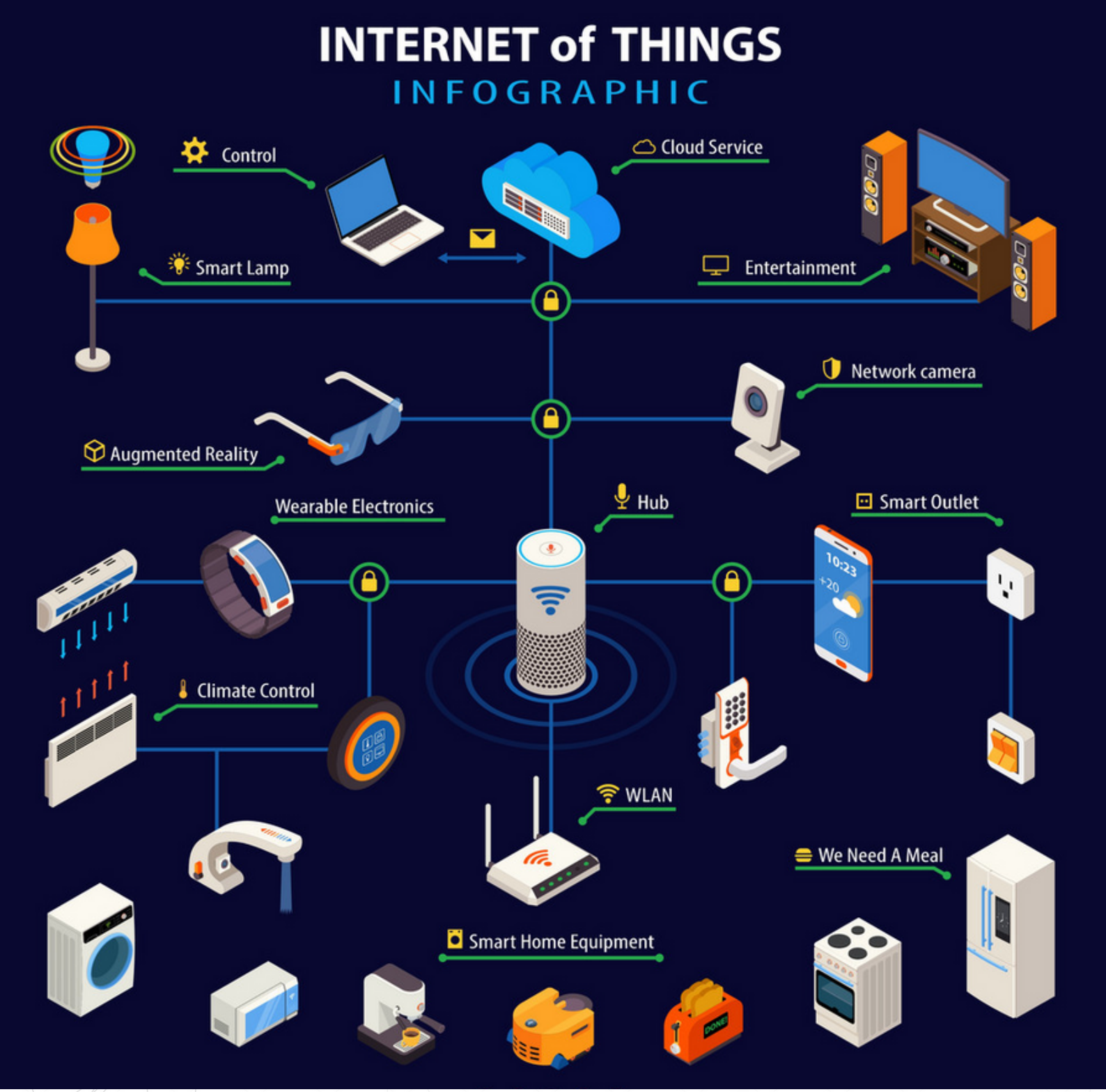

CENTER OF EXCELLENCE IN ARTIFICIAL INTERNET OF THINGS

SAN INSTRUMENTS

MEASUREMENT SOLUTIONS TO ACCERATE INNOVATIONS

Tektronix® KEITHLEY
A Tektronix Company

www.saninstruments.com

ARTIFICIAL INTERNET OF THINGS AIOT

Artificial Internet of Things (IOT) promises to change the world by connecting devices in larger, more interoperable systems controlled by softwares and analytics. Objective of this COE is to enable student to understand , learn and research on the upcoming technologies in field of IoT. As well as, this lab will help academia to collaborate with Industries and projects.

