Evariste Some

Final Project Proposal:
Wi-Fi IoT With CC3100

I. Project Overview

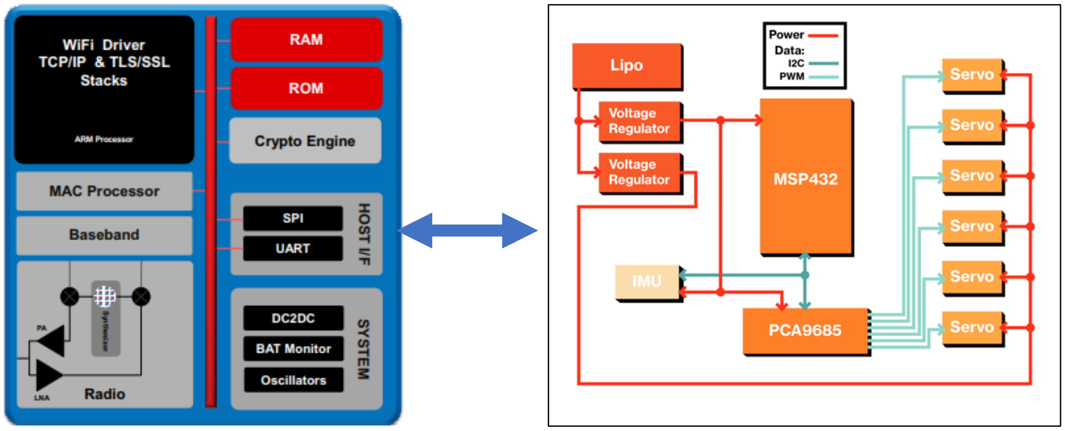
The Internet-of-Things (IoT) is the notion of all devices and products being connected to the Internet, rather than only computers and mobile devices, as has been the case until the recent past. The IoT is already booming, and its adoption will only accelerate in coming years. At the same time, the world continues to go wireless. Wired Internet and telephone connections are becoming rarer with each passing year, and consumers expect and demand wireless communications more and more. One critical enabling technology for the IoT is wireless communications: IP-cameras, printers, kitchen appliances, and more deliver greater flexibility in their design when they do not need a wired connection to access the Internet. In this project, we propose to build a highly integrated Wi-Fi SoC solution to meet continuous demands for efficient power usage, and reliable performance on the Internet of Things industry by using the Wi-Fi Development Tools TI CC3100 Boost.

II. Project Scope

The MSP432P401R launchpad is an easy to use evaluation module board. It contains everything needed to start developing on the MSP432 including on-board emulation for programming, debugging, and energy measurements (TI slau597a, p.3). The MSP432P401x devices are part of the Simple Link microcontroller (MCU) platform simplified by access to the 40-pin headers and a wide variety of BoosterPack plugin modules that enable technologies such as wireless connectivity, which consists of Wi-Fi, Bluetooth low energy, Sub-1GHz and host MCUs (TI MSP432P401r, p. 2). The SimpleLink MSP432P401x MCU are optimized wireless host MCUs with an integrated 16-bit precision ADC, delivering ultra-low-power performance including 80µA/MHz in active power. As an optimized wireless host MCU, MSP432P401x will allow us to add high precision analog to applications based on SimpleLink wireless connectivity (TI MSP432P401r, p. 2). Using the Code Composer Studio environment, the in-class project Quade will be used (optional). On top of Quade, a temperature sensor (optional), a low voltage buzzer (optional), and an LCD1602 (optional) will be deployed to respectively capture the temperature and plot in real time (optional), to emit a noise when the temperature goes below some threshold, and to display some information on the LCD. Finally, the complete and self-contained Wi-Fi networking capabilities, CC3100 Booster TCP/IP stack, will be deployed on the Quad through the I2C interfaces. Lastly, a particular focus will be made on the Wi-Fi Module CC3100 to analyze its pros and cons, any imperfection of the radio such as carrier leakage, I/Q phase matching, or baseband nonlinearities. CC3100 is a simple Link Wi-Fi Network Processor which integrates all protocols for Wi-Fi and internet with build-in security protocols. The CC3100 device can connect to any 8, 16, or 32 bit MCU over the SPI or UART interface. It can connect any low-cost, low-power microcontroller to the Internet of Things (IoT). Common applications are Cloud connectivity, Internet Gateway, Home automation, Industrial control, Home appliances, and Smart energy respectively (TI CC310 Simplelink).

