eLearning

Wi-Fi® SoC Module *WFI32E01*

參考範例應用篇

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

King Chou, Pr. ESE

2021

Microchip - Chinese [Traditional]

199 位訂閱者

已訂閱

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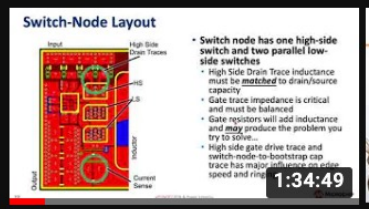

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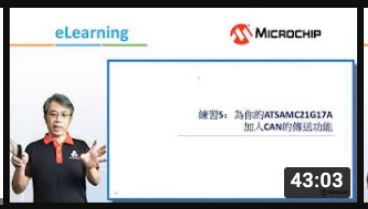

ATSAMC21G17A 101——跟著Microchip使用APP Nano...

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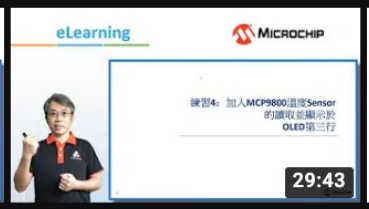

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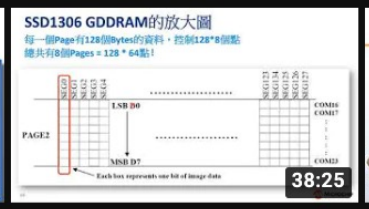

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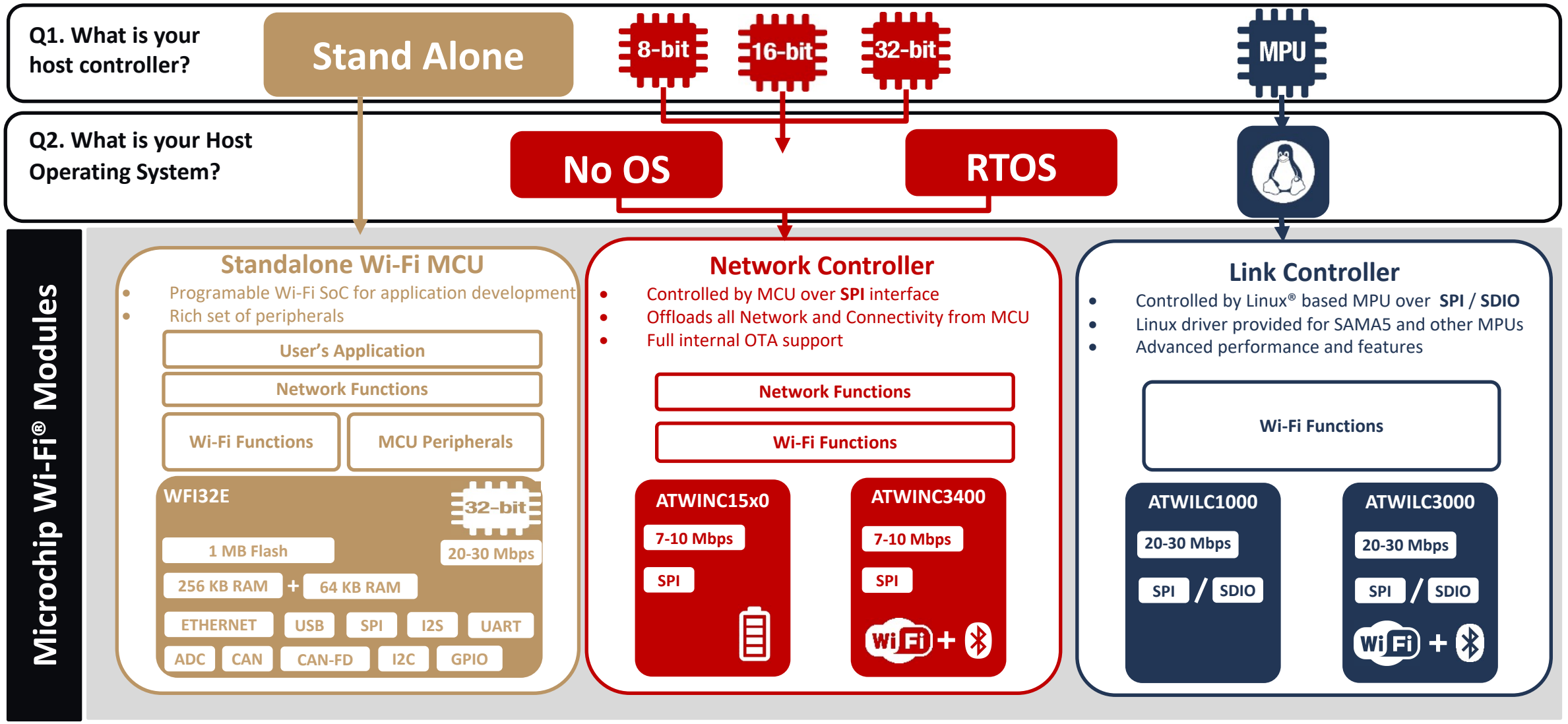
eLearning

Wi-Fi® SoC Module *WFI32E01*
介紹及軟體應用篇

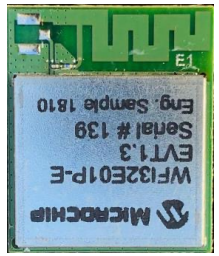
A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

Microchip Wi-Fi® Overview

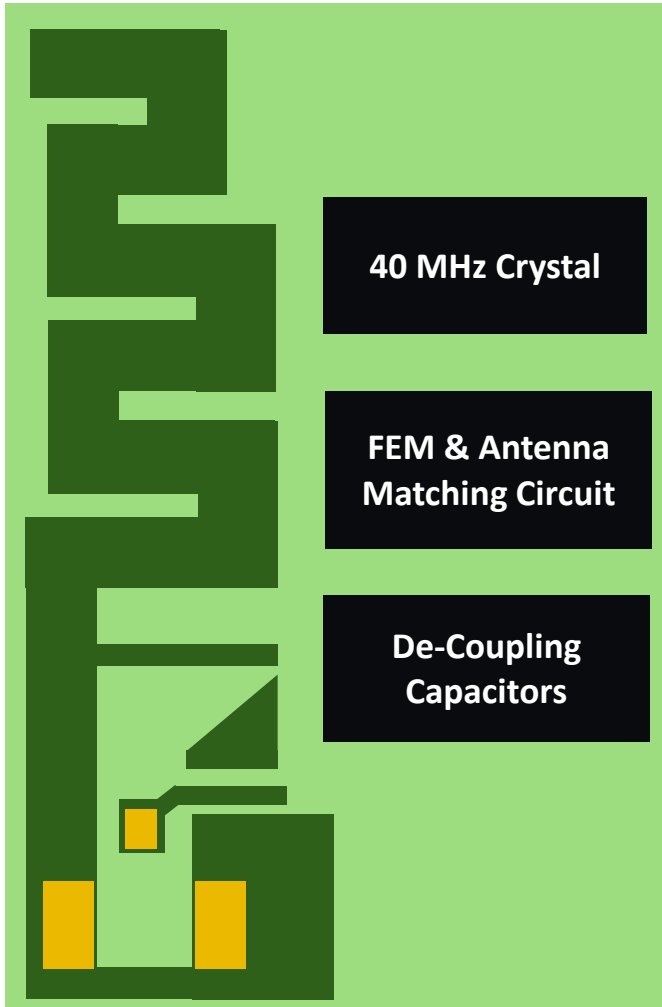


WFI32E01UE

Block Diagram for 54-Pad Module



- **Module Package:**
  - 54 pins SMD
  - 24.5 x 20.5 x 2.5 mm
- **Single Supply Voltage**
  - Operating Voltage: 3.0V to 3.6V
- **Operating Temperature:** -40°C to +85 °C



Encryption Engine
Data Crypto – AES, TDES
Public Key – ECC, ECHD, ECDSA, Curve25519, Ed25519

MIPS uAptiv UP Core
- 200 MHz
- FPU / DSP / DMA
- ICSP / Debug

Wi-Fi® 802.11 b/g/n
w/ Low Power Modes

1 MB Embedded Flash

320 KB RAM
- 256 KB SRAM
- 64 KB Wi-Fi Data Buffer

Die Temp Sensor

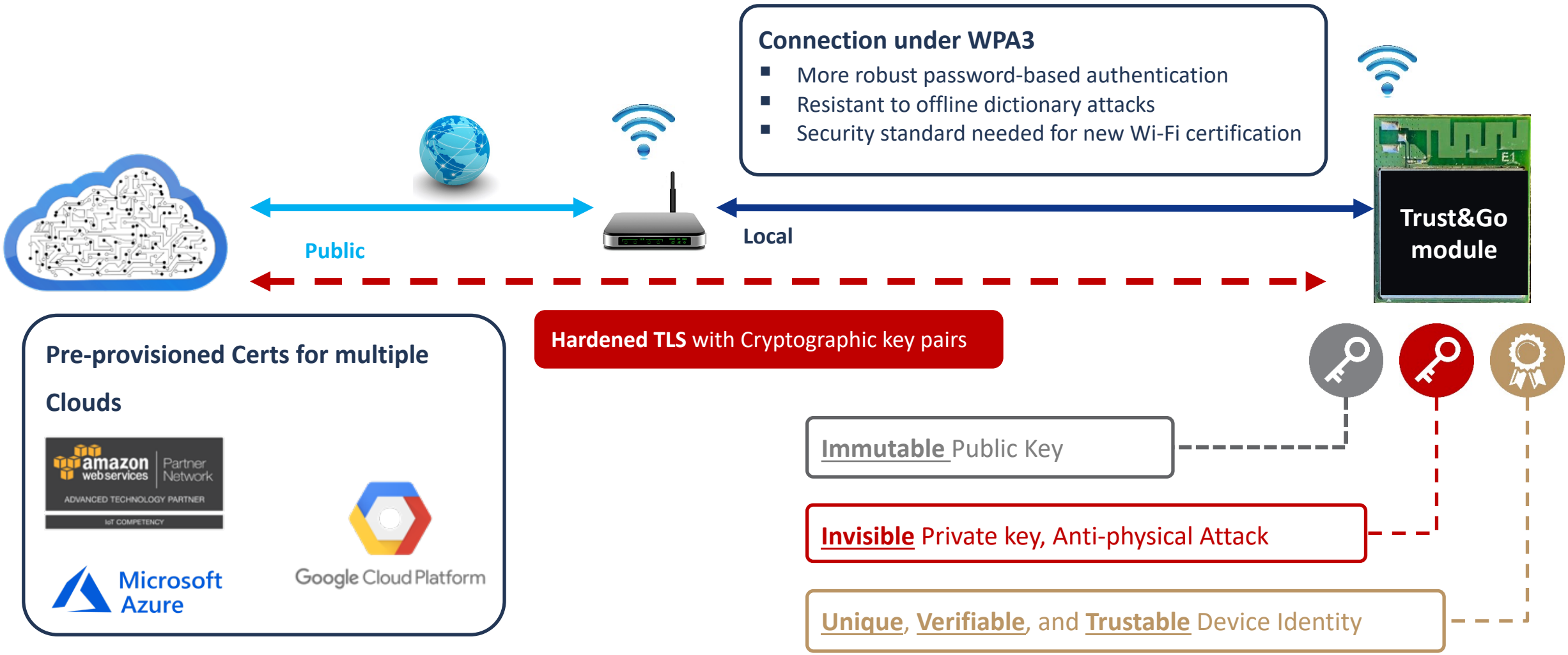
WWDT / DMT

Peripherals & Interfaces

- 8 MHz Internal Osc.
- LPRC, REFO
- 2x12-bit ADC, 1 MSPS, 12 ch.
  - Supports CVD Touch
- 6x32-bit / 16-bit Timers
- 4xCapture/Compare/PWM
- Peripheral Trigger Generator
- USB 2.0 Full Speed
- 10/100 Ethernet (RMII, IEEE1588)
- 3xUART/2xSPI/I²C/SQI/2xI²S
- CAN & CAN-FD
- 37 GPIO

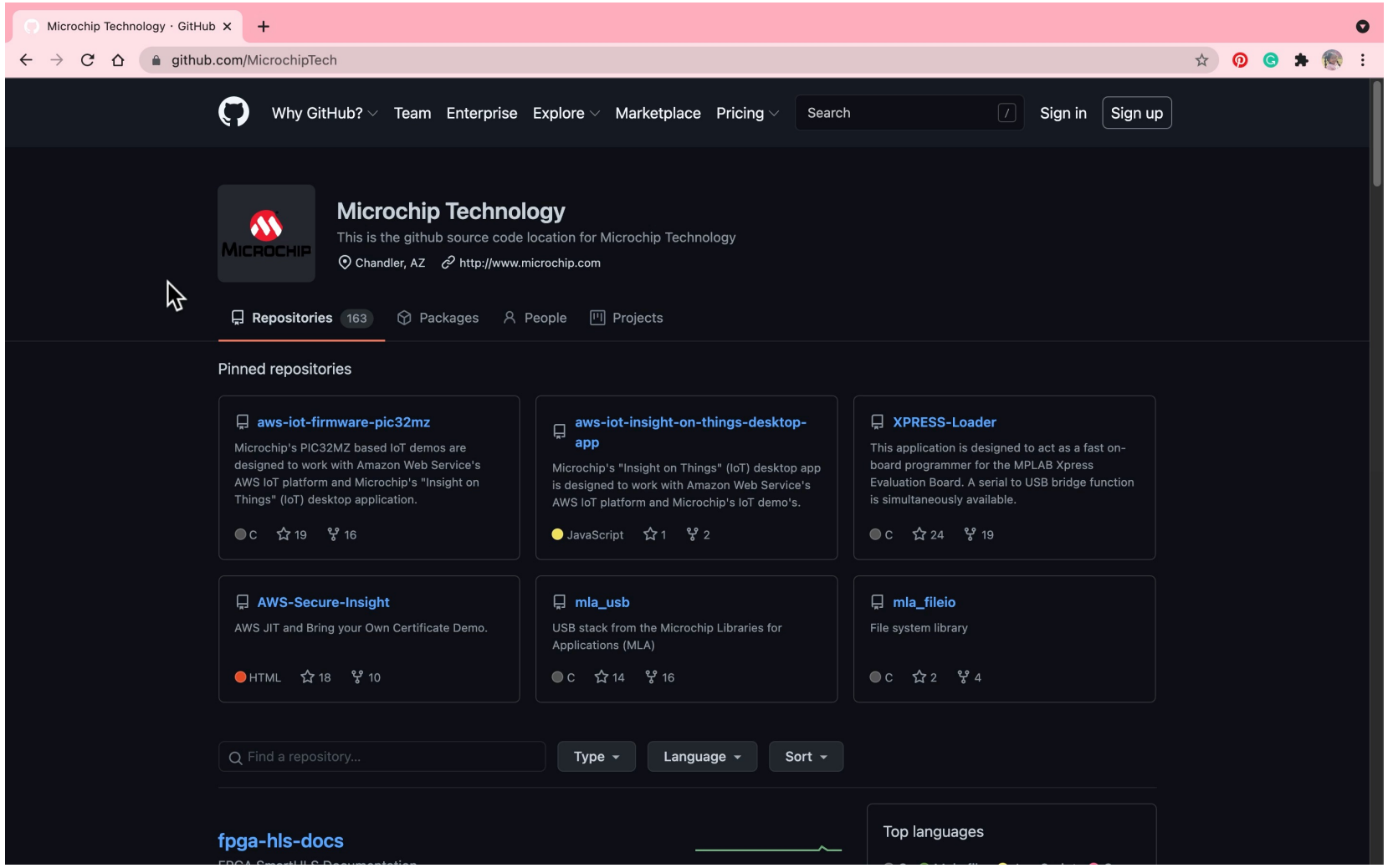
Build a Secure and Trustful IoT Connection

