cover the following topics:

Chapter	Topic
1	Overview of Internet-of-Things (IoT) System
2	Essentials of Power Circuits
3	Fundamentals of Power Measurement
4	Power Management Techniques
5	Overview of Sensor Technology
6	Sensor Measurement Techniques
7	Sensor in Action Case studies 1 - Low Power Sensor Node in Smart Home Case studies 2 - Weather Monitoring System Case studies 3 - Application of Drones in Smart Agriculture Case studies 4 - Efficient Data Aggregation and Processing for Wearable Sensor

Lab sheets

Lab sheet	Topic
1	Setup the U3810A
2	Advanced Digital Communication Serial, SPI and USB
3	MEMS Sensors for Inertial Measurement and Pressure
4	Characterizing IoT Static and Dynamic Power Consumption
5	Evaluating Dynamic Current Drain and Battery Life
6	Characterizing a Solar Panel and Incorporating Solar Power in an IoT Device
7	Techniques for Optimizing Sensor Power Consumption and Efficiency
8	Event-based Dynamic Power Measurement
A1	Comparing Two Methods of Altitude Measurements with IoT Sensors
A2	Design a Solar-Powered Wireless Temperature Sensor

Training Kit

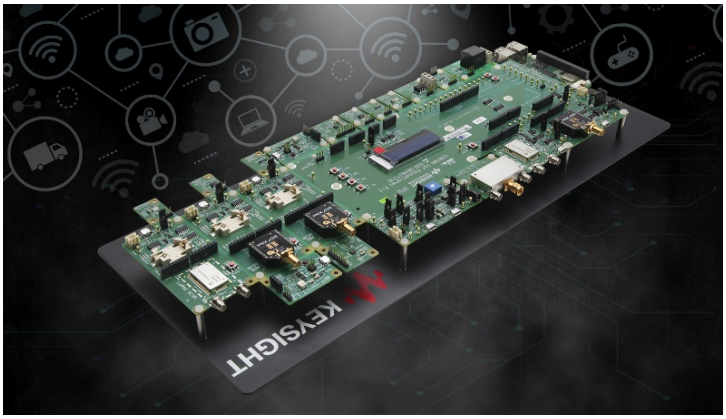
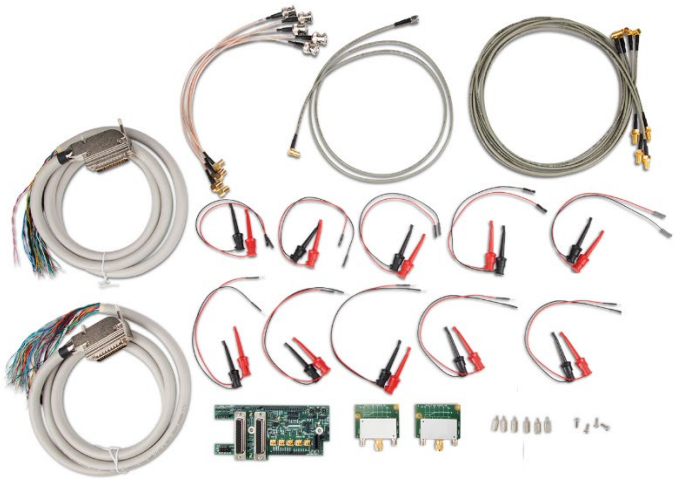


Figure 3: Advanced IoT Teaching Lab Training Kit

Note: BeagleBone® Green MCU is required to form a complete IoT training kit.
Keysight is not able to ship to all countries. Please refer to the country list below:

Countries	Description
USA, Canada, Europe, China, Russia, Japan, Korea, Vietnam, Malaysia, Hong Kong, Singapore, Thailand, India, Switzerland, Australia, New Zealand, Philippines, Taiwan, Indonesia, Brazil, Turkey, Colombia, Saudi Arabia and Mexico	Training kit includes BeagleBone® Green
All others	BeagleBone® Green must be purchased separately. https://beagleboard.org/green

U3810REM Remote Add-on Option for Advanced IoT Training Kit



U3810REM Remote Advanced IoT Teaching Lab Solution is an additional accessories kit to convert existing U3813A/14A, U3815A/16A and U3817A/18A IoT training kit to enable the remote connectivity.

The Remote Advanced IoT Teaching Lab Solution is used in conjunction with software ecosystem (PW9112EDU and PW9111EDU) along with U3900DAQ Switching System to provide an end-to-end remote lab solution.