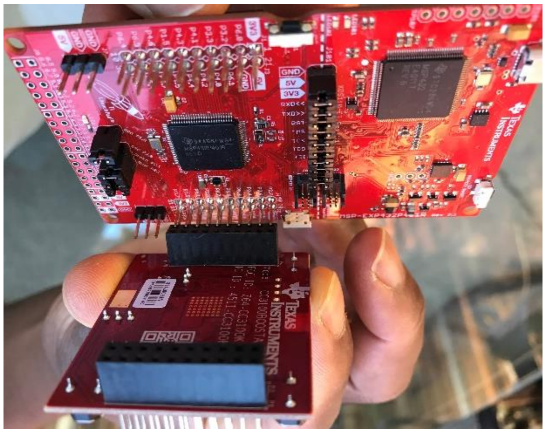
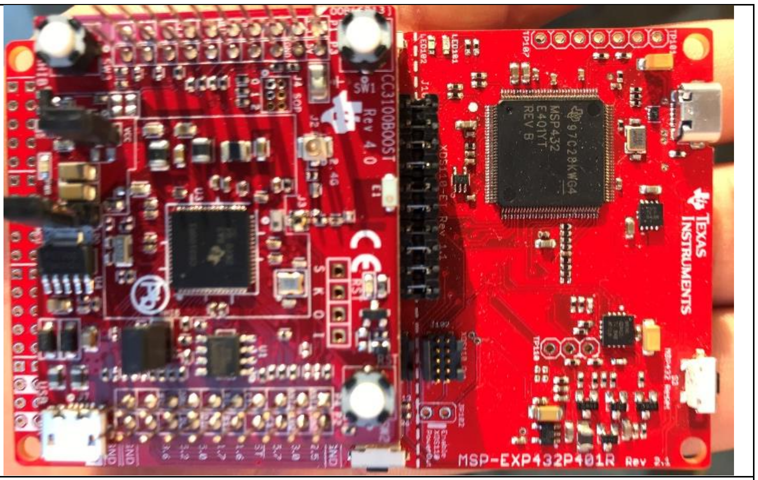
III. Functional Block and Wiring Diagrams

a) Functional Block Diagram



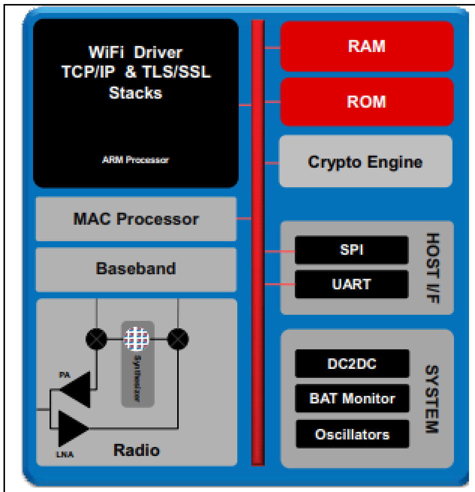
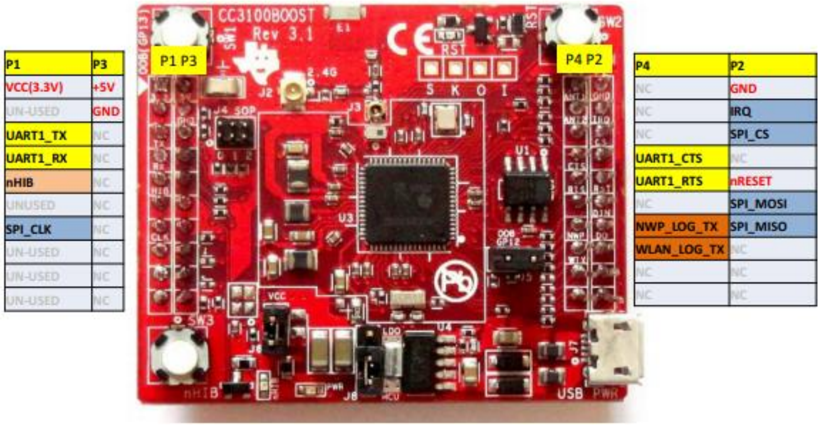
Block Diagram: CC3100 hardware overview MSP432 hardware overview

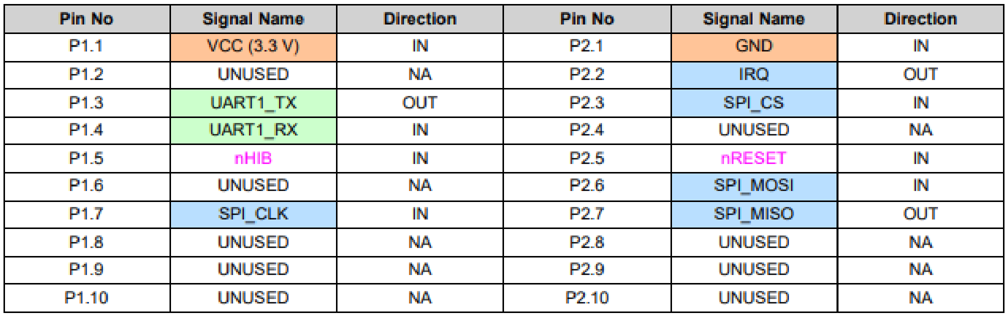
b) Wiring Diagram

	
Side view CC3100 overlapping the MSP432	CC3100 connected to the MSP432

IV. Deep Dive Into CC3100 Boost

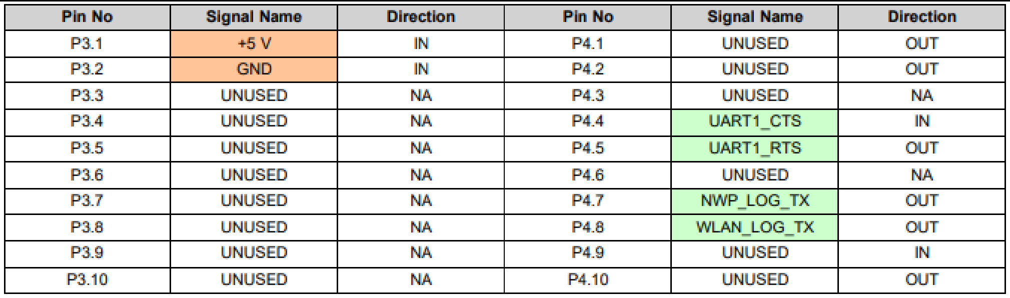
CC3100 Boost has the following features: Internet on a chip Wi-Fi, Network processor, Embedded TCP/IP stack for systems using external low-cost MCU.