Trust&Go Wi-Fi® module: WFI32E01PC-I



PIC32MZW1_Workshop

- https://github.com/MicrochipTech/PIC32MZW1_Workshop



Agenda

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- **Reference Example Codes**
  - Develop a Secured Smart Home Application from scratch
  - Wi-Fi ® Touch and OLED Display
  - Wi-Fi Provisioning over BLE
  - Wi-Fi to CAN Bus Bridge

MICROCHIP

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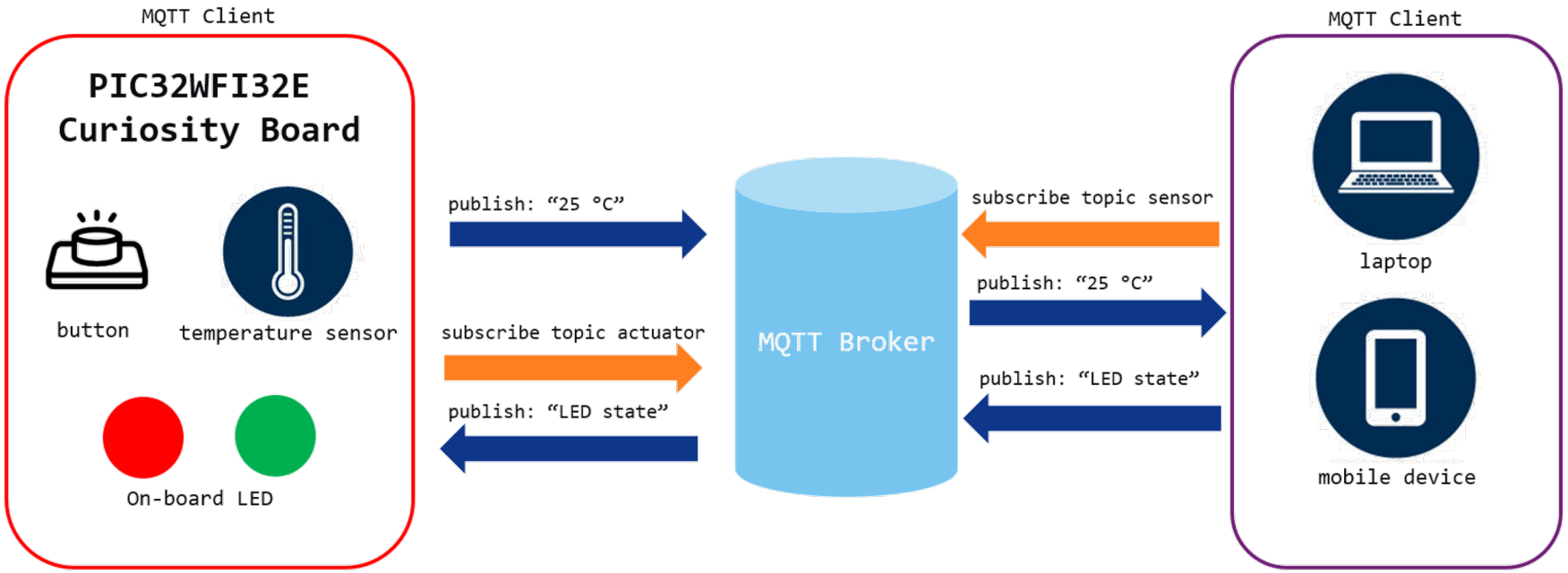
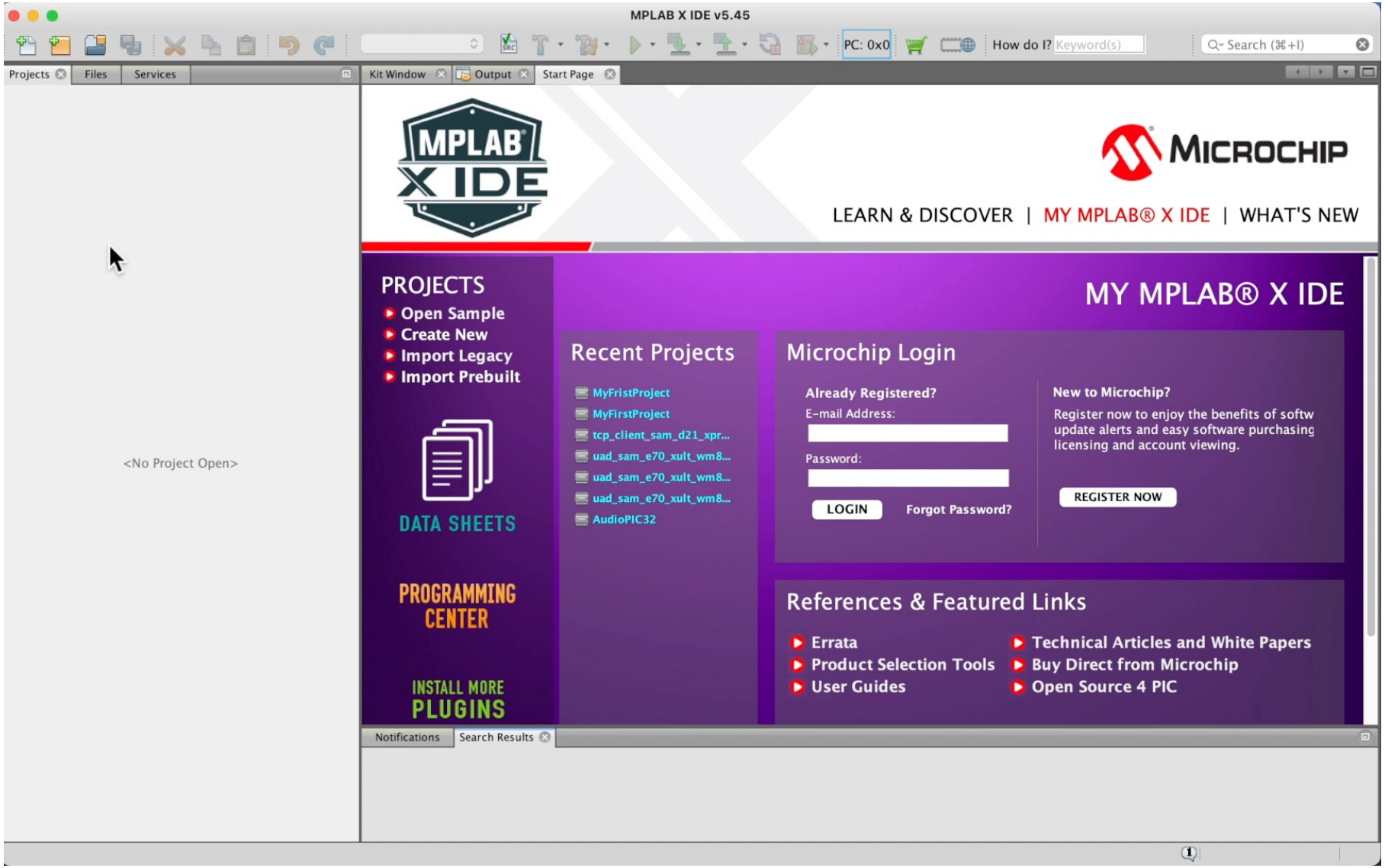
MICROCHIP

Develop a Secured Smart Home Application from scratch

- Make a simple Smart Home device based on WFI32E Curiosity Board connected to an MQTT Broker.
- The object will be monitored and controlled remotely thru a laptop or a mobile device. https://github.com/MicrochipTech/PIC32MZW1_Workshop/tree/master/06_develop



Develop a Secured Smart Home Application from scratch



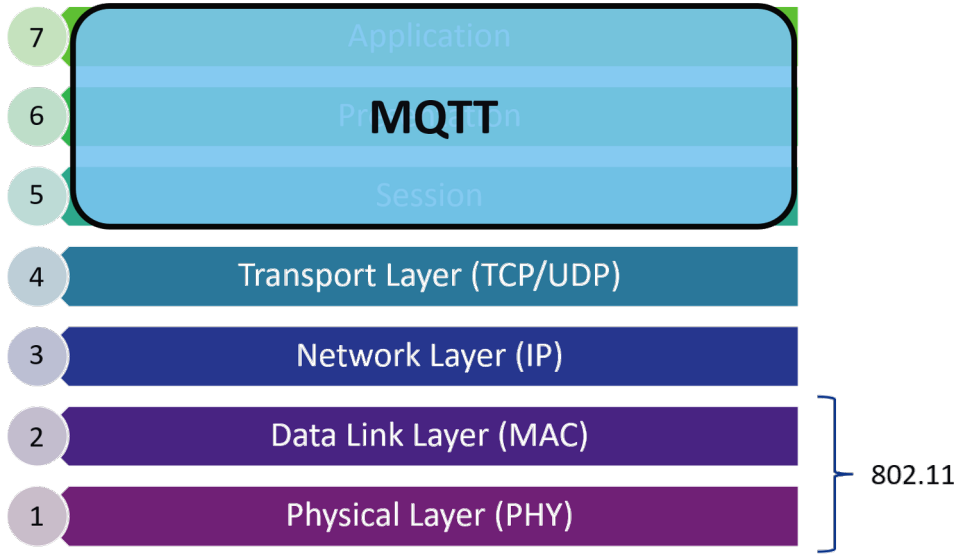
Develop a Secured Smart Home Application from scratch

MQTT Service

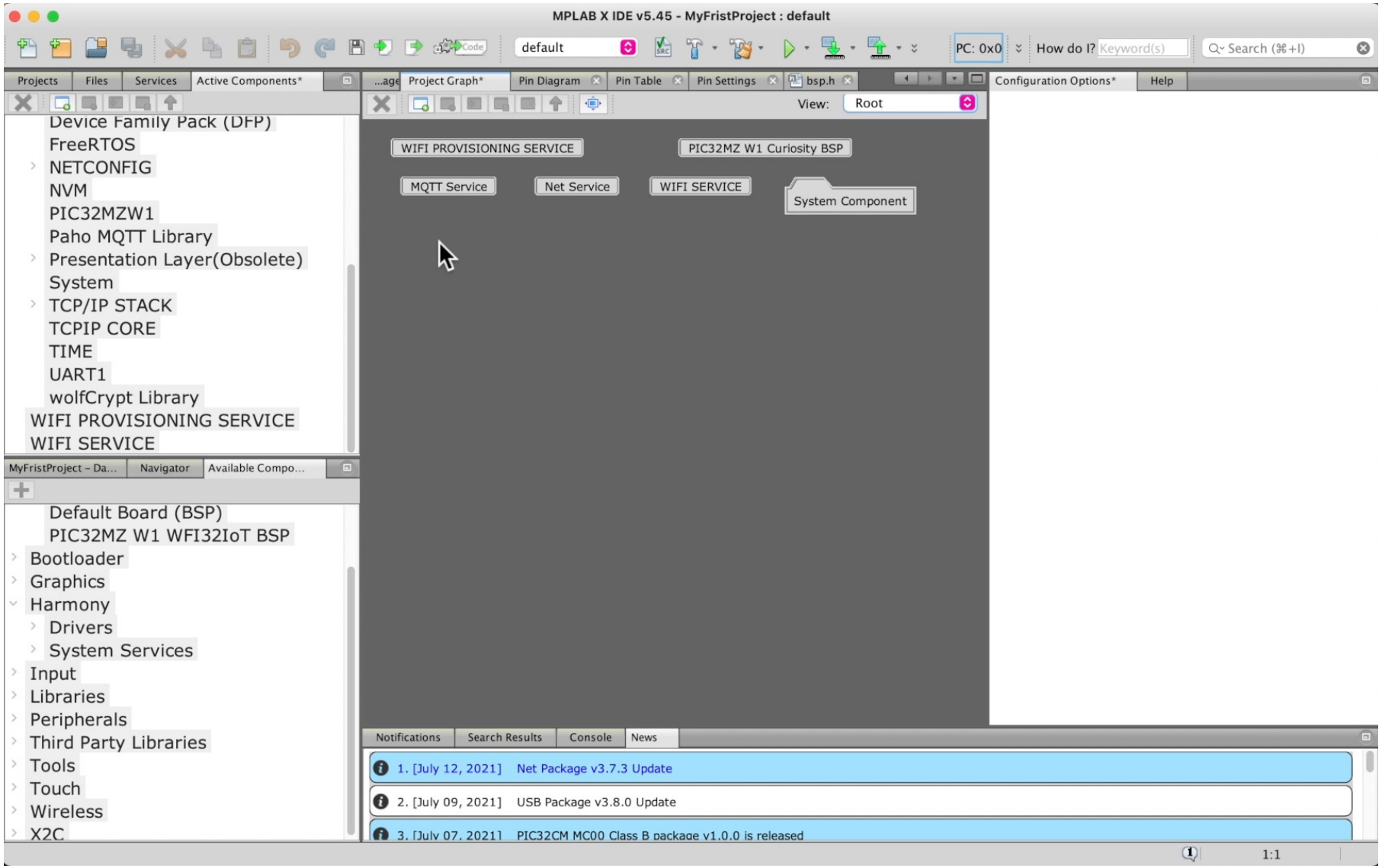
- **MQTT Service is an Harmony Networking layer which include components such as:** ***Net Service, Wi-Fi Service, NVM, Core Timer, UART1, Cryptographic, wolfCrypt Library, Time, Core, FreeRTOS, Console, Command, Debug, PIC32MZW1, Netconfig, TCPIP Core, BA414E, TCP/IP Application Layer Configuration, Netconfig, IPv4, ARP, UDP, ICMPv4, Wi-Fi Provisioning Service, Presentation Layer, Paho MQTT Library,...***