The U3810REM remote accessories kit includes:

1. Interface board
2. Splitter board
3. Cables

A programmable USB hub is required to form a complete Remote Advanced IoT Teaching Lab Solution. The USB hub can be purchased separately : https://acroname.com/store/s77-usbhub-2x4

IoT Development Kit Characteristics (U3810A)

IoT development kit	
Dimensions	45 cm (w) x 25 cm (d) x 5 cm (h)
Computer module	BeagleBone® Green Processor: Octavo Systems OSD3358 1GHz ARM® Cortex-A8 • 3D graphics accelerator • NEON floating-point accelerator • 2x PRU 32-bit microcontrollers • Debian Linux
RAM and flash storage	• 512MB DDR3 RAM • 4GB 8-bit eMMC on-board flash storage
Connectivity	USB client for power & communications USB host 802.11b/g/n 2.4GHz and *Bluetooth*® 4.1 plus BLE HDMI 2 x 46 pin headers
IoT development kit	
Supply voltage	USB port, or 6 to 12 V AC adapter (3.3 and 1 mm DC jacks)

System Requirements

General	
PC operating system	Windows 7 and 10
Interface	USB (2 ports)

Preview IoT Applied Courseware Contents

Please visit our solution page for more information about the contents of the Advanced IoT Teaching Lab Solution and to view samples of the teaching slides and lab sheets.

https://www.keysight.com/find/AdvancedIoT

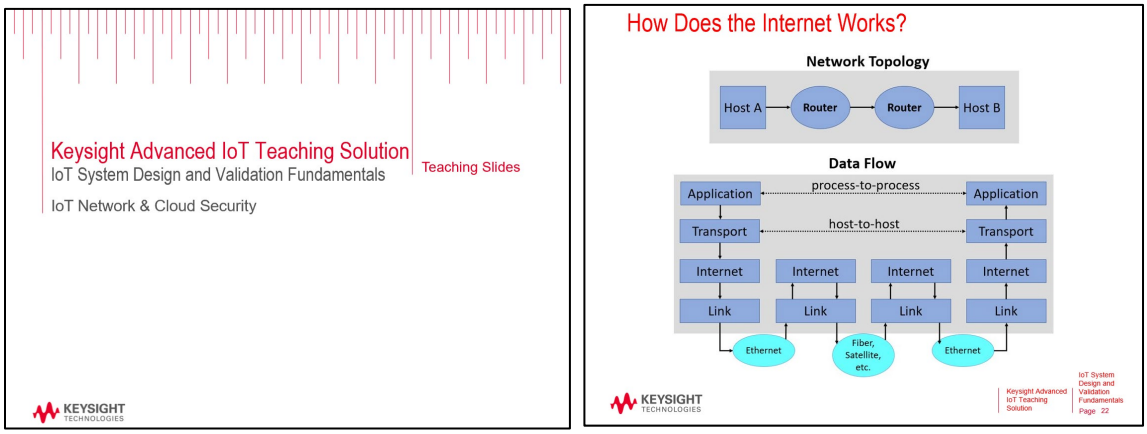


Figure 4. Sample teaching slide from IoT System Design and Validation Fundamentals