 WiFi Driver TCP/IP & TLS/SSL Stacks ARM Processor MAC Processor Baseband PA Synthesizer LNA Radio RAM ROM Crypto Engine SPI UART HOST I/F DC2DC BAT Monitor Oscillators SYSTEM	 CC3100BOOST Rev 3.1 P1 P3 P4 P2 P1 P3 VCC(3.3V) +5V UN-USED GND UART1_TX NC UART1_RX nHIB UNUSED SPI_CLK P4 P2 IRQ SPI_CS UART1_CTS UART1_RTS nRESET SPI_MOSI NWP_LOG_TX SPI_MISO WLAN_LOG_TX USB
The CC3100 hardware overview	The signal assignment on the 2x20 pin connector is shown. The convention of J1..J4 is replaced with P1…P4 to avoid confusion with the actual board reference.



Pin No	Signal Name	Direction	Pin No	Signal Name	Direction
P1.1	VCC (3.3 V)	IN	P2.1	GND	IN
P1.2	UNUSED	NA	P2.2	IRQ	OUT
P1.3	UART1_TX	OUT	P2.3	SPI_CS	IN
P1.4	UART1_RX	IN	P2.4	UNUSED	NA
P1.5	nHIB	IN	P2.5	nRESET	IN
P1.6	UNUSED	NA	P2.6	SPI_MOSI	IN
P1.7	SPI_CLK	IN	P2.7	SPI_MISO	OUT
P1.8	UNUSED	NA	P2.8	UNUSED	NA
P1.9	UNUSED	NA	P2.9	UNUSED	NA
P1.10	UNUSED	NA	P2.10	UNUSED	NA