- **Notice that FreeRTOS component has been added and the Application is configured for FreeRTOS support.**

- **The MQTT protocol is based on TCP/IP. Both the client and the broker need to have a TCP/IP stack.**

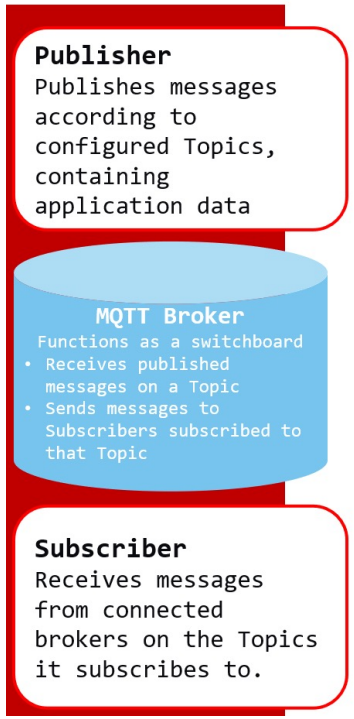


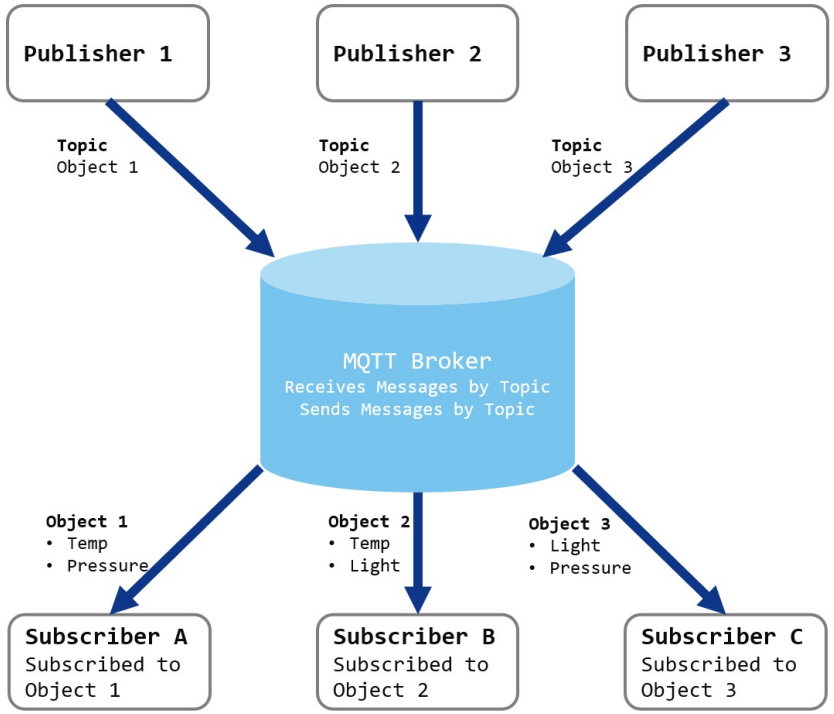
Develop a Secured Smart Home Application from scratch



Develop a Secured Smart Home Application from scratch

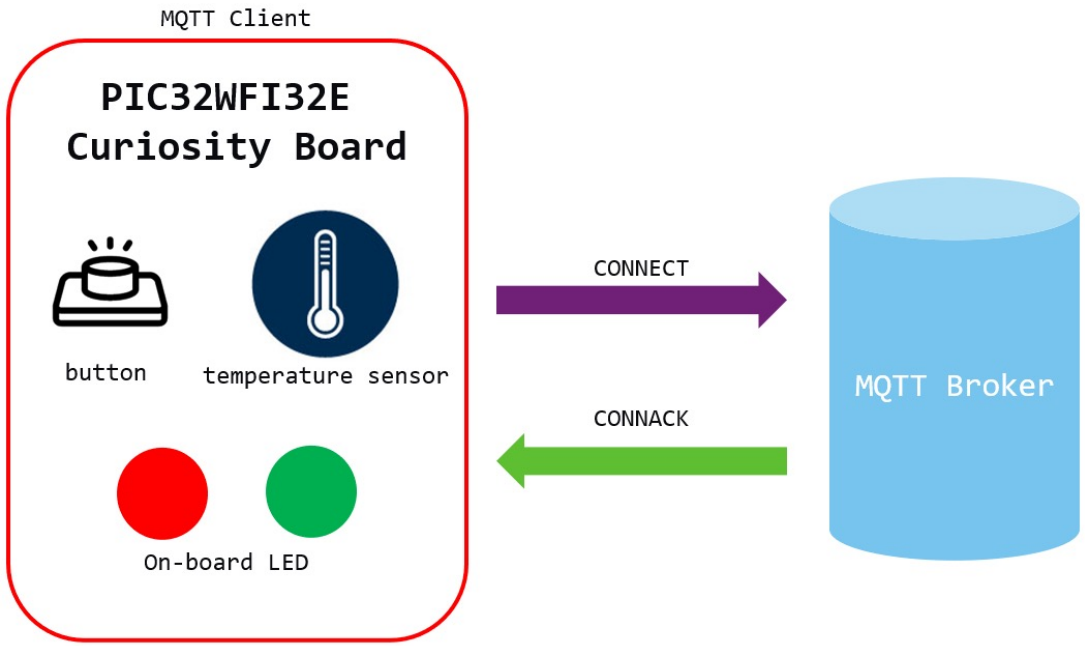
- To share information between MQTT clients over MQTT broker, you need to provide MQTT topics which is nothing more than a form of addressing. The MQTT connection is always between one client and the broker. Clients never connect to each other directly.





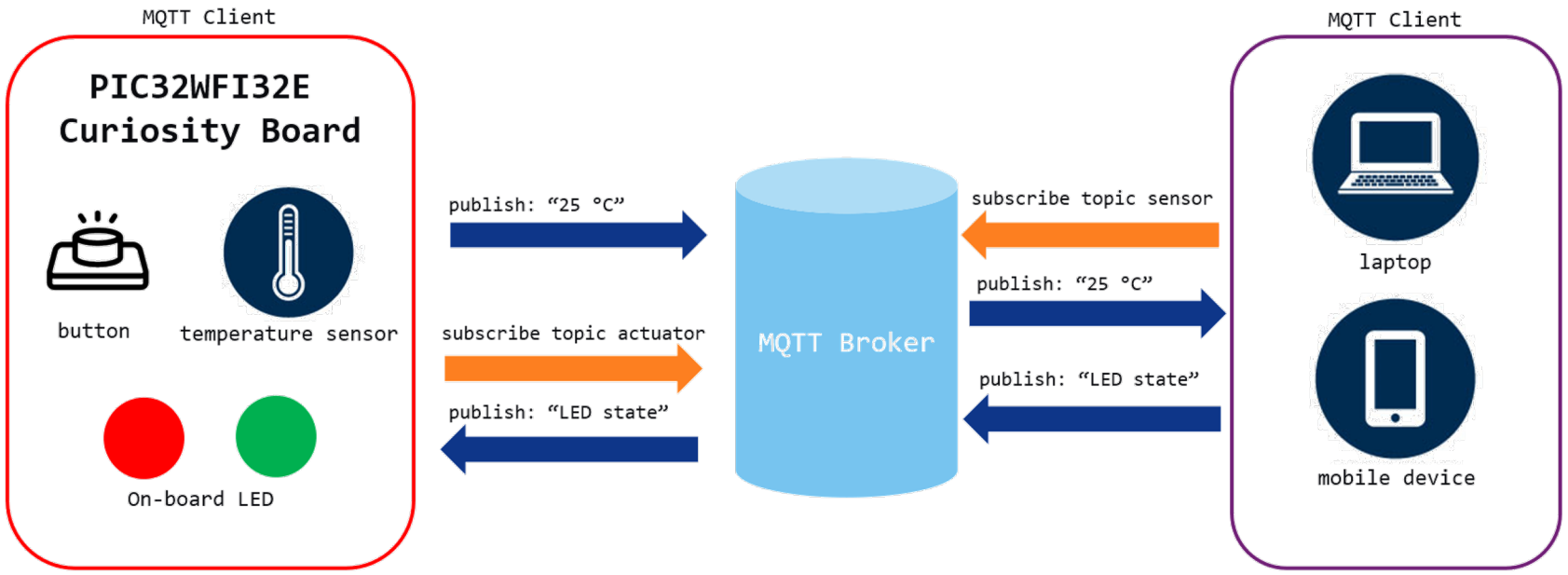
Develop a Secured Smart Home Application from scratch

- First, the client (PIC32MZ W1) sends a **CONNECT** message to the broker to initiate a connection
- The broker responds with a **CONNACK** message and a status code.
- Once the connection is established, the broker keeps it open until the client sends a disconnect command or the connection breaks.



Develop a Secured Smart Home Application from scratch

- The client (PIC32MZ W1) should subscribe to a topic to receive the command messages that another client sends for changing the state of the actuator (PIC32MZW1's on-board LED).
- The client (PIC32MZ W1) should publish sensor data to Broker over another topic. Thus, another client will be able to monitor the data.



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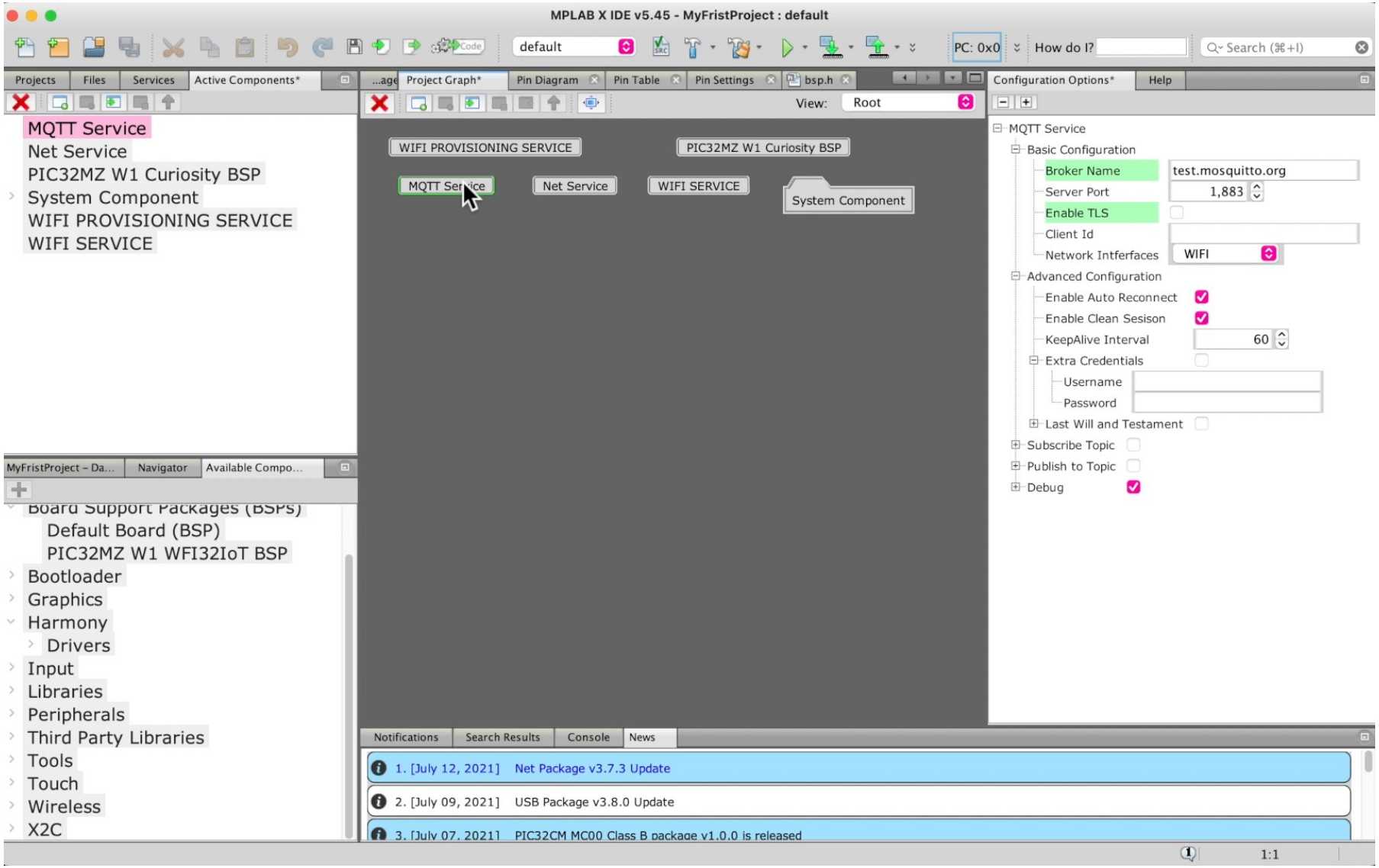
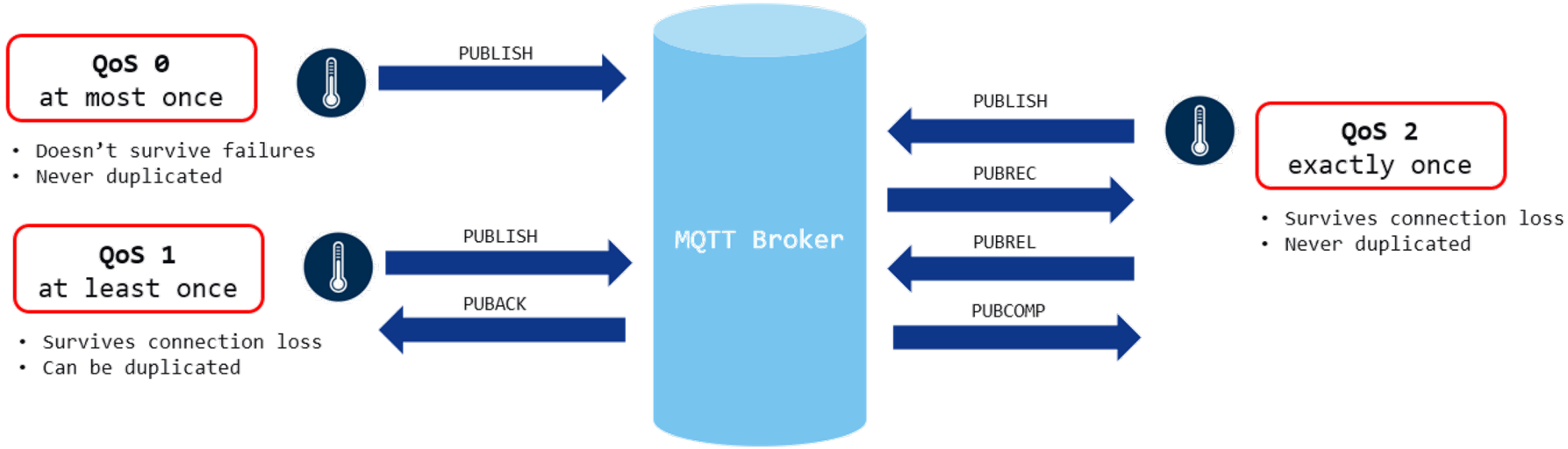