IoT CoE will help to address following Challenges

IoT Fundamentals: - This COE is designed as a resource for educators in college to teach students about the IoT's architecture, technologies and ecosystems. The COE also integrates hands-on industry relevant experiences and real-world applications in IoT design and testing.

I**oT Systems Design: -** The COE is designed to equip students with the knowledge on how to design and develop an embedded system with IoT capabilities.

List of few work flow layout of COE will include below details.

- Introduction to the IoT Development Kit
- Interfacing to IoT Devices
- Digital Communication Protocols for IoT
- Wireless Sensor Networks for IoT

IoT Wireless Communications: - This CoE is designed to equip students with the knowledge on how to develop typical IoT applications with various types of wireless connectivity. Students will also learn how to perform quick verification and design validation on these IoT applications, with training kit (development kit, sensor devices, XBee ZigBee®

I**oT Sensors and Power Management:** The COE is designed to equip students with the knowledge on how to characterize the power consumption of IoT devices onboard controllers, sensors and wireless modules. Students will understand the principles of power management.

- Characterizing IoT sensor board (device) static and dynamic power consumption
- Evaluating the impact of dynamic current drain and solar energy harvesting on IoT battery life
- Optimizing power consumption and efficiency using dynamic power management in sensor network

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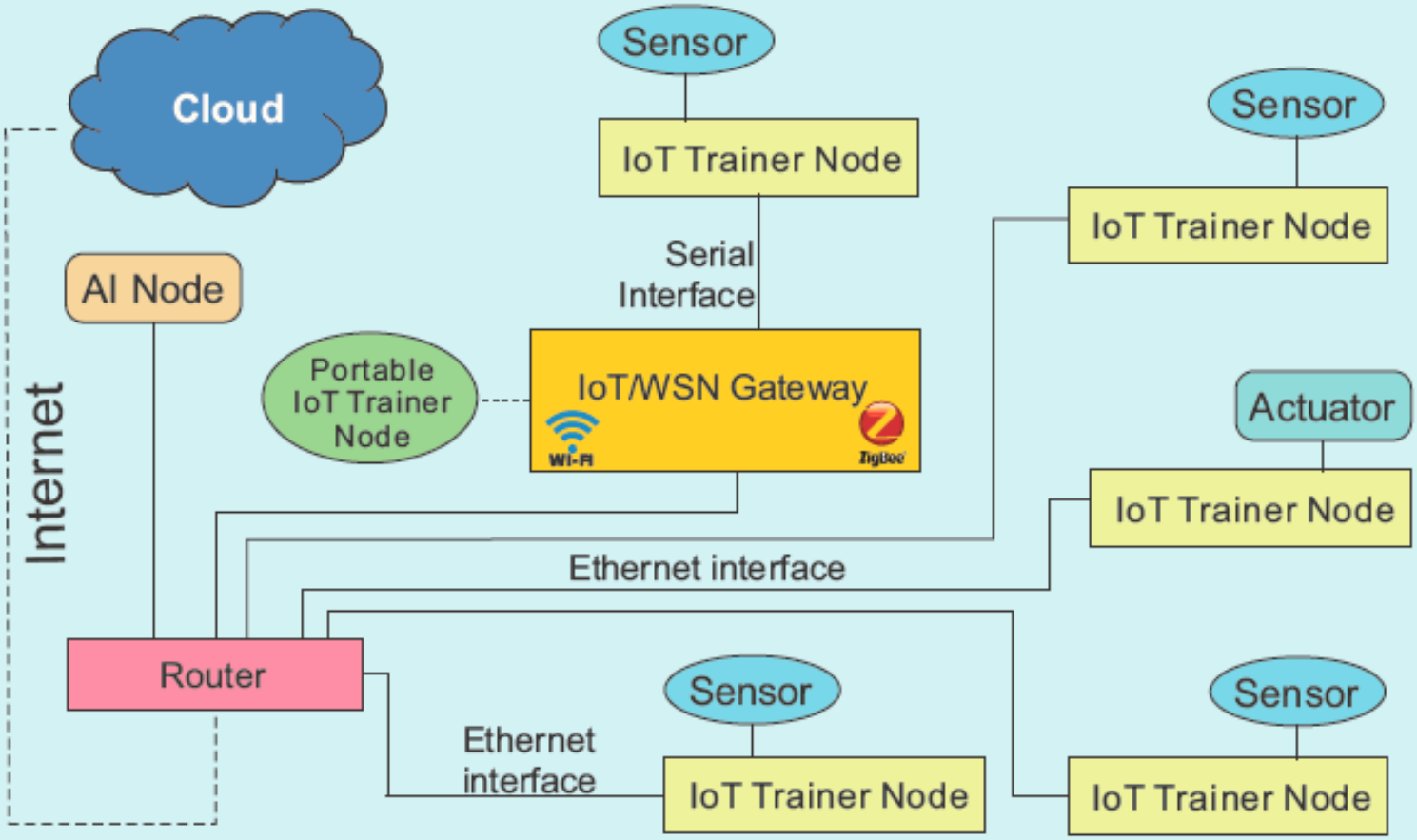
Industrial IOT/ Advanced Embedded RTOS Lab Educational and Research Development Platform