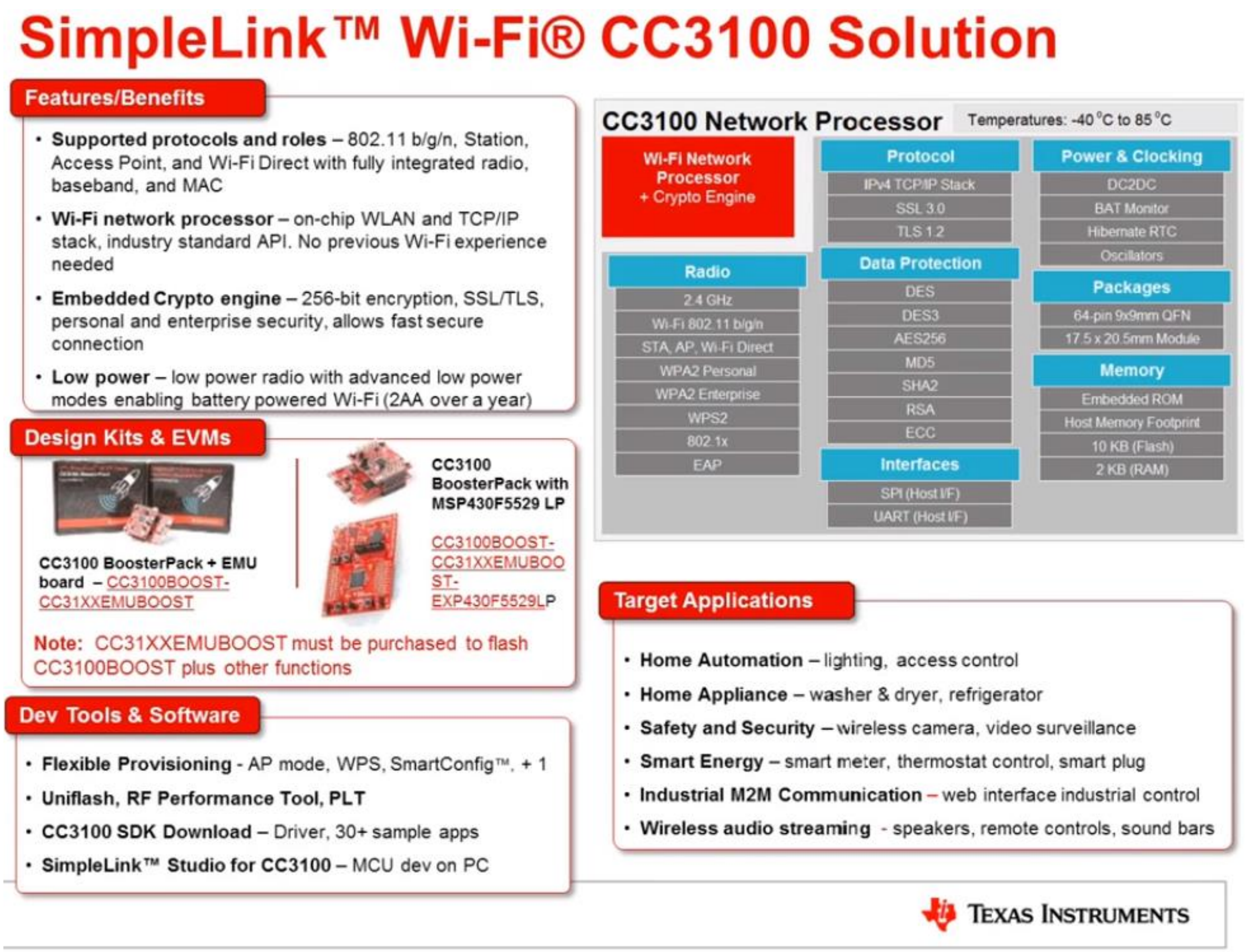
Outer Row Connectors



Pin No	Signal Name	Direction	Pin No	Signal Name	Direction
P3.1	+5 V	IN	P4.1	UNUSED	OUT
P3.2	GND	IN	P4.2	UNUSED	OUT
P3.3	UNUSED	NA	P4.3	UNUSED	NA
P3.4	UNUSED	NA	P4.4	UART1_CTS	IN
P3.5	UNUSED	NA	P4.5	UART1_RTS	OUT
P3.6	UNUSED	NA	P4.6	UNUSED	NA
P3.7	UNUSED	NA	P4.7	NWP_LOG_TX	OUT
P3.8	UNUSED	NA	P4.8	WLAN_LOG_TX	OUT
P3.9	UNUSED	NA	P4.9	UNUSED	IN
P3.10	UNUSED	NA	P4.10	UNUSED	OUT

Inner Row Connectors

NOTE: All signals are 3.3 V CMOS 400mA logic levels and are referred w.r.t. CC3100 IC. For example, UART1_TX is an output from the CC3100. For the SPI lines, the CC3100 always acts like a slave (TI, p.9).



SimpleLink™ Wi-Fi® CC3100 Solution

Features/Benefits

- **Supported protocols and roles** – 802.11 b/g/n, Station, Access Point, and Wi-Fi Direct with fully integrated radio, baseband, and MAC
- **Wi-Fi network processor** – on-chip WLAN and TCP/IP stack, industry standard API. No previous Wi-Fi experience needed
- **Embedded Crypto engine** – 256-bit encryption, SSL/TLS, personal and enterprise security, allows fast secure connection
- **Low power** – low power radio with advanced low power modes enabling battery powered Wi-Fi (2AA over a year)

Design Kits & EVMs

CC3100 BoosterPack + EMU board – CC3100BOOST-CC31XXEMUBOOST

CC3100 BoosterPack with MSP430F5529 LP

CC3100BOOST-CC31XXEMUBOOST-EXP430F5529LP

Note: CC31XXEMUBOOST must be purchased to flash CC3100BOOST plus other functions

Dev Tools & Software

- **Flexible Provisioning** - AP mode, WPS, SmartConfig™, + 1
- **Uniflash, RF Performance Tool, PLT**
- **CC3100 SDK Download** – Driver, 30+ sample apps
- **SimpleLink™ Studio for CC3100** – MCU dev on PC

CC3100 Network Processor

Temperatures: -40 °C to 85 °C

Wi-Fi Network Processor
+ Crypto Engine

Radio
2.4 GHz
Wi-Fi 802.11 b/g/n
STA, AP, Wi-Fi Direct
WPA2 Personal
WPA2 Enterprise
WPS2
802.1x
EAP

Protocol
IPv4 TCP/IP Stack
SSL 3.0
TLS 1.2

Data Protection
DES
DES3
AES256
MD5
SHA2
RSA
ECC

Interfaces
SPI (Host I/F)
UART (Host I/F)

Power & Clocking
DC2DC
BAT Monitor
Hibernate RTC
Oscillators

Packages
64-pin 9x9mm QFN
17.5 x 20.5mm Module

Memory
Embedded ROM
Host Memory Footprint
10 KB (Flash)
2 KB (RAM)

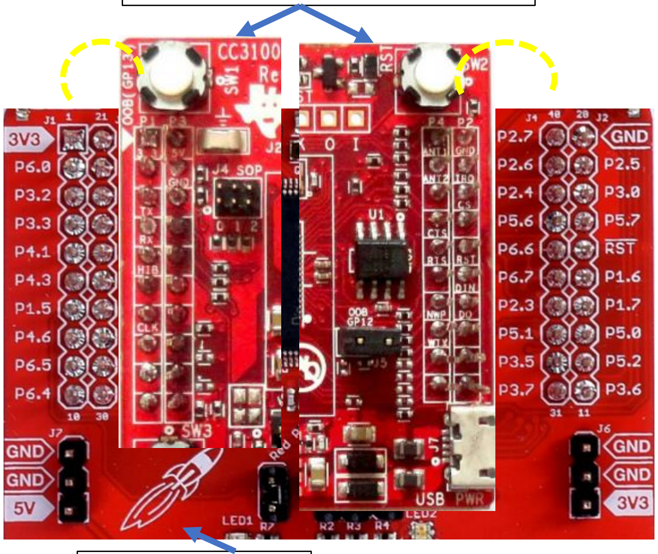
Target Applications

- **Home Automation** – lighting, access control
- **Home Appliance** – washer & dryer, refrigerator
- **Safety and Security** – wireless camera, video surveillance
- **Smart Energy** – smart meter, thermostat control, smart plug
- **Industrial M2M Communication** – web interface industrial control
- **Wireless audio streaming** - speakers, remote controls, sound bars