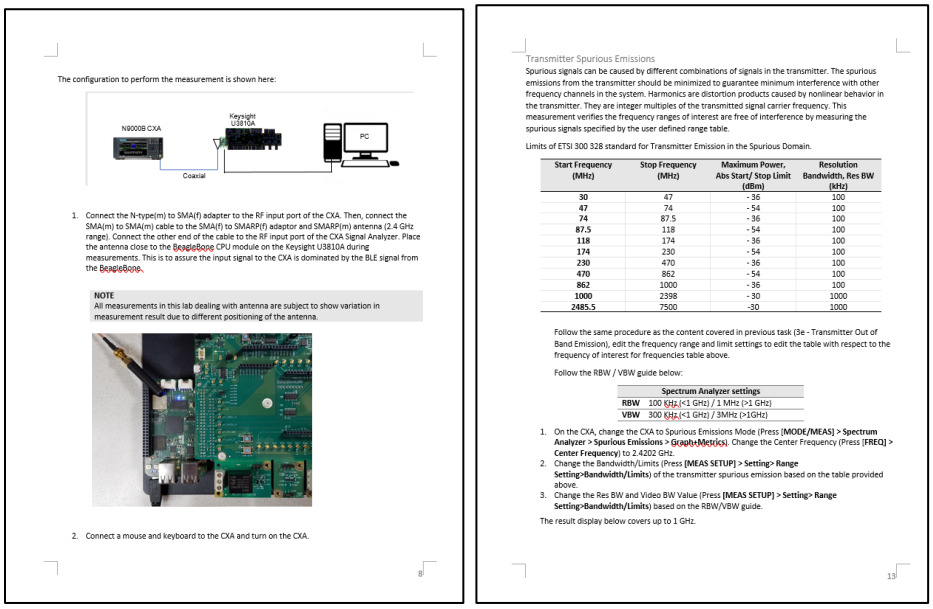


Figure 5. Sample lab sheet from IoT Wireless Communication and Compliance

Ordering Information

Product number	Description
Module 1: IoT System Design and Validation Fundamentals	
U3813A	IoT System Design and Validation Fundamentals applied courseware, with training kit and lab
U3814A	IoT System Design and Validation Fundamentals applied courseware, with training kit, lab and teaching slides
Recommended instruments	
34465A[1]	6½ digit, performance True*volt* digital multimeter
DSOX1204G	Oscilloscope: 70/100/200 MHz, 4 Analog Channels

Note: Other 34460 Series Truevolt DMMs models may be used, but 34465A is recommended as this model comes with a digitizing option for use with the IoT Sensors and Power Management applied courseware

Product number	Description
Module 2: IoT Wireless Communication and Compliance	
U3815A	IoT Wireless Communication and Compliance applied courseware, with training kit and lab
U3816A	IoT Wireless Communication and Compliance applied courseware, with training kit, lab and teaching slides
Recommended Instruments and Software	
N9000B	CXA Signal Analyzer - Multi-touch, 9 kHz to 7.5 GHz (minimum 3 GHz required) Option B25 - Analysis Bandwidth, 25 MHz
U3830A	Anechoic WaveChamber -Portable Wireless Anechoic Test Chamber (or equivalent)
For qualified education customers	
89600EDU-E15	89600 VSA software for education, 1-year support included, with 15 seats of perpetual floating license for student, and x1 transportable perpetual for instructor
X-Series Measurement Applications	X-App: Propose perpetual and node locked • N9077EM0E: WLAN 802.11a/b/g/j/p/n/af/ah Measurement Application • N9081EM0E: Multi-touch UI *Bluetooth*® Measurement Application • N6141EM0E: Multi-touch UI X-Series measurement application license for EMI measurements with multi-touch UI

Note: Customer are free to choose other type of license for X-App software according to desire lab size

Product number	Description
Module 3: IoT Precision Power Measurement and MEMS sensors	
U3817A	Precision Power Measurement and MEMS sensors applied courseware, with training kit and lab
U3818A	Precision Power Measurement and MEMS sensors applied courseware, with training kit, lab and teaching slides
Recommended Instruments and Software	
34465A DMM	• 6½ digit, performance Truevolt digital multimeter with high-speed digitizing and 2M memory • DIG + MEM + 34138A
DSOX1204G	Oscilloscope: 70/100/200 MHz, 4 Analog Channels
N6705C	DC Power Analyzer, Modular, 600 W, 4 Slots
N6781A	2-Quadrant Source/Measure Unit for Battery Drain Analysis, 20 V, ±1 A or 6 V, ±3 A, 20 W. Required 2 units in the courseware
X8712AD	Event based detector
KS833A2A	PathWave Event Based Power Analysis, Node Locked, subscription license

Product number	Description	
Remote Advanced IoT Teaching Solution		
U3810REM	Add Remote Teaching Option for U3810A Advanced IoT Series	
Recommended Instrument and Modules		
U3900DAQ	DAQ970A	Data acquisition system with USB and LAN
	DAQM901A	20 Channel multiplexer
	DAQM903A	20-Channel actuator/general purpose switch
	DAQM905A	Dual 4-Channel RF multiplexer 50 Ω

Note: To setup the lab in remote connectivity capability, you will be required both the U3810REM and U3900DAQ options. For U3900DAQ, you will need a DAQ970A mainframe and three modules DAQM901A, DAQM903A and DAQM905A for all the course modules (U3813A/14A, U3815A/16A, U3817A/18A). A U3810REM kit is required for each training kit to make the remote connectivity ready.

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

KEYSIGHT TECHNOLOGIES