Are you creating devices that need to talk with other machines? Do you need to ensure that they are meeting the countless standards and protocols of the Internet of Things?
We will guide and help you all the way from the blossoming of an idea as you navigate wireless standards and face the headache of module selection, to making sure your product meets the latest standards and pass compliance certification the first time.

"Together we'll ensure your device's signal can be seen amongst a thousand others. You have ideas, we have tools and together we can create better Things! "



Solving Key Six Challenges of IoT

- **Selecting the right wireless module**
- **Design and debug complex mix signal devices(Analog+Digital+RF)**
- **Maximizing Battery Life**
- **Passing Emi-EMC certifications**
- **Testing Wireless technology standards**
- **Combatting the Interference of things**

Features Of IOT Educational & Research Development Platform

- Focus on understanding the basic IoT Eco System
- Consideration of various types of nodes with different operational modes like sleep, deep sleep, power down, and wake up modes using interrupt handling for integration with sensors and actuators enabling the learner to understand the fundamentals. Nodes with Debugging facility enabling the students to debug the codes
- Use of ARM Cortex architecture-based nodes to explore the art of writing sensor drivers, implementation of communication protocols etc. which enables a powerful IoT solution
- Exploration of protocols like UART, I2C, SPI, Ethernet (Ipv4), Wi-Fi, Bluetooth, ZigBee, MQTT, CoAP, REST etc.
- Usage of various programing languages like C, C++, JavaScript, Python, XML etc.
- Art of Cloud configuration and using cloud services with IoT system & implementation of Gateway system
- Facilitates the use of Embedded concepts like OSGi framework, Linux etc. thus making the solution more featured.
- Support of ECO Systems like Mbed, GNU, ARM
- State of Art Lab solution to demonstrate the integration and combination of artificial intelligence (AI) technologies with the Internet of Things (IoT) infrastructure to achieve more efficient IoT operations, improve human-machine interactions and enhance data management and analytics
- Enabling the creation of database on the cloud platform and store the IoT data for further use and analytics
- Demonstration of WSN as a Subset of IoT thus enabling the learners to try hands-on using the ZigBee protocol in
- addition to other wireless protocols like Wi-Fi, Blue Tooth etc.
- Exploring the art of deployment of Trained Deep Learning Model on the AI node to demonstrate applications which needs image classification, segmentation etc.
- Support number of real time case studies thus encouraging learners to try IoT based curriculum projects
- Includes most of the latest features of IoT system development thus helping learners to become employable

SCOPE Of LEARNING FOR STUDENTS, RESEARCHER & INDUSTRY PERSONAL

Understanding of basic skills needed to implement IOT concept

- Definition of the Internet of things
- The Importance of the internet of things in world
- Applications of Internet of things
- Internet of things architecture , history
- Overview of IOT Educational and Research Development platform

Operating Systems Used For IOT Development Platform

- Linux operating system overview , study of Linux command line & shell
- Overview of Eclipse based Integrated Development Environment (IDE) tool.
- Setting up a Linux file system & understanding system initialization
- Connecting a System to the network
- Installing Linux and IDE configuration for IOT Development platform

Programming Languages used in IOT Development Platform

- C , C++ Programming
- Java , Java Script
- Python, XML

Hardware Interfacing for IOT Development Platform

- Set Of Sensors , Actuators
- Sensor calibration
- Study of Different sensors and there characteristics
- Writing sensor drivers and testing the sensor output on the UART port of IOT node

Analyzing & Decoding of Communication Protocol Used in IOT Development Platform

- UART Communication Protocol
- I2C Protocol device interfacing and decoding of signal
- SPI Protocol device interfacing and decoding of signal
- WIFI and Router interfacing
- Ethernet Configuration
- Bluetooth study and analysis of data flow
- Zigbee Interfacing and study of signal flow