Texas Instruments

V. Final Design Pins Mapping: CC3100 – MSP432

CC3100 reduced to two slices to illustrate pins overlapping with the MSP432

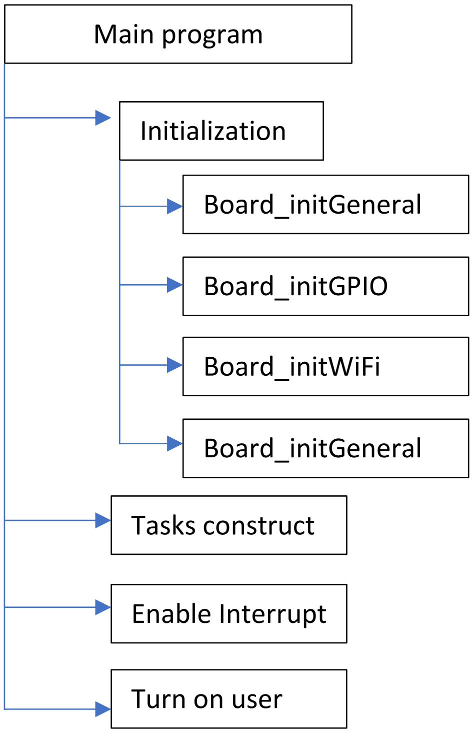


MSP432 red

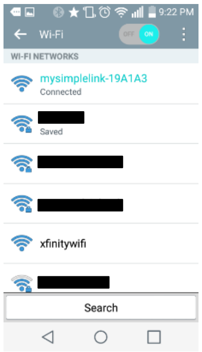
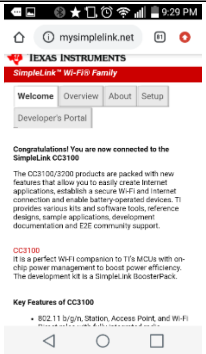
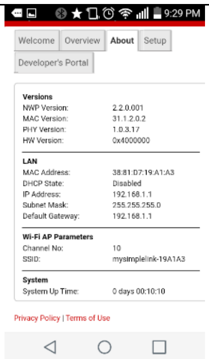
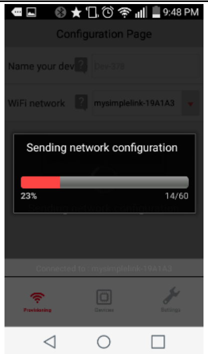
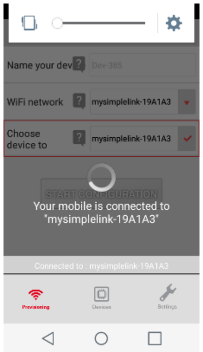
CC3100 inner side female overlaps with MSP432 front side male pins as illustrated

Align the pin1 of the boards together using the triangle marking on the “PCB”. An incorrect connection can destroy the boards permanently. Ensure that none of the header pins are bent before connecting the two boards. Jumper settings on the CC3100BOOST.

VI. Software Diagram



Execution Outcome

 9:22 PM Wi-Fi OFF ON WI-FI NETWORKS mysimplelink-19A1A3 Connected [redacted] Saved [redacted] [redacted] xfinitywifi [redacted] Search	 9:29 PM mysimplelink.net TEXAS INSTRUMENTS SimpleLink™ Wi-Fi® Family Welcome Overview About Setup Developer's Portal **Congratulations! You are now connected to the SimpleLink CC3100** The CC3100/3200 products are packed with new features that allow you to easily create Internet applications, establish a secure Wi-Fi and Internet connection and enable battery-operated devices. TI provides various kits and software tools, reference designs, sample applications, development documentation and E2E community support. CC3100 It is a perfect Wi-Fi companion to TI's MCUs with on-chip power management to boost power efficiency. The development kit is a SimpleLink BoosterPack. **Key Features of CC3100** • 802.11 b/g/n, Station, Access Point, and Wi-Fi	 9:29 PM Welcome Overview About Setup Developer's Portal **Versions** NWP Version: 2.2.0.001 MAC Version: 31.1.2.0.2 PHY Version: 1.0.3.17 HW Version: 0x4000000 **LAN** MAC Address: 38:81:D7:19:A1:A3 DHCP State: Disabled IP Address: 192.168.1.1 Subnet Mask: 255.255.255.0 Default Gateway: 192.168.1.1 **Wi-Fi AP Parameters** Channel No: 10 SSID: mysimplelink-19A1A3 **System** System Up Time: 0 days 00:10:10 Privacy Policy | Terms of Use	 9:48 PM Configuration Page Name your dev Dev-378 WiFi network mysimplelink-19A1A3 Sending network configuration 23% 14/60 Connected to : mysimplelink-19A1A3 Provisioning Devices Settings	 Name your dev Dev-385 WiFi network mysimplelink-19A1A3 Choose device to mysimplelink-19A1A3 START CONFIGURATION Your mobile is connected to "mysimplelink-19A1A3" Connected to : mysimplelink-19A1A3 Provisioning Devices Settings
Connection established	Navigation to mysimplelink.net	Initial configuration setup	Connecting to internet	Mobile connected

Further work to consider

We can associate to the current setup a grove moisture sensor for instance, and use TI cloud development environment. Software-wise, the Code Composer Studio (CCS) Cloud is recommended to create an Energia-based software project. Temboo server can be used to generate code to be flashed to the hardware, which enables the launchpad to interface with a cloud service called Nexmo using REST APIs. (TI-Cloud-Connected) proposes a step by step walk through.