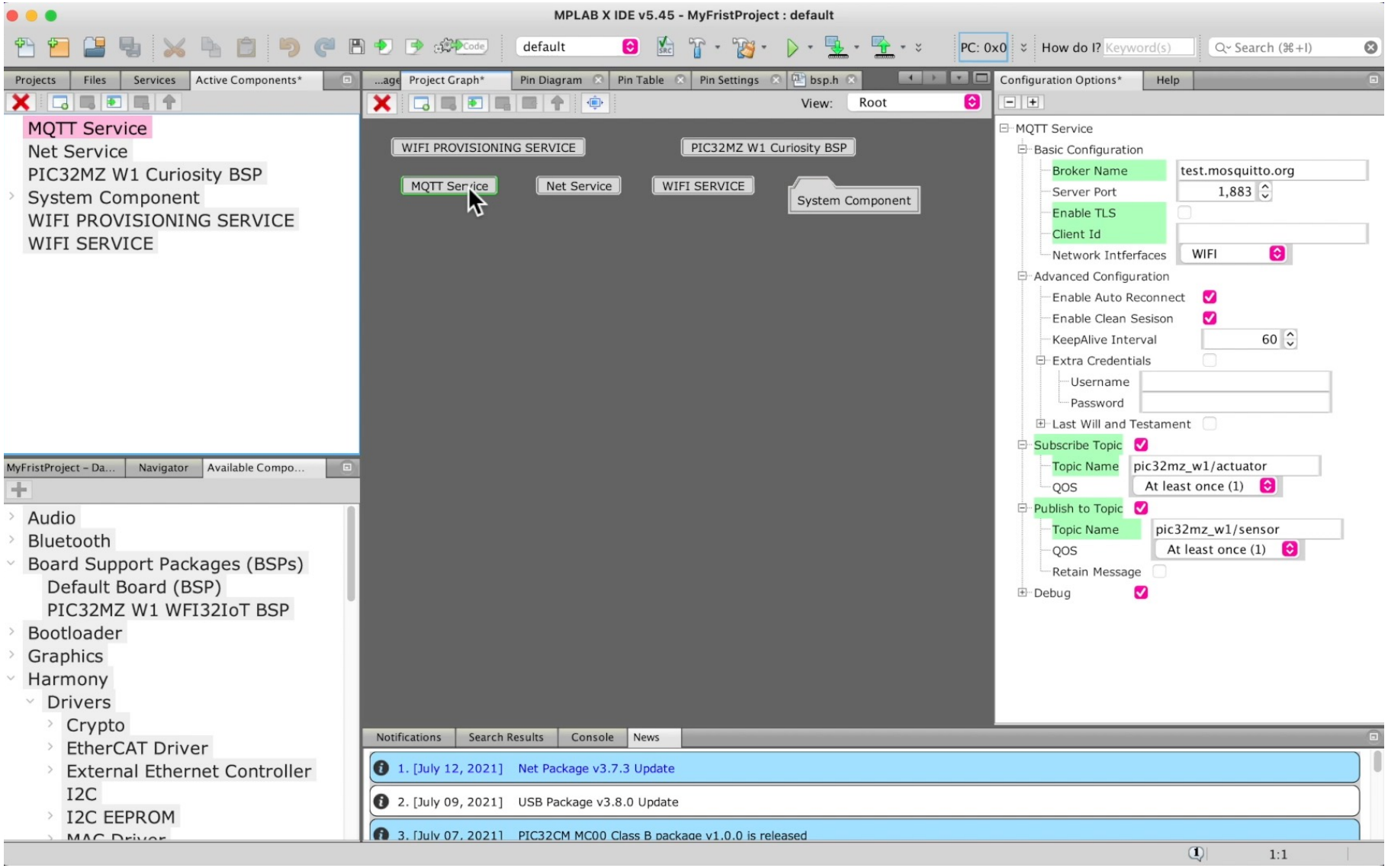
Develop a Secured Smart Home Application from scratch

QoS (Quality of Service) contains 3 levels for the messages emitted:

- ***QoS 0*** guarantees that the message is delivered ***at most once***, or it is not delivered at all. The sender does not care about the message after broadcasting (fire and forget).
- ***QoS 1*** guarantees that the message is always delivered ***at least once***. If the sender does not receive an acknowledgement, the message can be sent multiple times.
- ***QoS 2*** guarantees that the message is always delivered ***exactly once*** and no messages are lost. This is ensured by a two-step confirmation with additional messages.



Develop a Secured Smart Home Application from scratch



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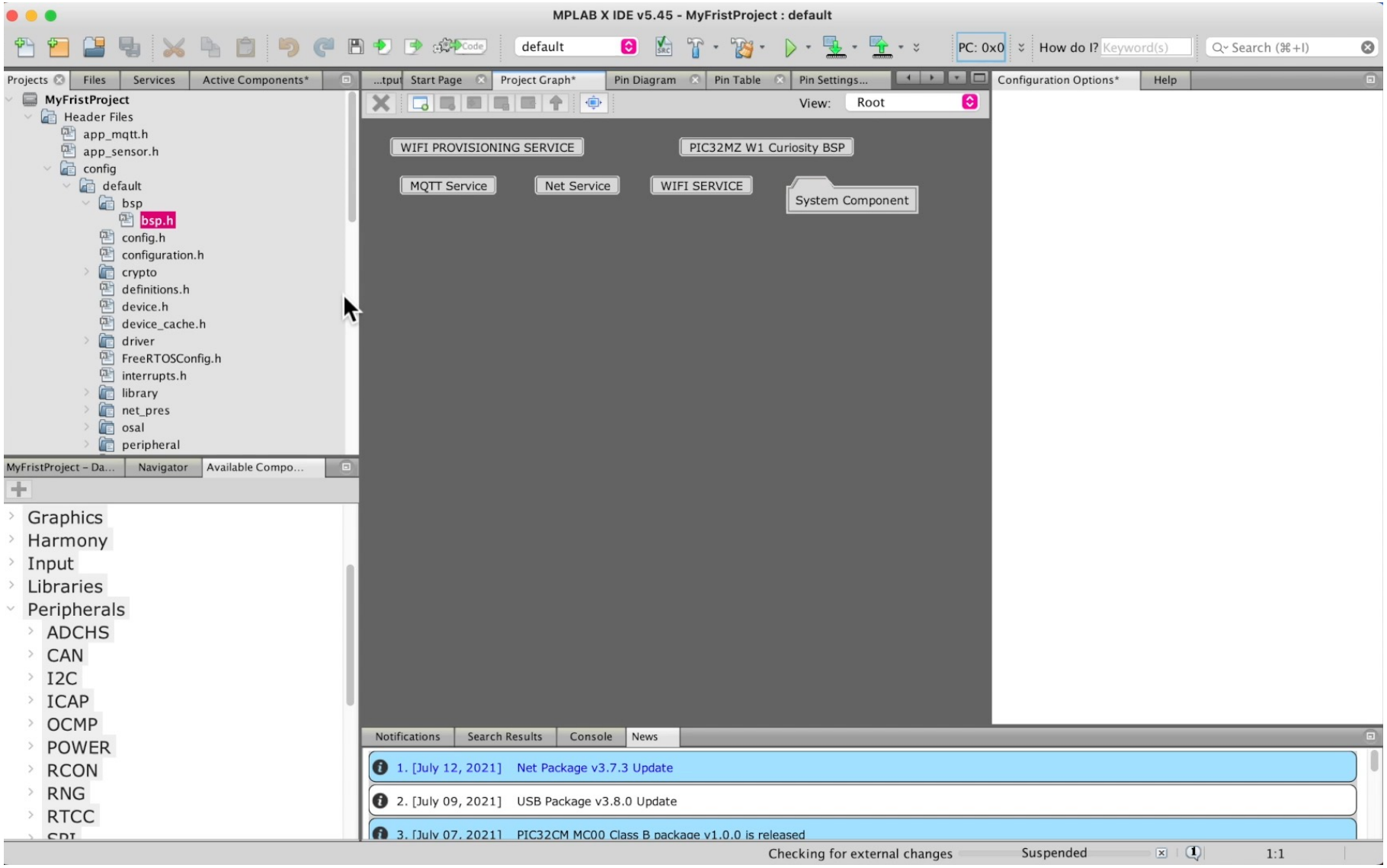

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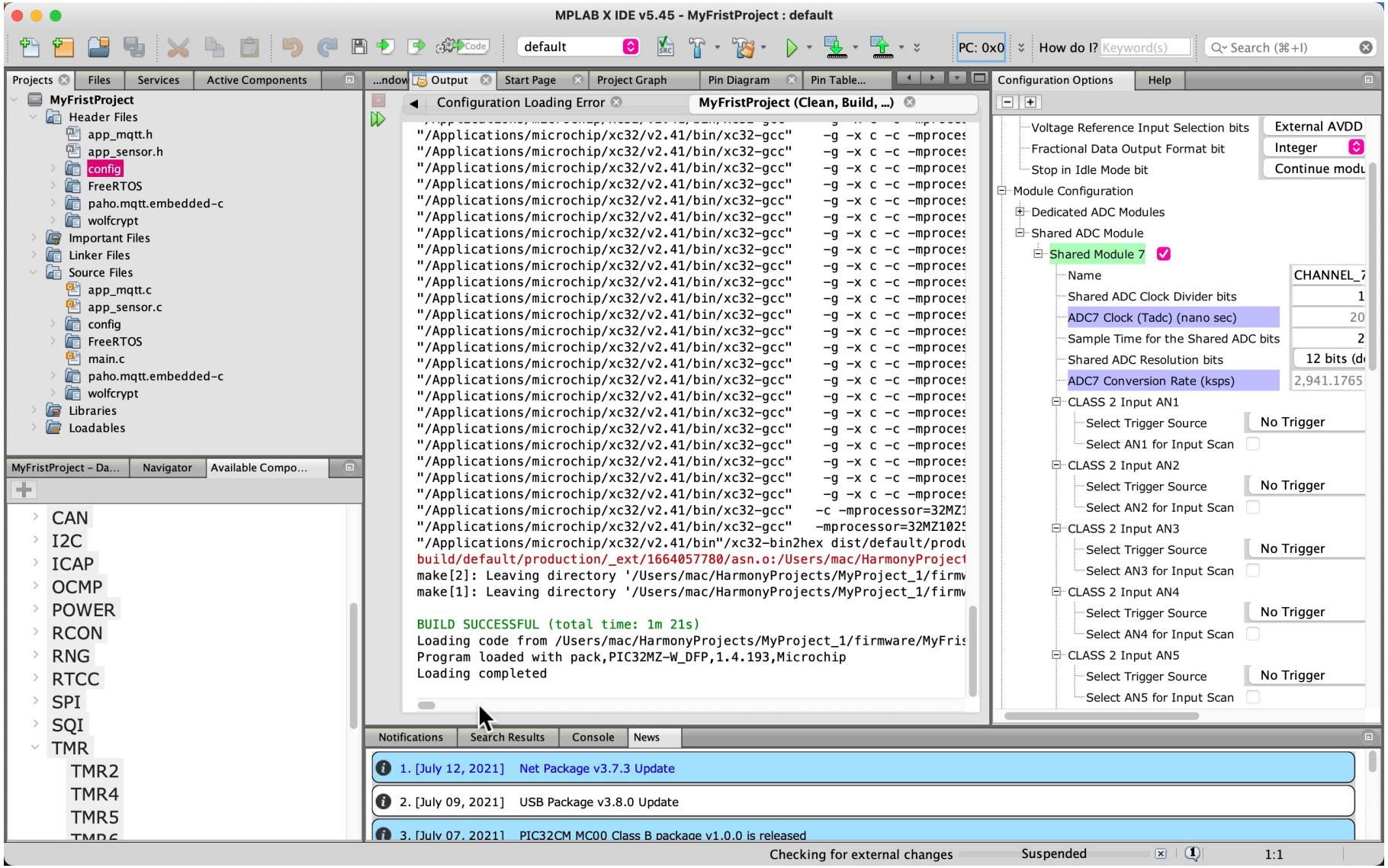
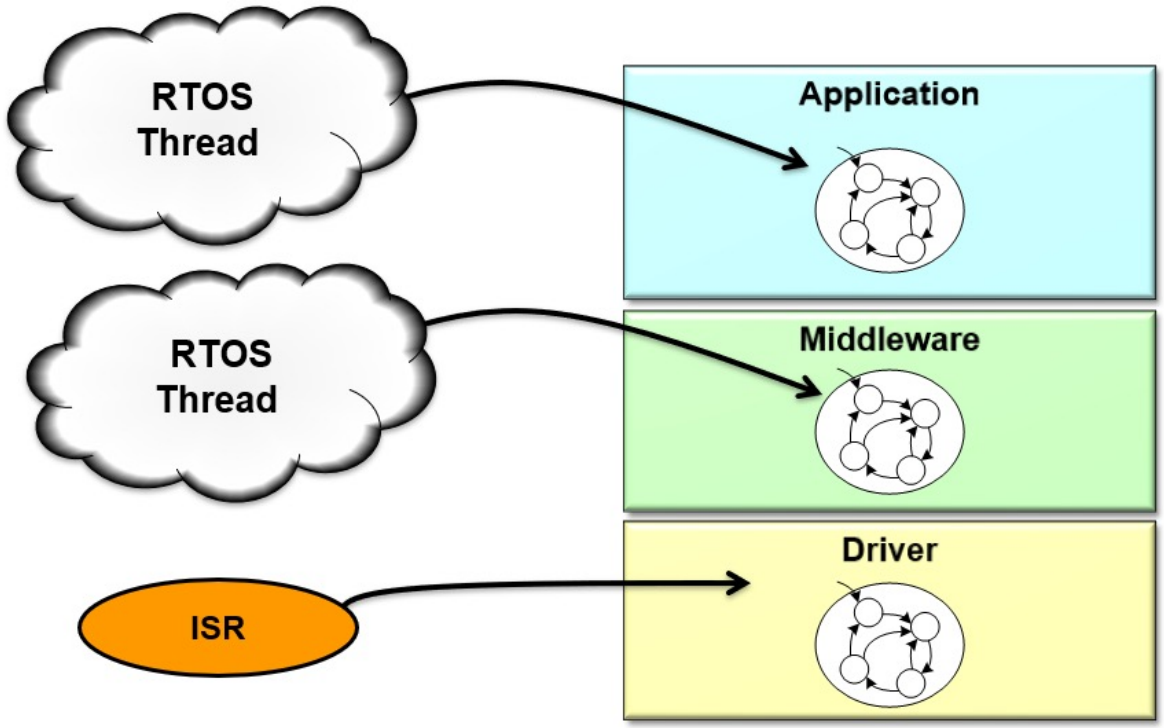