Cloud Services used in IOT Development Platform

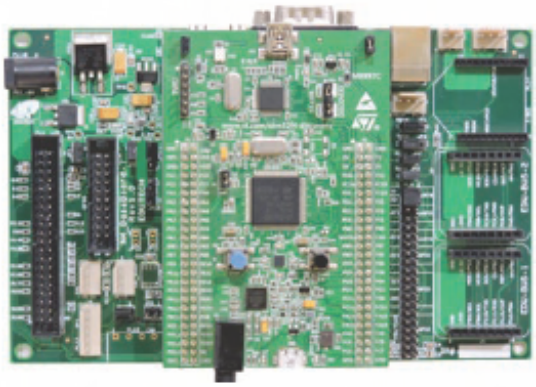
- Configuration of the cloud platform
- Sending data from the IOT nodes to the gateways using different communication options
- Transferring data from gateway to the cloud
- Exploring the web services like mail, Messaging (SMS) and Twitter etc.
- Tracking of cloud data as per the requirement

CHALLENGES & SOLUTIONS IN DESIGNING IOT SOLUTIONS

- Selecting the Right Wireless Module - Tektronix Real Time Spectrum Analysis
- Designing and Debugging Complex Mixed Signal Devices - Tektronix Mixed Domain Oscilloscopes along with protocol analysis
- Maximizing Battery Life - keithley Battery simulator & precision DMM
- Passing EMI and EMC Certification - Tektronix EMI EMC Solution
- Standards Certification - Tektronix Power analyser

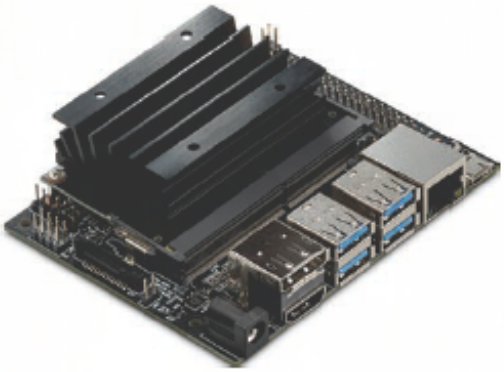
IOT Lab Components

IOT Node (Model: EPB_M4)



- STM32F407VGT6 ARM 32-bit Cortex™-M4 CPU with real-time accelerator (ART Accelerator™), frequency up to 168 MHz, 1 Mbyte of Flash memory, 192 Kbytes of RAM, 16-stream DMA controller
- Serial wire debug (SWD), JTAG interface
- On Board Data Transfer interfaces includes USB connector for UART4, DB9 connector for UART6, 3Pin and 4Pin Header for UART4 & 6, USB OTG, Flash Drive interface, EDU-BUS connector with ADC, PWM, UART, I2C and SPI, 20 pin GPIO interface connector
- On Board WSN feature to be used within an IoT system.
- **Special on Board Functionality includes** TFT, Ethernet, Audio jack interface, MIC for audio recording, Accelerometer, Camera Interface

AI Node (Model: AI_Node)



- A small, low power, powerful AI computer node that lets you run multiple neural networks in parallel for applications like image classification, object detection, segmentation, and speech processing thus demonstrating a complete AIoT concept.

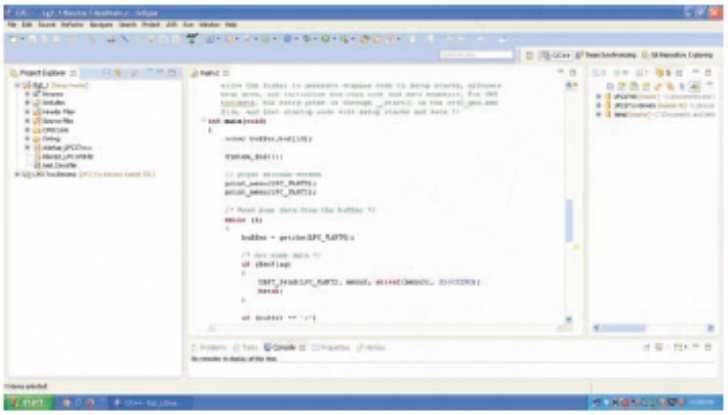
Portable Sensor Node (Model: EDU_PSN)

- Portable Sensor Node uses wireless connection to post the data to the cloud.

IOT Gateway

- Embedded gateway featuring CPU up to 1.2GHz Quad Core, 1GB RAM
- On board Wifi and Bluetooth for wireless connectivity
- Nodes can be connected to the gateway via Ethernet, Serially or using Wifi or Bluetooth
- Collects the data from the nodes and posts it to cloud

Eclipse based Integrated Development Environment (IDE) Tool:

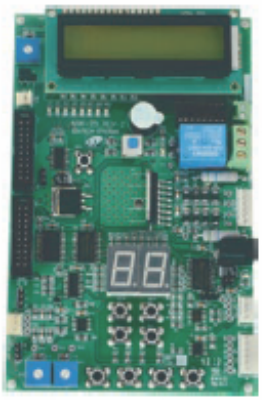


Eclipse IDE is an easy to use development platform which can be used for windows as well as Linux environment.
This IDE tool supports different micro-controller platforms like 8051, PIC, AVR, ARM7 & Cortex-M4.
It can be interfaced with the debugger using external plug in. This tool is unique as it allows users to work with multiple controller platforms thus reducing the learning time and making it easy to develop applications, projects and lab exercises.