I. Project Requirement

(…**in progress**… Update is made as the implementation goes)

This project embedded many subsystems that interact with each other. The following will be required to make the project successful:

- CC3100: The CC3100 device is the industry's first Wi-Fi CERTIFIED chip used in the wireless networking solution. The CC3100 device is part of the new SimpleLink Wi-Fi family that dramatically simplifies the implementation of Internet connectivity. The CC3100 device integrates all protocols for Wi-Fi and Internet, which greatly minimizes host MCU software requirements. With built-in security protocols, the CC3100 solution provides a robust and simple security experience (TI CC3100, p. 2).
- MSP432: All pins of the MSP-EXP432PxR device are fanned out for easy access. These pins make it easy to plug in 20-pin and 40-pin BoosterPack modules that add additional functionality including Bluetooth low energy, Wi-Fi wireless connectivity, and more.

II. Proposed Timeline

October 2020													November 2020								
19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9
MSP & ESP8266 Testing																					
				MSP-ESP8266 Testing																	
					Add LCD to project																
						Add DHT11 tp project															
												Project update									
													Use MSP & CC3100								
															Overall Test						
																Final report					

(…Grant chart **in progress**…)

Note on 10-26-2020: implementation of MSP432-LCD-ESP8266-DHT11 in progress. CC3100 may be added and to remove ESP8266.

III. Bill of Materials

(…**in progress**…giving the orientation, we might add or remove some components)

Device	Description	Cost	Observation	URL
MSP432	Development board		In class Kit project	
CC3100	IoT device	$20.00	In-class Kit project	https://www.ti.com/tool/CC3100BOOST?DCMP=432&HQS=ep-mcu-msp-432-pr-evm-cc3100boost-en#order-start-development
Miscellaneous	Other cost	$10.00		
TOTAL COST		$30.0		

IV. Trade Study

The project started with a vision to connect a Quade to the MSP432, a DHT11 sensor, an LCD, an ESP8266. As time passed, we couldn’t get the ESP8266 to work properly in CCS. Therefore, focus has been changed to use a different IoT device, the CC3100 Boosterpack. Because of its versatility, CC3100 has a complete and self-contained Wi-Fi networking capabilities, and a Booster TCP/IP stack. The LCD 16x2, and the DHT11 have been removed from the main project for the project emphasizes on Internet of Thing connectivity. The concept has been proven in this project. Additional works could be added to the current project to make it more practical. For instance, MSP432 and CC3100 could be connected to Quade hardware system and the overall remotely control.

V. Theoretical Analysis

Although the CC3100, a Wireless Network Processor with on-chip Wi-Fi, internet, and robust security protocols can be used to connect any low-cost, low-power microcontroller (MCU) to the Internet of Things (IoT), a CC3200 would be preferred for a serious IoT application that requires real time responsivity. the CC3100 can only handle some small package size. A CC3200, a Wireless MCU integrating high-performance ARM Cortex-M4 MCU with on-chip Wi-Fi, internet, and robust security protocols would be strongly recommended. It can be used to develop an entire IoT application with a single IC. Additional, at this time, November 2020, there is only a minimal difference of five dollars. Overall, the CC3100 has been used to create a station, which can be used to remotely control some states or actions.

VI. Version Control Repository Set Up

A new repository has been created on the trunk evso9816.
The address is: https://github.com/evso9816/Embeddedd-App-ECE2440

All update can be found at this repository.

References

(…**in progress**…)

1. TI CC3100 SimpleLink™ Wi-Fi® and IoT Solution BoosterPack Hardware, can be found at: https://www.ti.com/lit/ds/swas031d/swas031d.pdf?ts=1604303858023&ref_url=https%253A%252F%252Fwww.google.com%252F
2. MSP432P401R SimpleLink™ Microcontroller LaunchPad™ Development Kit (MSP-EXP432P401R), can be found at: https://components101.com/sites/default/files/component_datasheet/MSP432%20User%20Manual.pdf
3. TI-Cloud-Connected: dev.ti.com
   www.energia.nu
   www.temboo.com/hardware/ti

Appendix

This appendix contains the previous design.