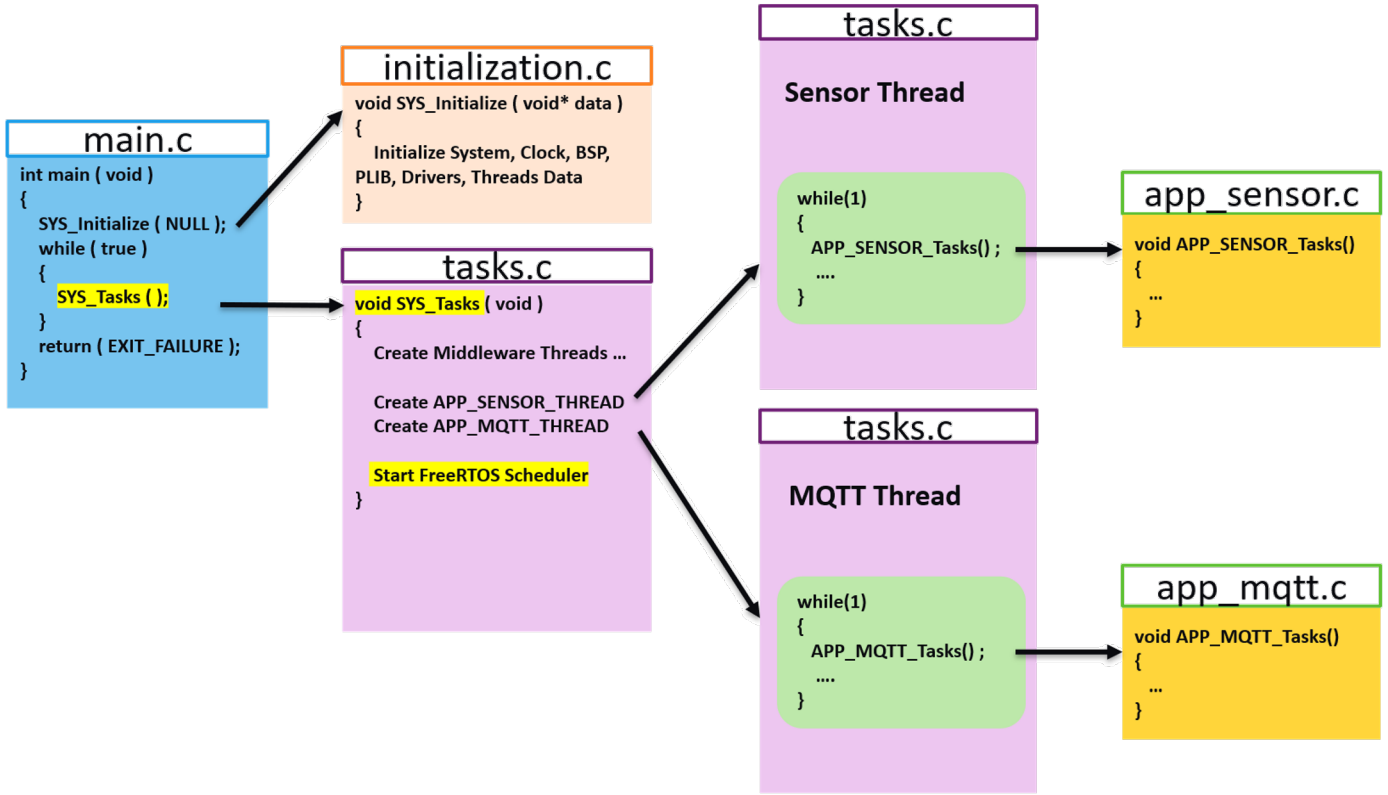
Develop a Secured Smart Home Application from scratch

- The project is using FreeRTOS library to create application threads & intercommunicate between application threads.
- Allows the individual task to be assigned a priority
- Interrupts support the best real-time response latency



Develop a Secured Smart Home Application from scratch

- The System task routine then calls the RTOS scheduler, thereafter all RTOS threads will be managed by the scheduler and the **SYS_Tasks** function will not return.
- MHC also generates the individual daemon threads that will run the MPLAB Harmony libraries and the application tasks (**_APP_SENSOR_Tasks** and **_APP_MQTT_Tasks**).



Develop a Secured Smart Home Application from scratch

- The **main.c** file calls the **SYS_Tasks()** routine, which create the sensor and MQTT threads and makes a call to FreeRTOS API **vTaskStartScheduler()** to start the scheduler.

tasks.c

```
void _APP_SENSOR_Tasks(  void *pvParameters  )
{
    while(1)
    {
        APP_SENSOR_Tasks();
        vTaskDelay(50 / portTICK_PERIOD_MS);
    }
}

void _APP_MQTT_Tasks(  void *pvParameters  )
{
    while(1)
    {
        APP_MQTT_Tasks();
        vTaskDelay(50 / portTICK_PERIOD_MS);
    }
}

void SYS_Tasks ( void )
{
    xTaskCreate((TaskFunction_t) _APP_SENSOR_Tasks, "APP_SENSOR_Tasks", 1024, NULL, 1, &xAPP_SENSOR_Tasks);
    xTaskCreate((TaskFunction_t) _APP_MQTT_Tasks,   "APP_MQTT_Tasks", 1024, NULL, 1, &xAPP_MQTT_Tasks);

    vTaskStartScheduler(); /* This function never returns. */
}
```

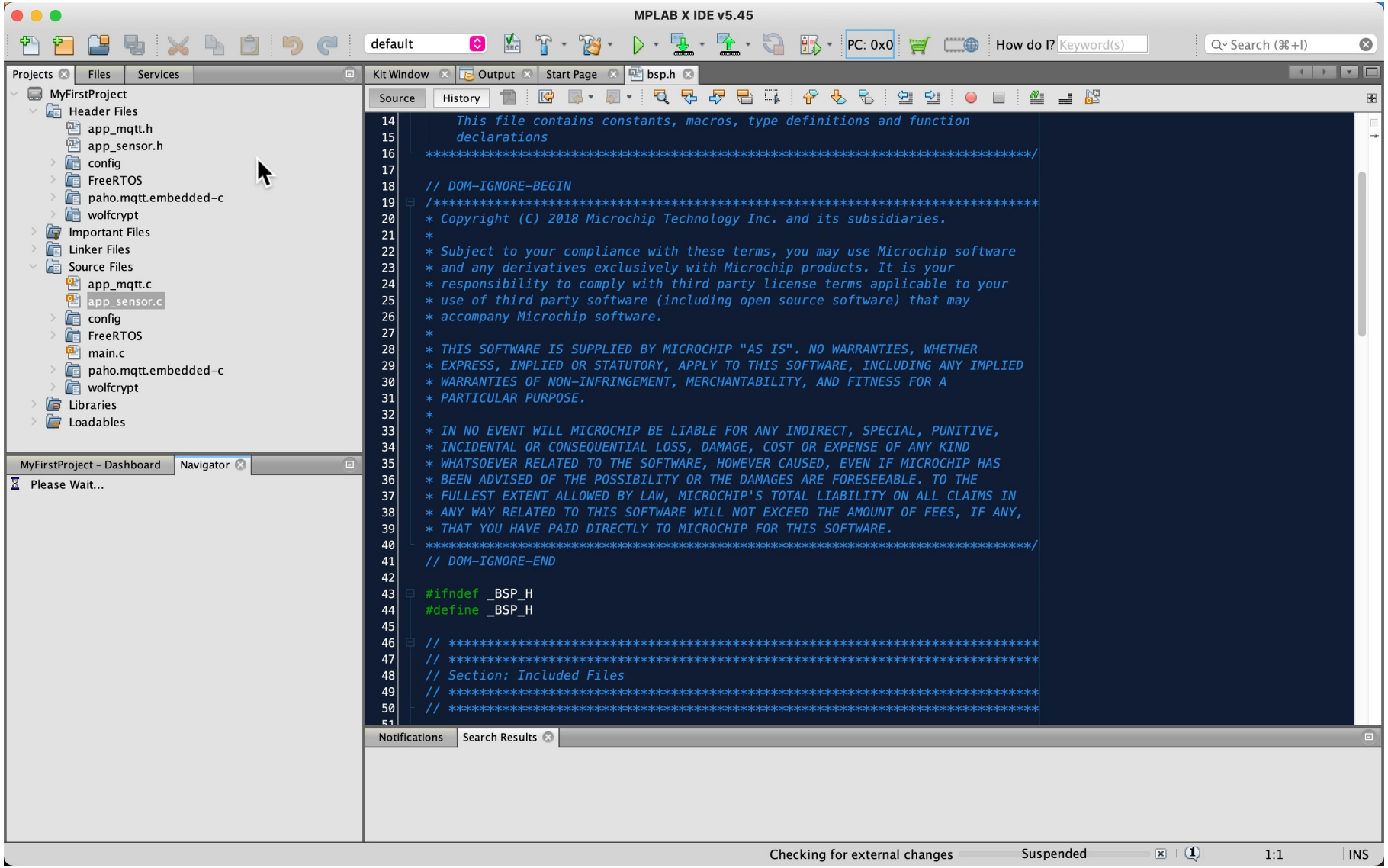
Thread Functions

FreeRTOS Specific

Develop a Secured Smart Home Application from scratch

- The MPLAB® Harmony components configured for MQTT and RTOS based application and you are ready to begin developing your application logic of two independent Application Tasks.
  - **_APP_SENSOR_Tasks**
  - **_APP_MQTT_Tasks**
    - pusblishing data to temperature topic
    - subscribing to actuator topic and control the on-board LEDs
  - The application is already developed and is available in the files:
    - app_sensor.c,
    - app_sensor.h,
    - app_mqtt.c,
    - app_mqtt.h

Develop a Secured Smart Home Application from scratch



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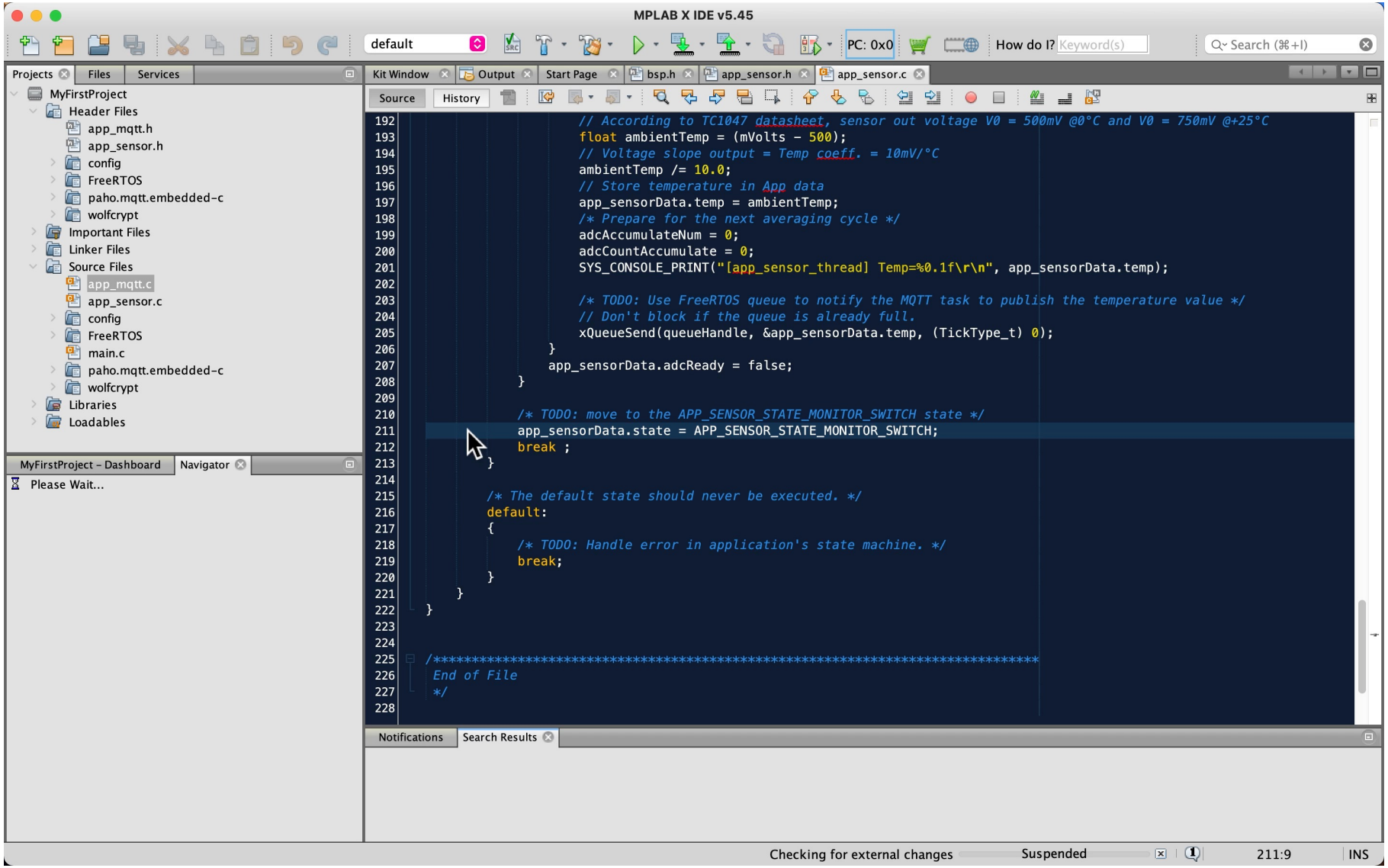