All-in-one General Purpose Board (Model: ASK-25)

The All-in-one GPIO board is specially designed to suit the experimentation on different GPIO devices with the micro controllers.

Features:



- On board display options includes 8 LED, 16x2 character LCD, 2 digit 7-segment display
- Switches include 4 general purpose keys and 2x2 matrix keyboard
- I2C and SPI based EEPROMs for protocol demonstration experiments
- Stepper motor interface with built-in H-bridge driver IC
- DC motor interface
- Relay output
- Facility to provide 2 channel ADC input using potentiometer and unity gain amplifier for protection
- Compatible with different Educational Practice Board

Learning Outcomes and Skill Enhancement

Using Serial and Ethernet Protocol

- Programs to monitor analog data received on ADC remotely on cloud
- Program to toggle LEDs remotely using cloud application
- Programs to remotely toggle relay using cloud application
- Control speed and direction of stepper motor remotely using cloud application
- Control speed and direction of DC motor remotely from cloud
- interfacing various sensors to the node and reading the data on the cloud and perform necessary action based on the information received

Using Voice Control

- Program to control LEDs using Google Assistance.
- Program to control relay using Google Assistance.
- Program to control DC motor using Google Assistance.
- Program to control Stepper motor using Google Assistance.

Using Artificial Intelligence

Case studies on Deep learning and Machine Learning based applications

- Attendance system using Finger print/RFID module
- Error detection using Deep Learning Inference
- People detection and counting using Deep Learning
- Controlling device using temperature data and Machine Learning
- Demonstrating Working of Mesh networking concepts

Using Wireless Protocol (BLE and Wi-Fi)

- Program to interface Bluetooth and Ultrasonic Ranger to monitor distance and send to the cloud
- Program to interface Bluetooth and implement DC Motor
- Program to interface Wio node and Temperature and Humidity sensor and monitor values on the cloud
- Studying Bluetooth analysis and measurement of Signals
- studying WLAN analysis of
- 802.11a/b/g/j/p, 802.11n, 802.11ac Signals

Using Cloud Service

- Program to cross communicate between nodes
- Program to add trigger to send email if ADC value is above certain level or below
- Program to add trigger to send twitter message if ADC is above certain level or below
- Program to add trigger to send SMS with message bird if ADC is above certain level or below
- Program to control LEDs using OpenHAB service running on Amazon cloud
- Program to control Relays using OpenHAB service running on Amazon cloud.

IOT Based Application & learning Prototypes

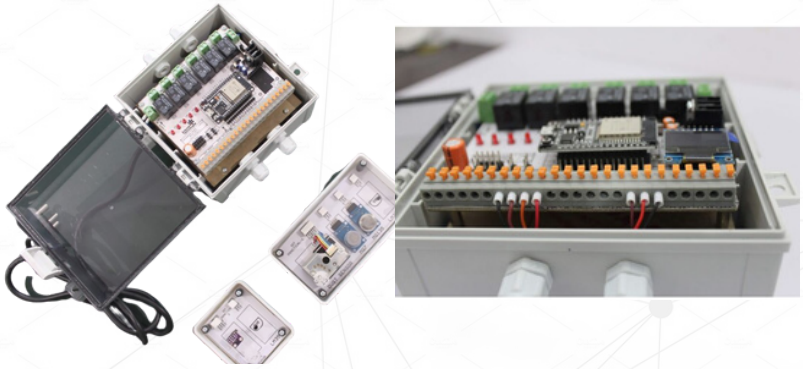
IOT Learning Box

Applications

Home Automation: Home Automation is the project based on IoT to remotely control and program the appliances in your home. It can be useful in detecting and avoiding thefts.

Patient Monitoring System: Patient Monitoring system identifies health problems. The patterns of heart rate, pulse, digestive system, and blood pressure can be monitored and diagnosed for anomalies.

Air Pollution Monitoring System: This experiment detects Air pollution. We can monitor the emissions from factories and vehicles to minimize air pollution.