I. Functional Block Diagram

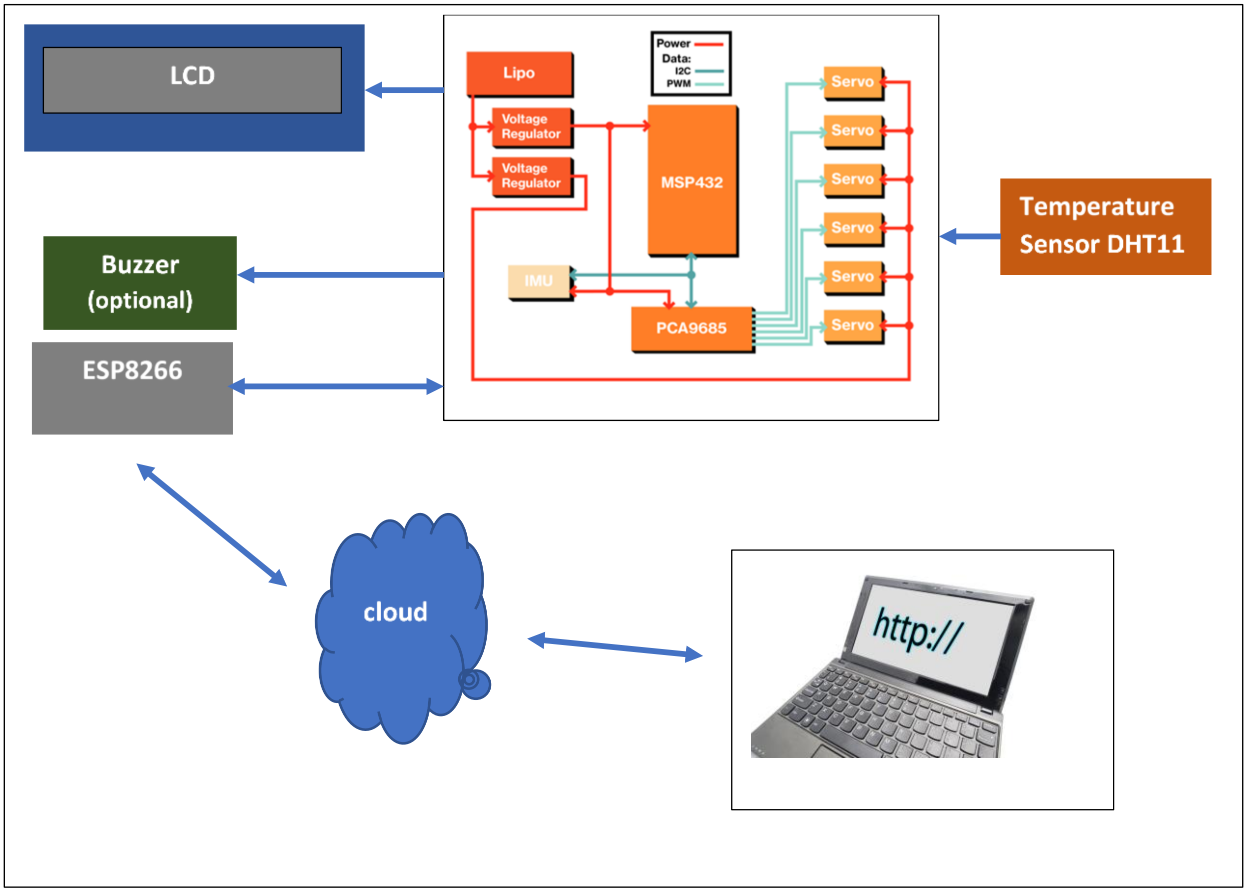
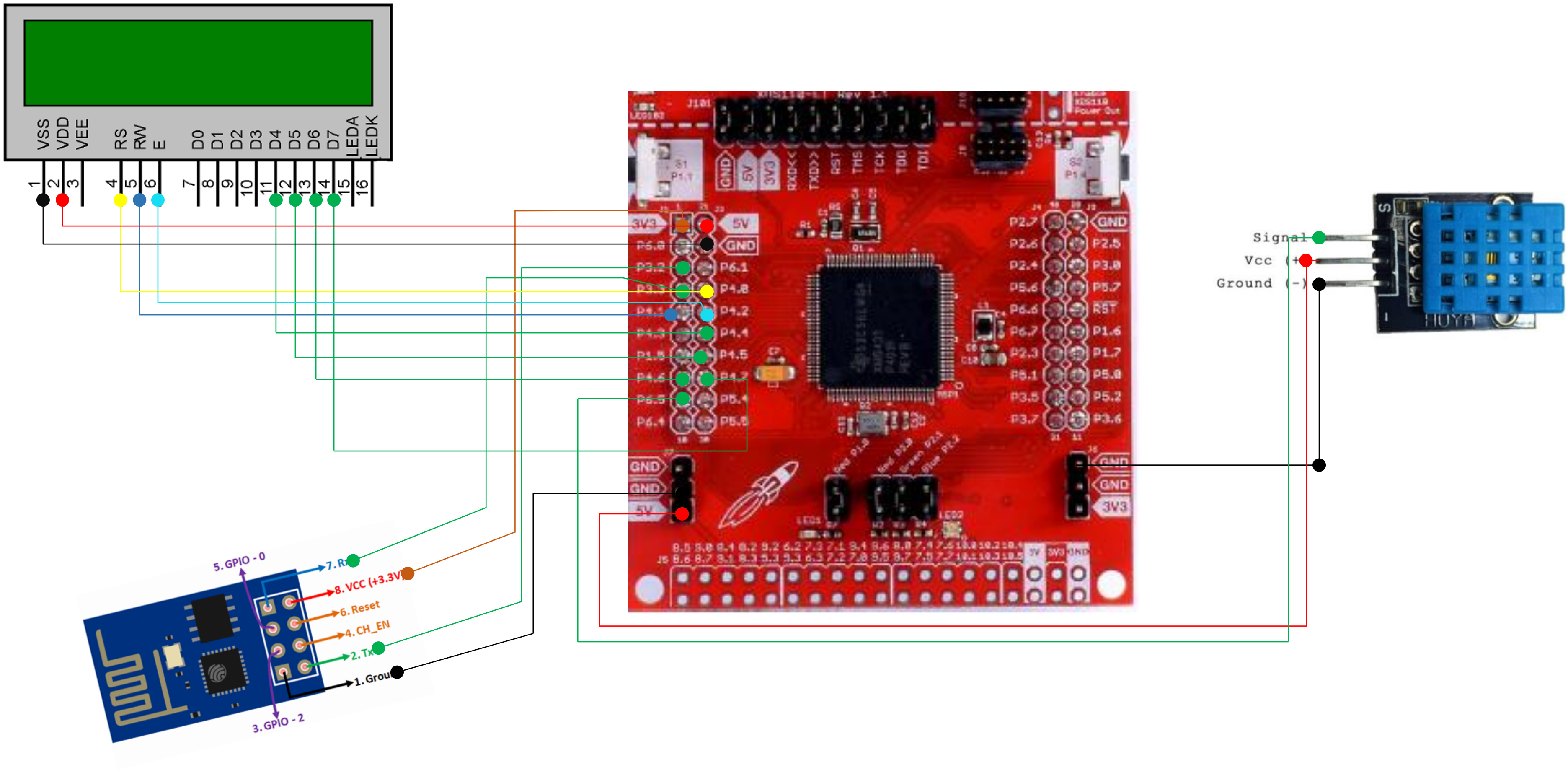