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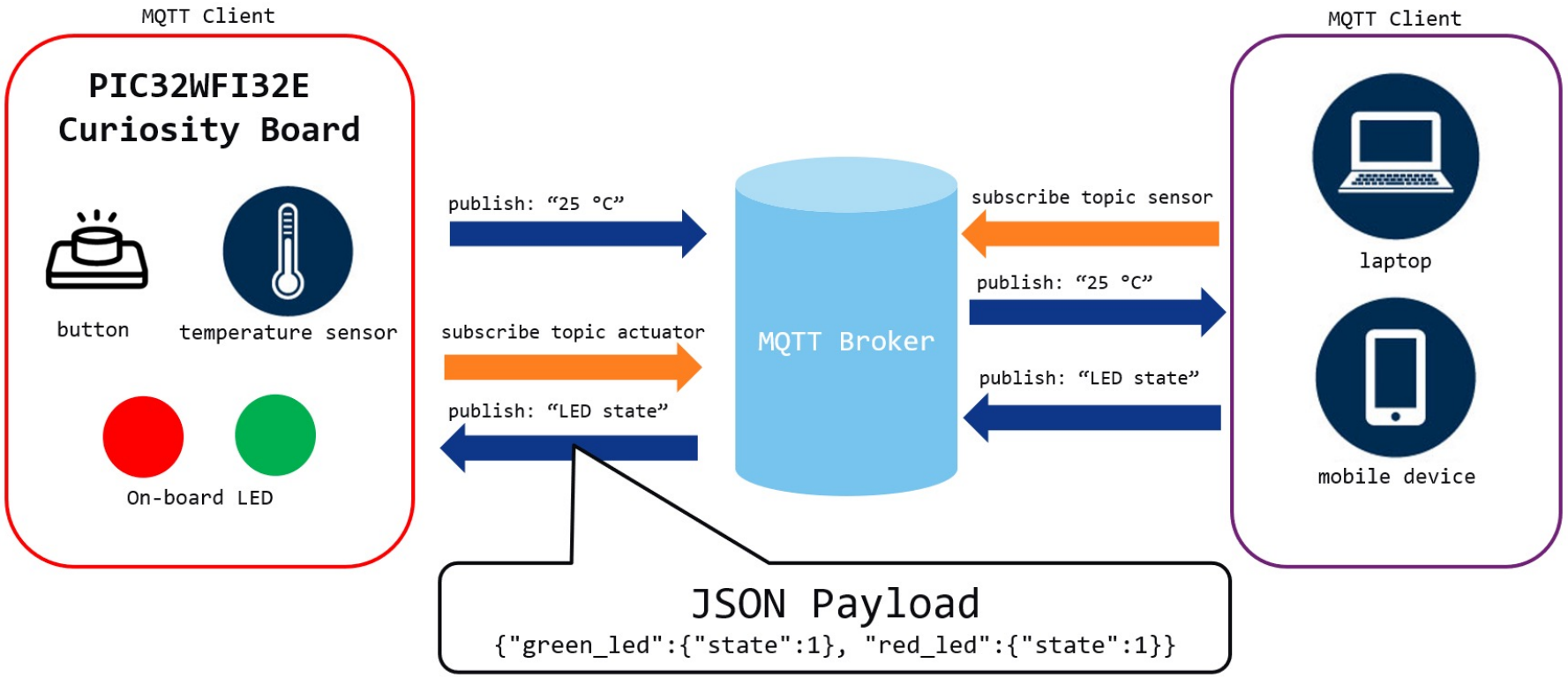
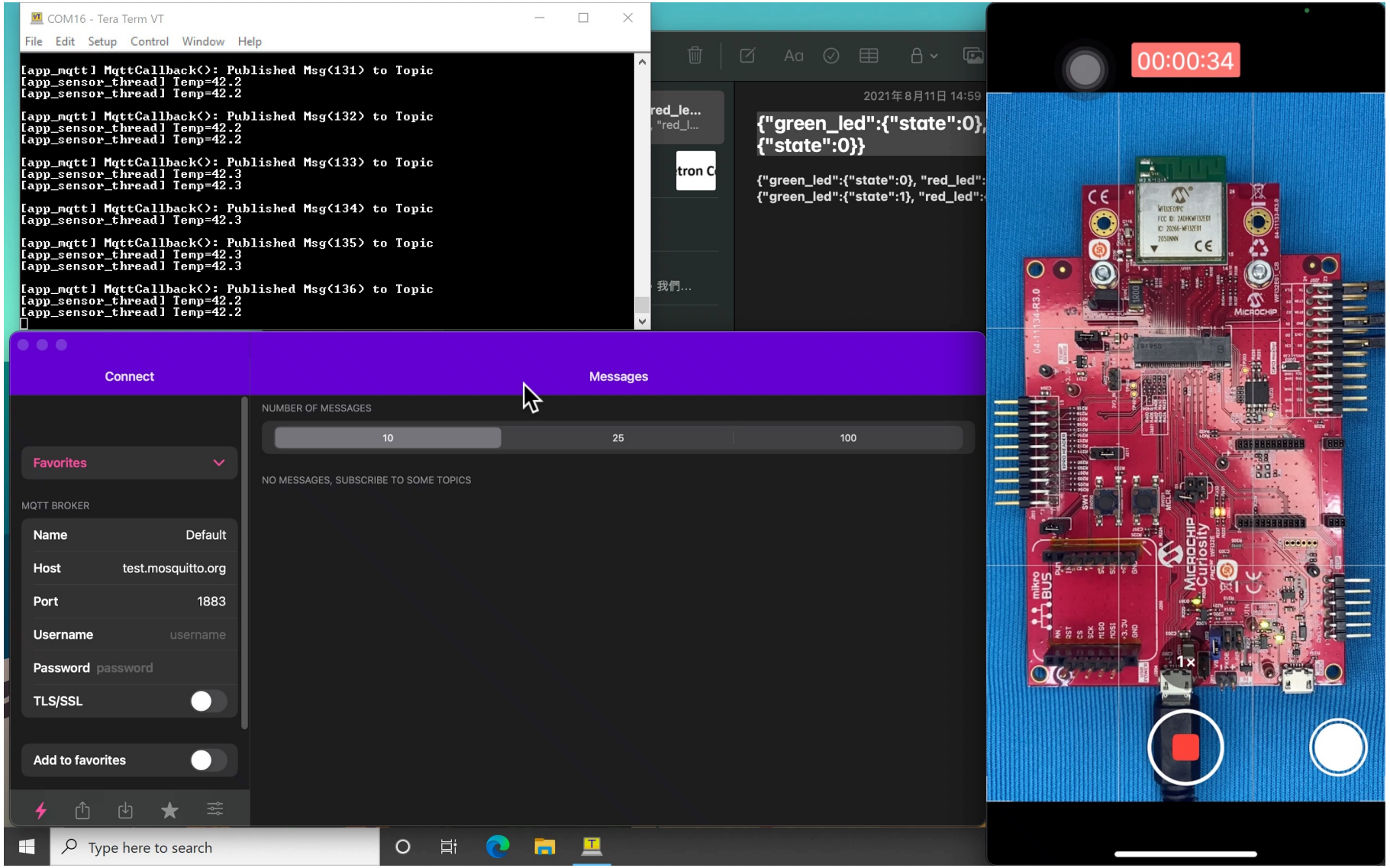


Develop a Secured Smart Home Application from scratch

Demo



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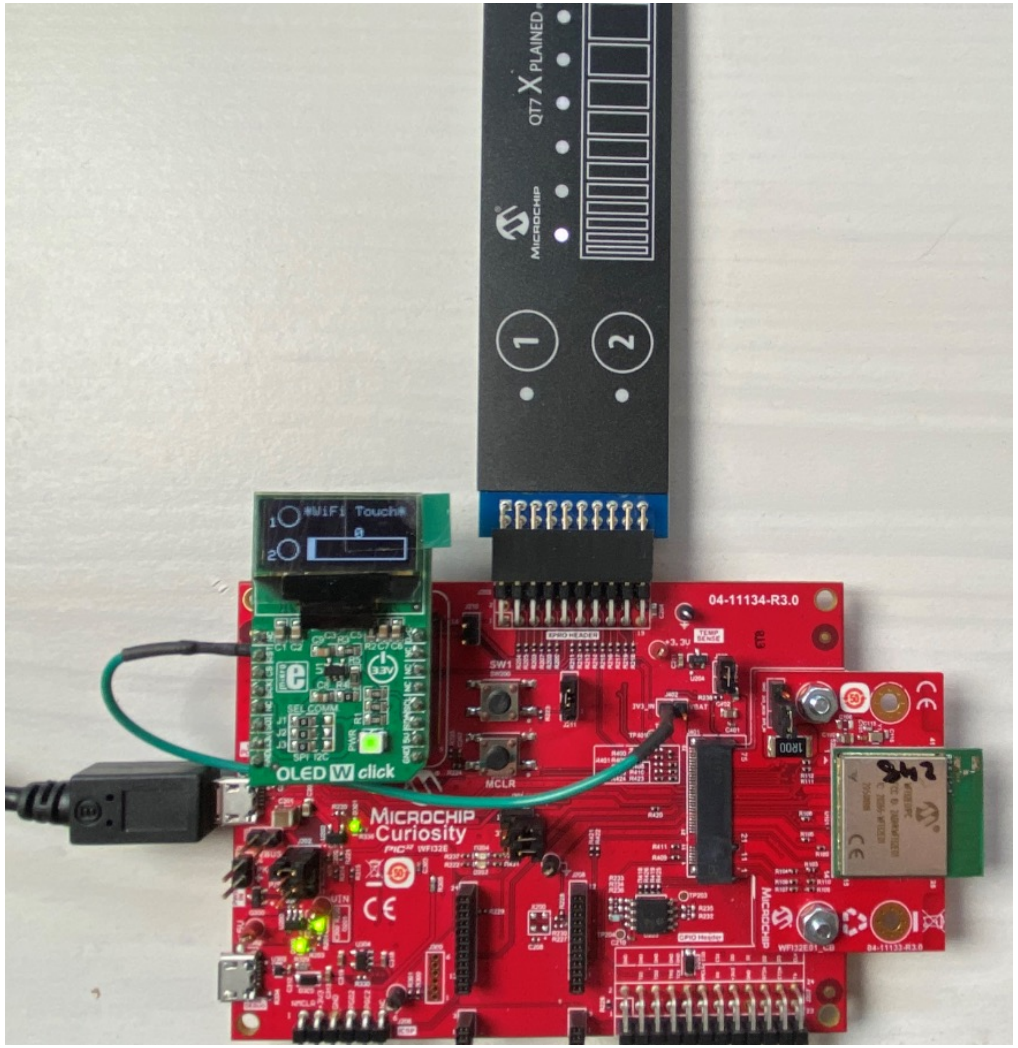
MICROCHIP

Wi-Fi Touch and OLED Display

- Sample application showcasing Wi-Fi connectivity, Capacitive Touch and OLED Display control.
- The application acts as a TCP Server to which a TCP Client can connect and visualize QT7 Touch Xpro data.
- The Touch data are also printed on an OLED Display.

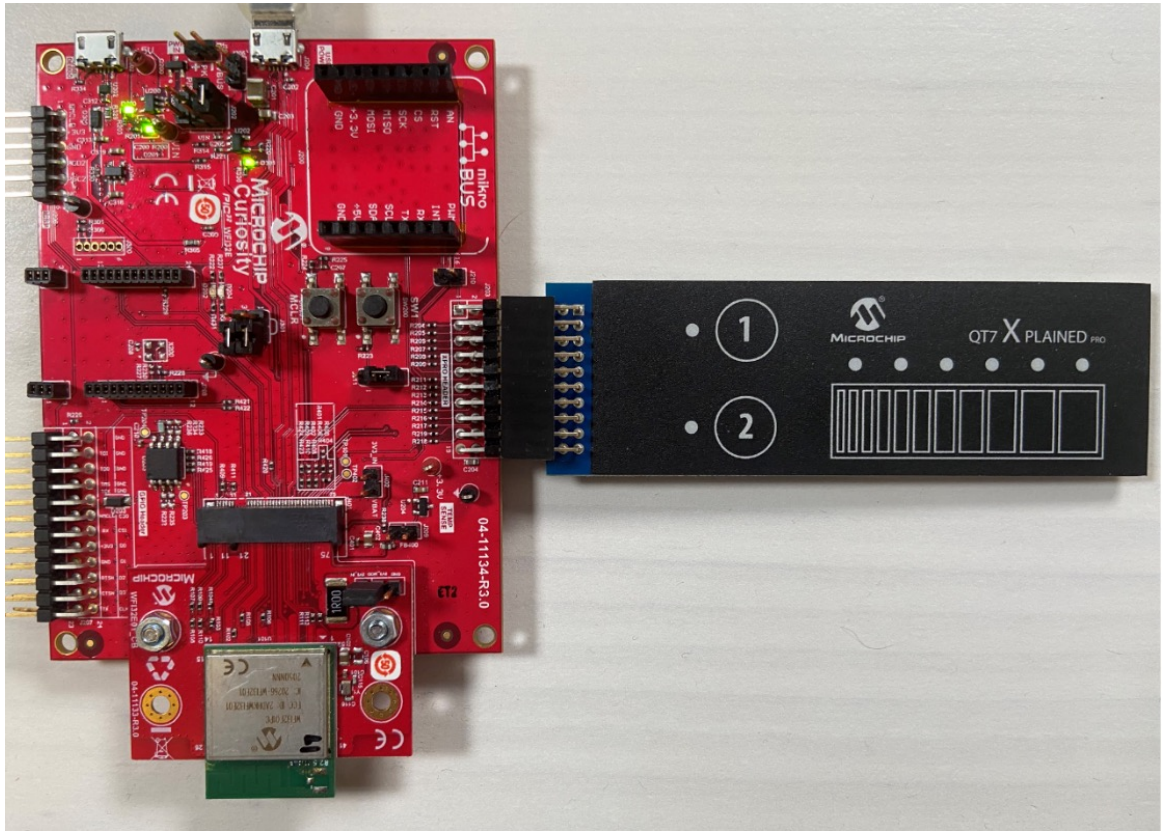


https://github.com/MicrochipTech/PIC32MZW1_Workshop/tree/master/07_projects#wi-fi-touch-and-oled-display