Features

- We can use IoT Learning Box for various mini and major projects as it is having 36 i/o pins. One can easily add other components or modules to it.
- Works on Standard 230V AC Power Outlet.
- Easily accessible hinged door box that is rust-free, splashproof and shockproof.
- Uses Thingsboard open-source IoT Platform for data collection, processing, visualization, and device management.
- Built-in WIFI and Bluetooth Connectivity.
- It uses the industry-standard IoT protocol – MQTT for device Connectivity.
- IoT Learning box consumes ultra-low power for its functioning.
- We can also use IoT Learning Box for Commercial Use.
- In addition to the state-of-the-art, high-quality hardware provided, after registering online, students will have access to a dedicated e-learning platform and other learning materials.

IOT CAR

Features

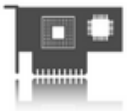
- In-depth practical learning on IoT
- Based on Linux Debian Operating System
- Python Programming
- Study interfacing of various Sensors and Actuators
- Learn and implement various Communication Protocols
- GSM and GPS included
- GUI based IoT experiments demonstration
- IoT Gateway using WiFi and Ethernet
- Bluetooth interface
- vision-based experimentation

IoT Car is a product that allows users to learn, visualize and implement Internet of Things in fun and engaging manner. It is a physical product embedded with electronic and mechanical components such as microprocessor, sensors, actuators, touch panel, and network connectivity.

IoT Car is based on the Raspberry Pi platform.It is embedded with a variety of sensors like Humidity and Temperature sensor, Accelerometer sensor, GPS and GSM Sensor and Camera sensor. It is driven by a DC motor, and Servo motor based steering(Ackerman) mechanism. Specially designed graphical user interface(GUI) displays various sensors parameters and can also be used to operate the IoT Car. Iot Car is controlled and programmed using the inbuilt Touch Panel or the wirelessly connected Host Computer.

The Device Food Chain

The opportunities to reinvent existing objects into connected devices that include sensors and transmitters are abundant. However, these opportunities are accompanied by technical challenges. How do we make tools and machines that have not changed in form or function for decades into electronic devices that are smart, connected, and compliant? Further, how do we ensure that the devices we design in the lab are able to perform in the field?

THE DEVICE FOOD CHAIN				
What are you building?	Chip 	Module 	Device 	System 
Key Challenges:	• RF Design and Debug • EMI/EMC Pre Compliance	• RF Design and Debug • EMI/EMC Pre Compliance • Speeding Through Wireless Standards	• Selecting a Wireless Module • RF Design and Debug • EMI/EMC Pre Compliance • Maximizing Battery Life in IoT Devices • Speeding Through Wireless Standards	• The Interference of Things

CHALLENGE 1- SELECTING THE RIGHT WIRELESS MODULE

When adding wireless connectivity to your products there are a number of technologies to choose from, including Wi-Fi®, Bluetooth®, ZigBee®. You may opt to buy a wireless module rather than build your own custom RF design to save time and money. However there are dozens of modules out there, and several factors to consider.

With so many modules in production and more coming, choosing a wireless module can feel overwhelming.

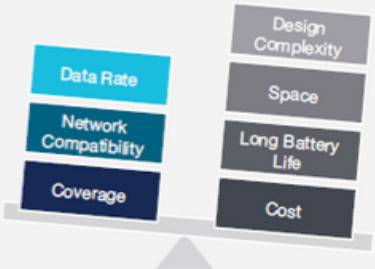
Choosing the wrong module could delay product development, so getting the right module the first time is critical. Some factors to consider are:

- Cost / Develop versus Buy decision
- Security
- Wireless technology and protocol
- Data throughput, Latency, connection setup speed
- Network topology
- Power consumption
- Real Estate
- Pre-certified or Non-pre-certified module selection
- Future-proof & Long term availability
- Robustness
- Interchangeability
- Vendor's application industry vertical focus, global presence, quality manufacturing, and support operations
- Regulatory and Industry standards compliance/ qualifications requirements

4 Common Wireless Module Trade-Offs

No one wants to compromise on the design features that matter most, so it is important to balance trade-offs well. Here are four of the most common trade-offs and what they can mean for your design.

1. Module vs Reference Design
2. Data Rate vs Range vs Power Requirements
3. Robustness vs Interchangeability
4. Cost vs Everything



CHALLENGE 2- DESIGNING AND DEBUGGING COMPLEX MIXED SIGNAL DEVICES (ANALOG, DIGITAL, AND RF)

Traditionally, radio devices for most applications would have been designed by highly experienced RF design engineers. Now there are countless radio “modules” that can be purchased and integrated into your project with reference designs. These modules are helping to fuel the huge boom in IoT devices and can speed along development time. However, when it comes time to system level troubleshooting, design teams struggle to figure out if the problem lies with their module or with their device.