Figure 1: Functional Diagram

In Fig. 1, the LCD, buzzer, ESP8266 and the temperature sensor will be mounted on the Quade.

II. Wiring Diagram



Note: after programming the above peripherals, I never got the ESP8266 connectivity to work properly. As stated previously, the main goal of this project is to emphasis on IoT. Therefore, I changed the hardware configuration to adapt the needs. In a first step, I paired the Wi-Fi CC3100 Boost with the MSP432 to enable flashing, RF performance evaluation and MCU software development using SimpleLink Studio on a PC.

Attempt Design 1 Pins Mapping

MSP432 Microcontroller and LCD1602 pins connection description

MSP432 Microcontroller	LCD1602	Description
GND	GND	Ground (-)
VCC (+5)	VCC (+5)	Source (+)
P4.0	RS	Register Select
P4.1	R/W	Read/Write
P4.2	EN	Enable
P4.4	D4	Data 4
P4.5	D5	Data 5
P4.6	D6	Data 6
P4.7	D7	Data 7

MSP432 Microcontroller and ESP8266 pins connection description

MSP432 Microcontroller	ESP8266	Description
GND	GND	Ground (-)
3V3	3V3	Source (+)
P3.2	TxD	Transmit Data
P3.3	RxD	Receive Data

MSP432 Microcontroller and DHT11 pins connection description

MSP432 Microcontroller	DHT11	Description
GND	GND	Ground (-)
VCC(+5)	VCC (+5)	Source (+)
P6.5	DOUT	Transmit Data

VII. Project Requirement

(…**in progress**… Update is made as the implementation goes)

This project embedded many subsystems that interact with each other. The following will be required to make the project successful:

- Buzzer: an alarm is triggered when a defined particular action is true [defined actions are still in progress]. The buzzer is physically connected to the Quad to some pins illustrated on the wiring diagram. A program module is required to act upon a given action from the Quad.
- LCD1602: it will display a set of state that we are still defining
- ESP8266: this radio connection is shown on the wiring diagram and operates on the 2.4GHz transceiver band with high speed clock generators and crystal oscillator. The ESP8266 supports the frequency channels 2447MHz, 2452MHz, 2457MHz, and 2462MHz (Espressif ESP8266EX Datasheet, p.17). A program module is required to allow an interaction between Quad – ESP8266 – Remote user actions.
- Temperature Sensor (undecided, but DHT11 is likely to be used): the sensor is connected to some pins illustrated on the wiring diagram. It measures the temperature and humidity of the field. Data can be displayed on the LCD or transmitted to the remote user via ESP8266 for further processing.
- Quad system: [description in progress]
- CC3100: The CC3100 device is the industry's first Wi-Fi CERTIFIED chip used in the wireless networking solution. The CC3100 device is part of the new SimpleLink Wi-Fi family that dramatically simplifies the implementation of Internet connectivity. The CC3100 device integrates all protocols for Wi-Fi and Internet, which greatly minimizes

host MCU software requirements. With built-in security protocols, the CC3100 solution provides a robust and simple security experience (TI CC3100, p. 2).

(text needs update)

I. Bill of Materials

(…**in progress**…giving the orientation, we might add or remove some components)

Device	Description	Cost	Observation	URL
ESP8266	Wi-Fi Module		In class Kit project	https://www.mouser.com/ProductDetail/SparkFun/WRL-13678?qs=WyAARYrbSnZdmwzlRTs1Tw%3D%3D&gclid=EAIaIQobChMI9ITJqdTA6gIVE9bACh38gwhOEAQYAiABEgKgZvD_BwE
LCD1602	To display customized information	$9.90	The connection to MSP432 and ESP8266 requires some resistors	https://www.mouser.com/Search/Refine?Ntk=P_MarCom&Ntt=139536055
DHT11	Temperature and humidity sensor	$5.00	The connection to MSP432, ESP8266, and LCD requires some resistors.	https://www.adafruit.com/product/386
Quad	Quadruped robot using MSP432 and additional supports	$95.00	In-class Kit project	
Miscellaneous	Additional cost	$10.00		
TOTAL COST		$129.9		