Wi-Fi Touch and OLED Display

Touch example with CVD and QT7 Xpro

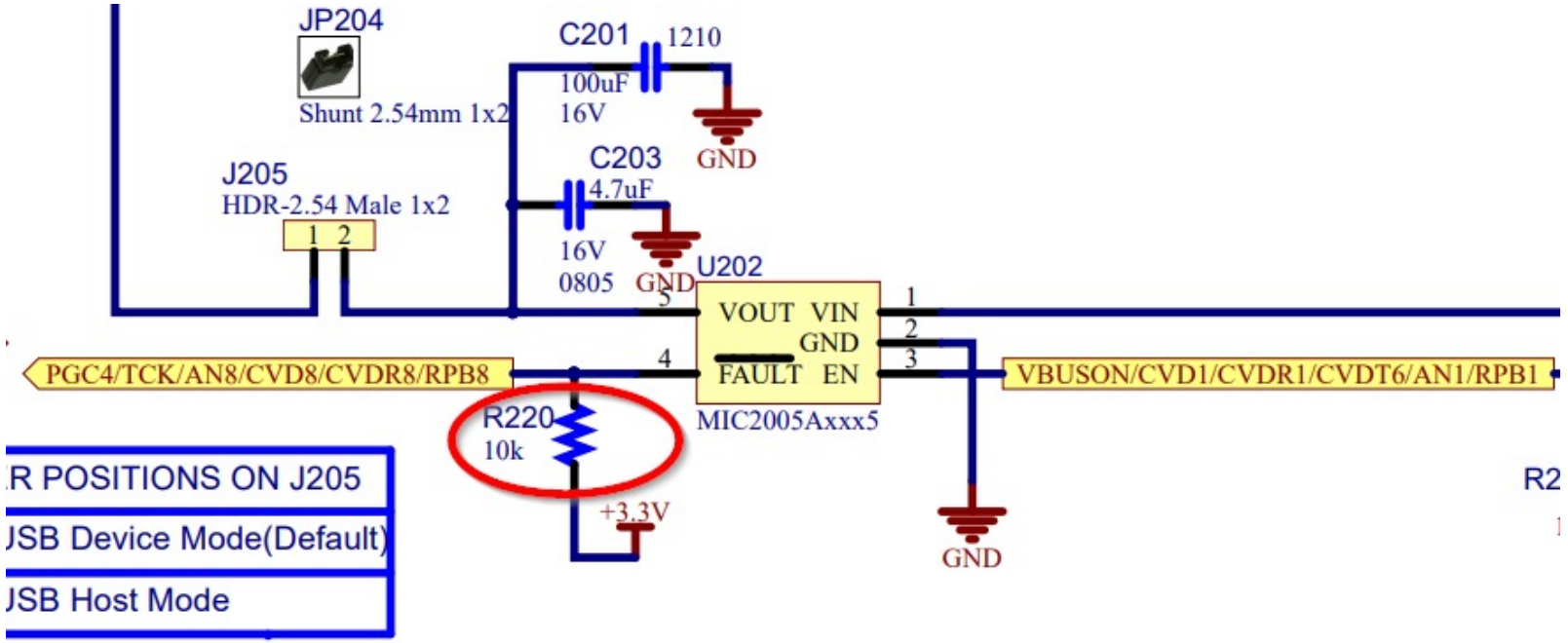
- Basic CVD provides a touch interface based on self capacitance touch sensing.
- The ADC module embedded in the PIC32MZ-W1 device supports CVD feature by using the shared ADC core to perform a modified scan of all 2nd and 3rd class channels.



Wi-Fi Touch and OLED Display

Touch example with CVD and QT7 Xpro

- One of the slider sensor line (Y-line2) is connected to U202 and the line is loaded with 10k (R220) resistor. You could remove R220 to not interfere the measurement of the slider sensor.



Wi-Fi Touch and OLED Display

Touch example with CVD and QT7 Xpro

- QT7 uses one slider & 2 touch buttons.

QT7 Xpro Header Pin	Function	Description	WFI32E01 Module Pin
1	ID	-	-
2	GND	-	-
3	Y-LINE-5	Driven shield	RB6 (X1 in MHC)
4	Y-LINE-1	Button 1 Sensor	RA14 (button 0/Y14 in MHC)
5	LED0	LED for Slider	RB12 (LED_SLIDER_6 in MHC)
6	LED6	LED for Button 1	RK6 (LED_BUTTON_1 in MHC)
7	Y-LINE-2	Slider Sensor	RB8 (slider 0/channel 4/Y8 in MHC)
8	Y-LINE-3	Slider Sensor	RA13 (slider 0/channel 3/Y15 in MHC), shared with Temp sensor)
9	Y-LINE-4	Slider Sensor	RA10 (slider 0/channel 2/Y17 in MHC)
10	Y-LINE-0	Button 2 Sensor	RB2 (button 1/Y2 in MHC)

Wi-Fi Touch and OLED Display

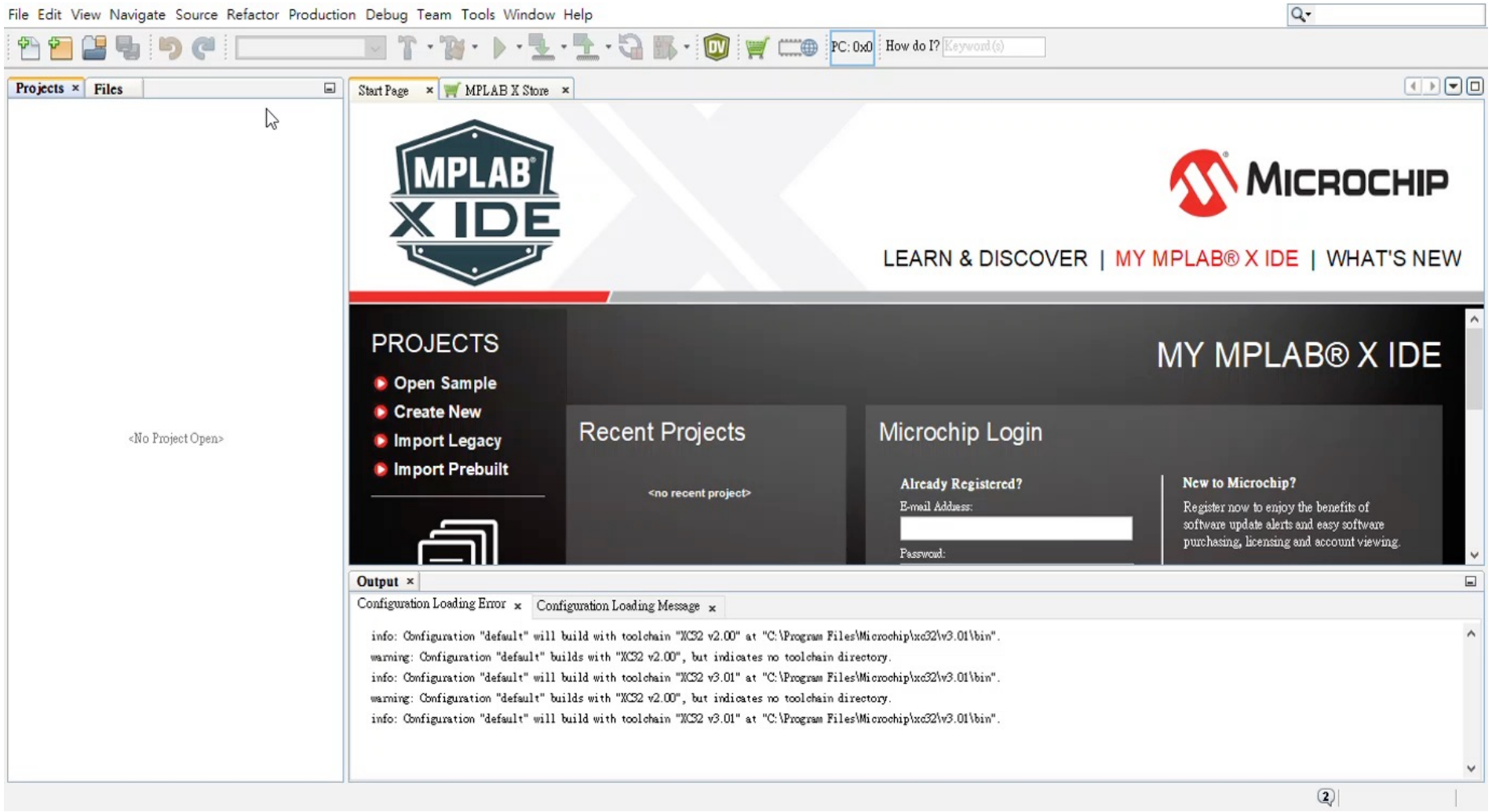
Touch example with CVD and QT7 Xpro

- QT7 uses one slider & 2 touch buttons.

QT7 Xpro Header Pin	Function	Description	WFI32E01 Module Pin
11	LED7	LED for Button 2	RA5 (LED_BUTTON_2)
12	LED1	LED for Slider	RA4 (LED_SLIDER_5)
13	NC	-	-
14	NC	-	-
15	LED2	LED for Slider	RB7 (LED_SLIDER_4)
16	LED3	LED for Slider	RK5 (LED_SLIDER_2)
17	LED4	LED for Slider	RK4 (LED_SLIDER_3)
18	LED5	LED for Slider	RA11 (LED_SLIDER_1)
19	GND	-	-
20	VCC	-	-