Accelerate your design with comprehensive solutions for debugging complex Digital, Analog and RF system problems

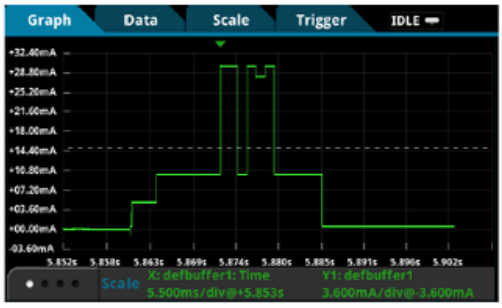
RSA306B USB Spectrum Analyzer and Signal-Vu PC
Ensure that your IoT device is transmitting at the correct power level and frequency

TSG4100A RF Vector Signal Generator
Perform powerful functional and sensitivity tests on RF Receivers.

MDO3/4 Mixed Domain Oscilloscope
Verify system level operation through correlation of correlating analog and digital signals with RF.

CHALLENGE 3- MAXIMIZING BATTERY LIFE

Power management is a primary concern in IoT design. The battery life of IoT devices varies greatly, from hours to years, depending on the application and its operating environment. In all cases, however, the ability to accurately describe the device’s power consumption is essential. Robust power analysis helps designers identify opportunities to reduce energy consumed and optimize battery life.



A typical IoT device contains at least one sensor, a processor, and a radio chip that operates in different states and consumes currents from tens of nA to hundreds of mA in a matter of tens of microseconds. As a result, it is important to remember these challenges when choosing equipment to perform the analysis with power measurement challanges

10 Power Analysis Measurement Challenges

1. Measuring a wide dynamic range of current levels
2. Determining ultra-low deep sleep current
3. Measuring transmit and receive current
4. Capturing short transients and fast transitions
5. Ensuring sufficient measurement bandwidth for your sample rate
6. Triggering to isolate specific events
7. Recording device operations over extended states
8. Analyzing power consumption from complex waveforms
9. Isolating device design issues from power source issues
10. Providing a stable voltage for all device operating conditions

TEKTRONIX DMM7510. Experience unprecedented signal analysis that will help you design more energy efficient devices. Featuring a touch screen display, for quick and intuitive navigation.

SERIES 2281S WITH BATTERY SIMULATOR. Create stable low noise voltage supply for every state of your IoT device, from sleep to transmit. Record and generate battery sources with the Battery Simulator option.

SERIES 2280S. Delivers Analog and Advanced vector and digital modulation capabilities critical for EMI/EMC testing. Its flexible configuration offers CAPEX protection.

Maximize your mobile to mobile device's battery life, Accurately measure your IoT and M2M device's current draw and power consumption in active, standby and sleep modes.

- Very accurate low and high current sourcing and measurement (from nA to A) throughout the different stages of the radio.
- DMM7510 has high resolution digitizer for accurate transient current measurements during changing modes
- The 2281S Power Supply offers the same great features of the 2280S DC Power supply with additional battery recording and simulation functionality
- The 2281S Power Supply is essential when creating stable low noise voltage supply for every state of
- your IoT device, from sleep to transmit. Record and generate battery sources with its Battery Simulator option.
- Create stable low noise voltage supply for every state of your IoT device, from sleep to transmit, with the linear, programmable, 2280S Power Supply.

CHALLENGE 4 - PASSING EMI AND EMC CERTIFICATION

The race to add products to the Internet of Things brings a degree of complexity to EMI testing. Not only do product manufacturers need to learn how to properly add a wireless capability to their product, but from an EMI perspective it requires additional intentional radiator testing. EMI regulations are in place throughout the world to provide improved reliability and safety for users of electrical and electronic equipment.

CHALLENGE 5 - STANDARDS CERTIFICATION

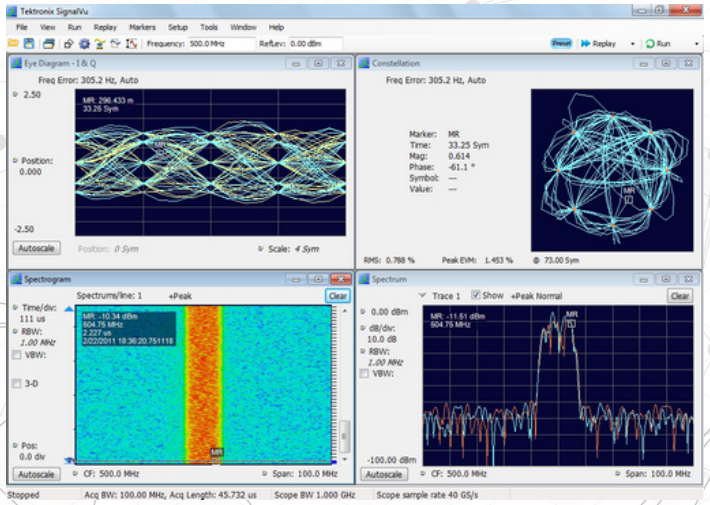
Wireless technology standards are needed to ensure that products can interoperate within the ecosystem where they will be deployed. There are a number of technologies to choose from, including Wi-Fi®, Bluetooth®, ZigBee®. However to adhere to the standard, new products will need to meet qualification as defined per the standard selected. Failing qualification can mean design turns that will delay the final product release and draw additional significant development cost.

CHALLENGE 6 - COMBATTING THE INTERFERENCE OF THINGS™

Over the past decade there has been a dramatic increase in the population of wireless transmitters found in the world. Arguably the spectrum in the 2.4 GHz is the most popular operating area for low-cost, license free applications and there are literally millions of radios operating in this frequency band. Utilizing license exempt spectrum is attractive because of the cost savings, but you get NO protection from all the other people using the same channels.

EMI Solution
Don't Let EMI/EMC Compliance Certification Slow You Down

Wireless Standards Solution
Get to market faster with compliance tests on RF transceivers



Combatting Interference
Interference Hunting made fast, easy and inexpensive for M2M connectivity in Factory Automation/ Industrial Process Control and Spectrum Management.

SAN INSTRUMENTS

Recommended Bench Product Descriptions

These products were chosen to meet the unique needs of the education lab.

Oscilloscopes

3 Series MDO Oscilloscope › NEW!
With a touchscreen interface and built-in spectrum analyzer option, this scope is perfect for the student RF analysis lab. **Compatible passive probes included (one per channel).**

TBS2000B Oscilloscope ›
Featuring bandwidths up to 200 MHz and 4-channels, familiar, easy to use controls, context sensitive help system and a standard 5-year warranty. Perfect for the beginning engineering lab. **Compatible passive probes included (one per channel).**

Probes

TCP0030A Current Probe ›
You can use the TCP0030A current probe to make accurate measurements from DC to 120 MHz. The probe combines proven Hall-effect technology with the Tektronix TekVPI® oscilloscope interface.

Digital Multimeters

DMM6500 Digital Multimeter ›
Leading touchscreen bench DMM with built-in premium features for the education lab.

Power Supplies

2231A-30-3 Power Supply ›
Multi-channel programmable DC power supply ideal for testing a wide range of devices in the education lab.

2280S Power Supply ›
Delivers up to 192W of low output noise power and superior load current measurement sensitivity. Built-in plotting functions offers plenty of versatility for your education bench.

Arbitrary Function Generator

AFG1062 Arbitrary Function Generator ›
A building block for an education bench solution, this AFG generates all of the waveforms needed for a teaching lab.

AFG31000 Arbitrary Function Generator ›
A high-performance AFG with built-in arbitrary waveform generation, real-time waveform monitoring, and the largest touchscreen on the market. Perfect for the modern teaching lab.

Source Measure Units

2450 Source Measure Unit ›
Simultaneously sources and measures current. The touchscreen interface minimizes the learning curve and enables students and to learn faster, work smarter, and invent easier.

USB Signal Analyzers

RSA306B USB Signal Analyzer ›
This affordable RSA enables students to capture results of experiments, perform analysis, and generate lab reports on their laptops, saving time and optimizing learning opportunities.

USB Vector Network Analyzer

TTR500 USB Vector Network Analyzer ›
A full-featured 2-port, 2-path VNA at a breakthrough price. Now students can validate S-parameters of real-world RF designs for comparisons against simulations.

Vector Signal Generators

TSG4100 Vector Signal Generator ›
Generates a variety of RF signals starting from true DC up to 6 GHz, with up to 200 MHz modulation bandwidth, the TSG4100 offers mid-range RF performance, ideally suited for the engineering student.

Software and Service

TekSmartLab™ ›
Manage your lab with ease using TekSmartLab, a network-based lab instrument management solution for quickly setting up and efficiently managing basic electronics in engineering laboratories at colleges and universities.

SignalVu-PC Software ›
Used with Tektronix spectrum analyzers and oscilloscopes to help students and professors validate RF/Wireless designs directly from their own computer.

Kickstart Software ›
KickStart simplifies what you need to know about the instrument so that in just minutes you can take the instrument out of the box and get real data on your device.

Total Product Protection ›
Protect your investment with a complete service plan providing coverage for all of your test and measurement lab equipment.

To learn more about recommended bench configuration & details of trainers kit visit : **saninstruments.com/education**

SAN INSTRUMENTS

Measurement Solutions To Accelerate Innovations

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