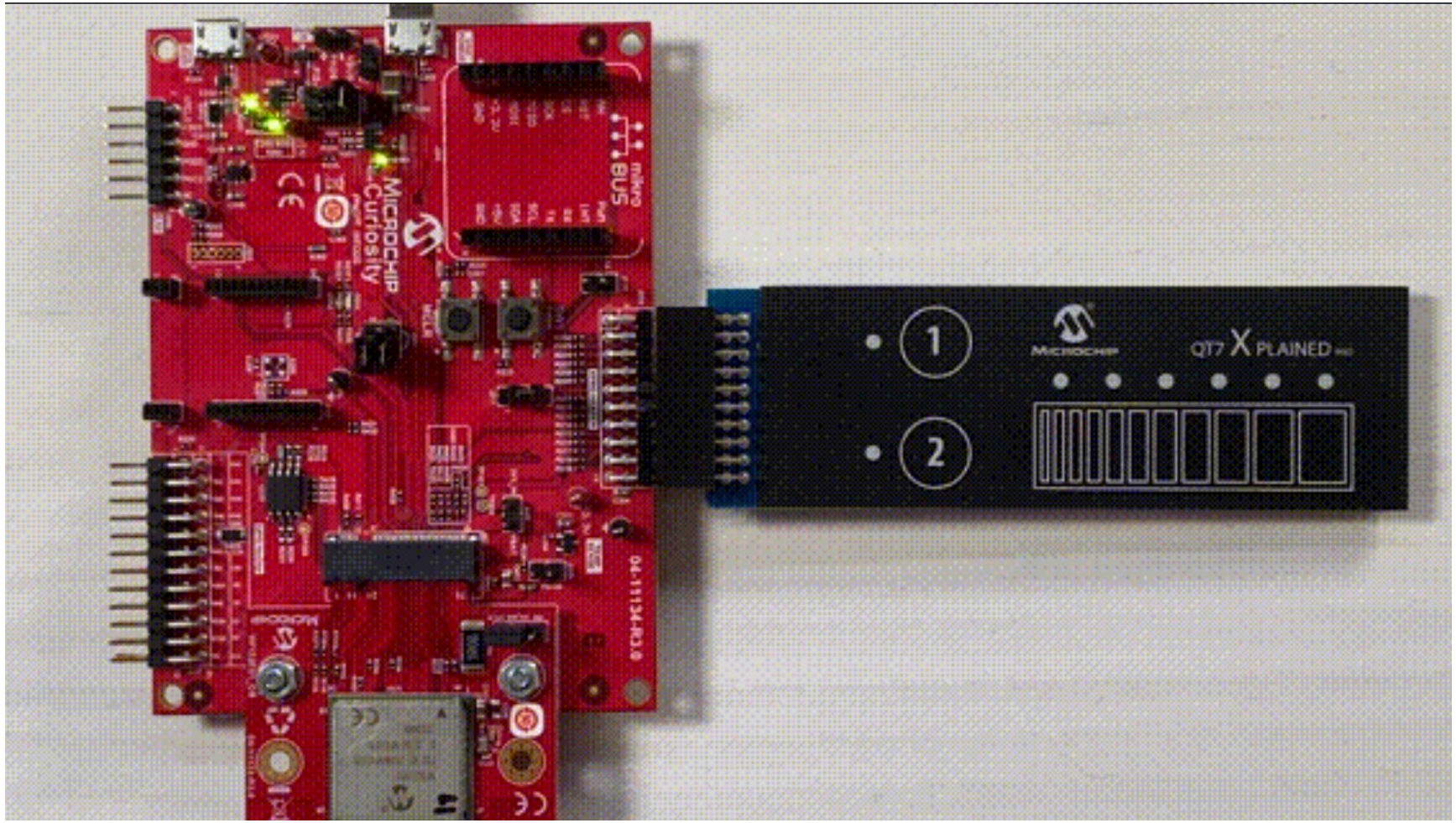
Wi-Fi Touch and OLED Display

Touch example with CVD and QT7 Xpro



Wi-Fi Touch and OLED Display

Touch example with CVD and QT7 Xpro

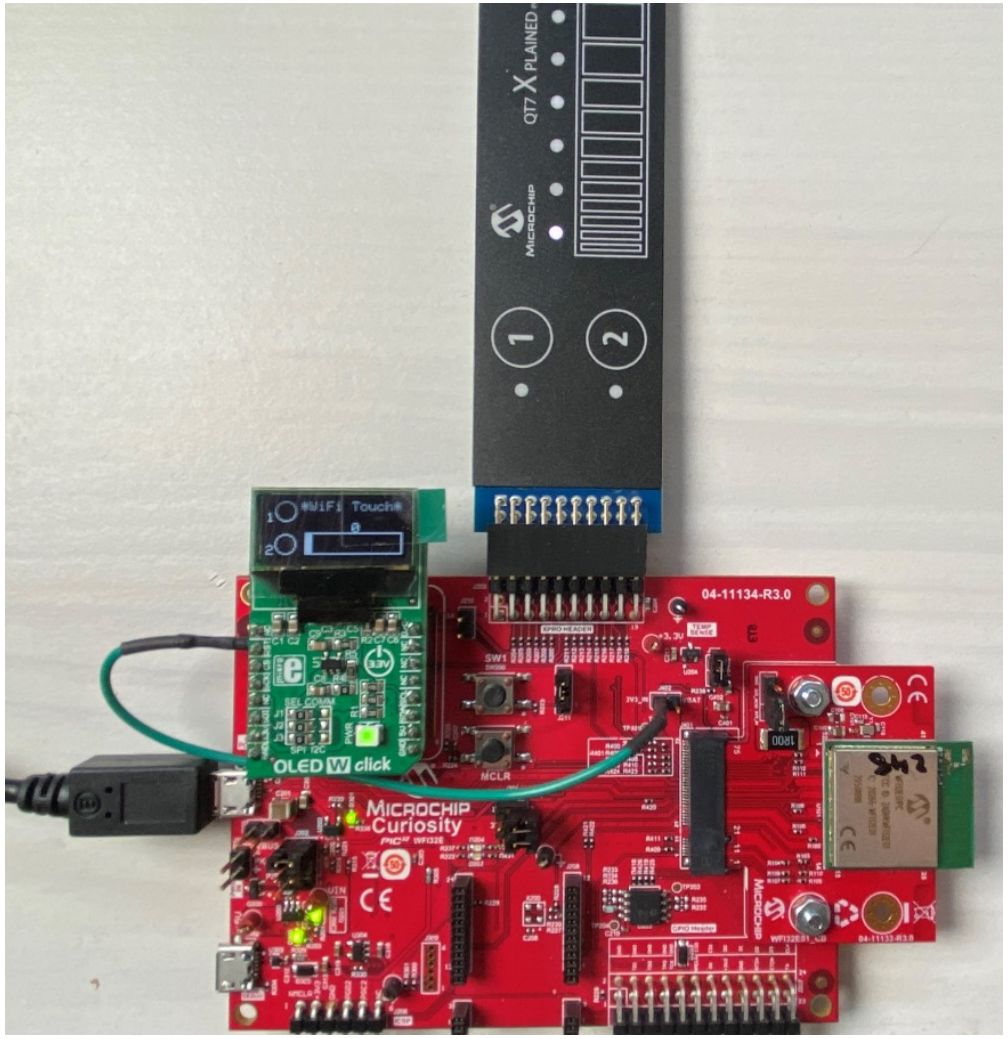


MICROCHIP

Wi-Fi Touch and OLED Display

Touch example with QT7 Xpro & OLED W Click

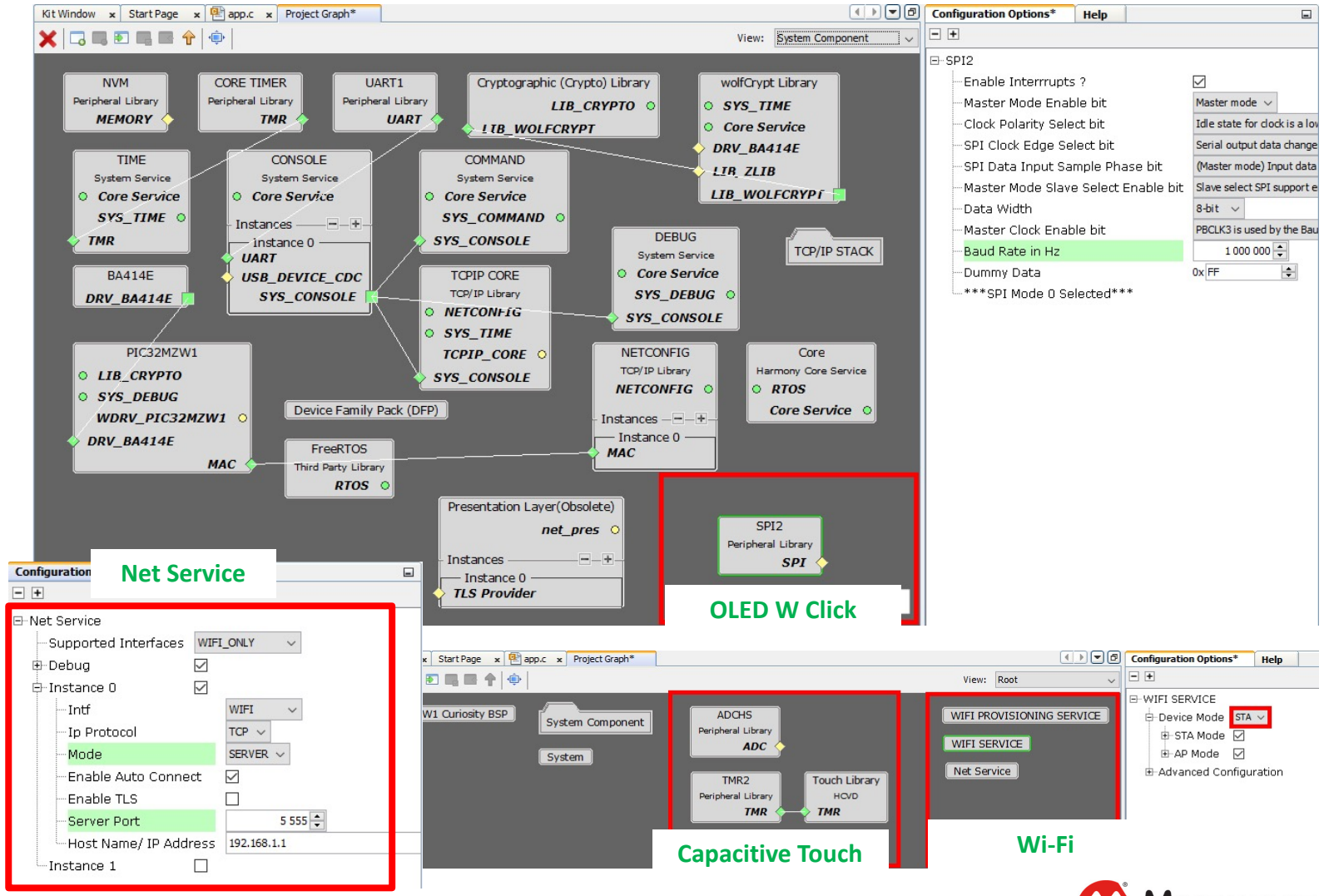
- The OLED W click carries a 96 x 39px white monochrome passive matrix OLED display. To drive the display, OLED W click features an SSD1306 controller.
- In this demo, the OLED W click communicates with the WFI32 MCU through SPI lines.



Wi-Fi Touch and OLED Display

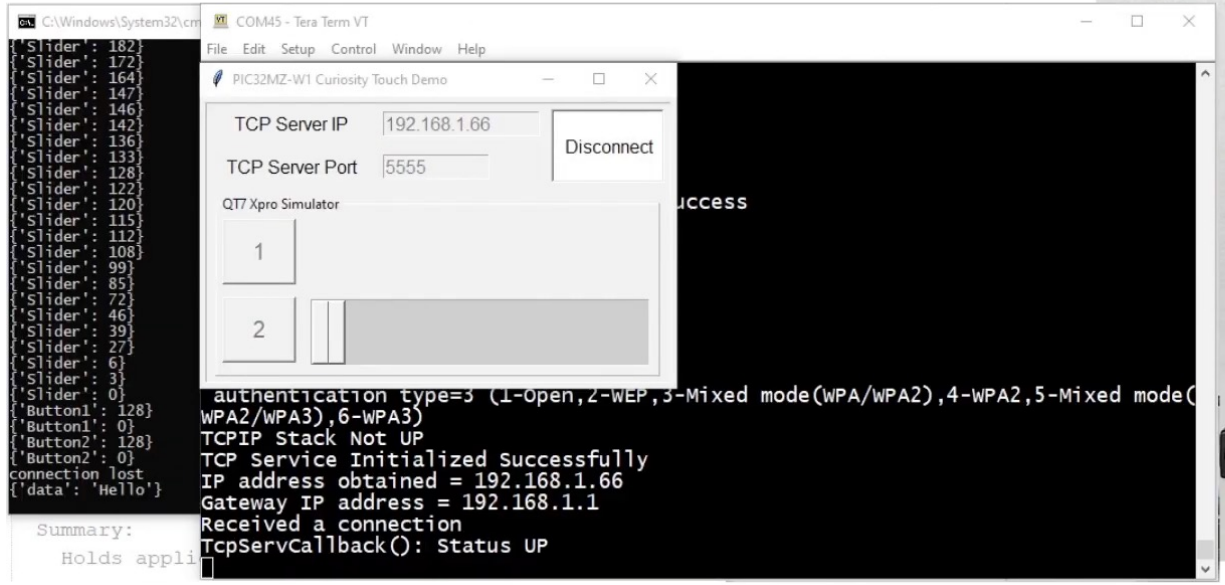
Touch example with QT7 Xpro & OLED W Click

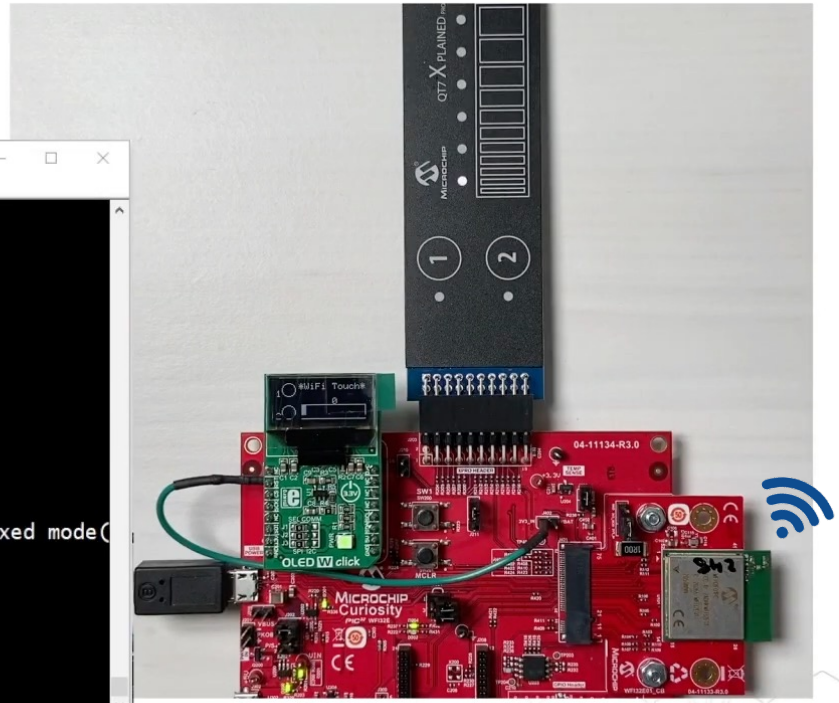
- SPI2 for OLED W click interface
- Touch Library using ADCHS and TMR2 components
- Wi-Fi Service, Wi-Fi provisioning and Net services



Wi-Fi Touch and OLED Display

Touch example with QT7 Xpro & OLED W Click





Agenda

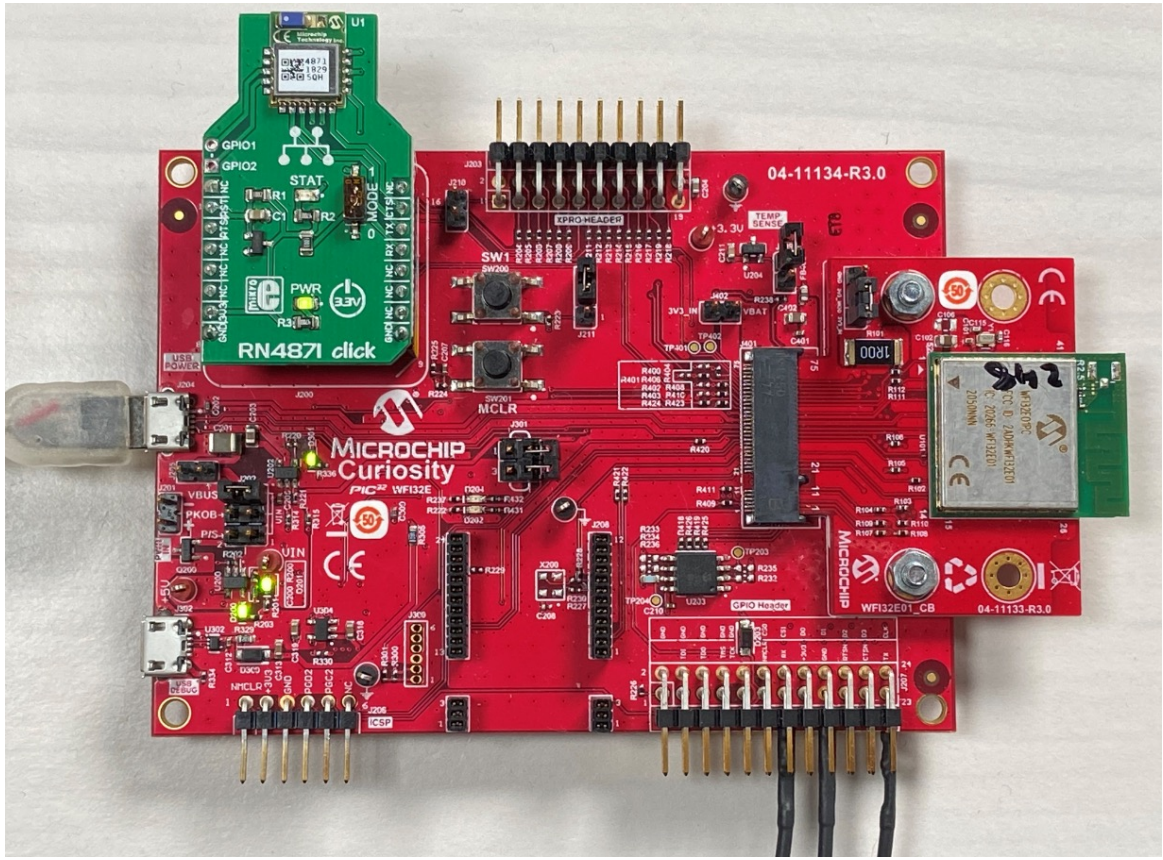
eLearning

- **Reference Example Codes**
  - Develop a Secured Smart Home Application from scratch
  - Wi-Fi ® Touch and OLED Display
  - Wi-Fi Provisioning over BLE
  - Wi-Fi to CAN Bus Bridge

MICROCHIP

Wi-Fi Provisioning over BLE

- Attach external BLE device to WFI32E Curiosity board and enable Wi-Fi communication and configuration over BLE.
- Watch the video and see how to enable Wi-Fi provisioning over BLE with WFI32E Curiosity board



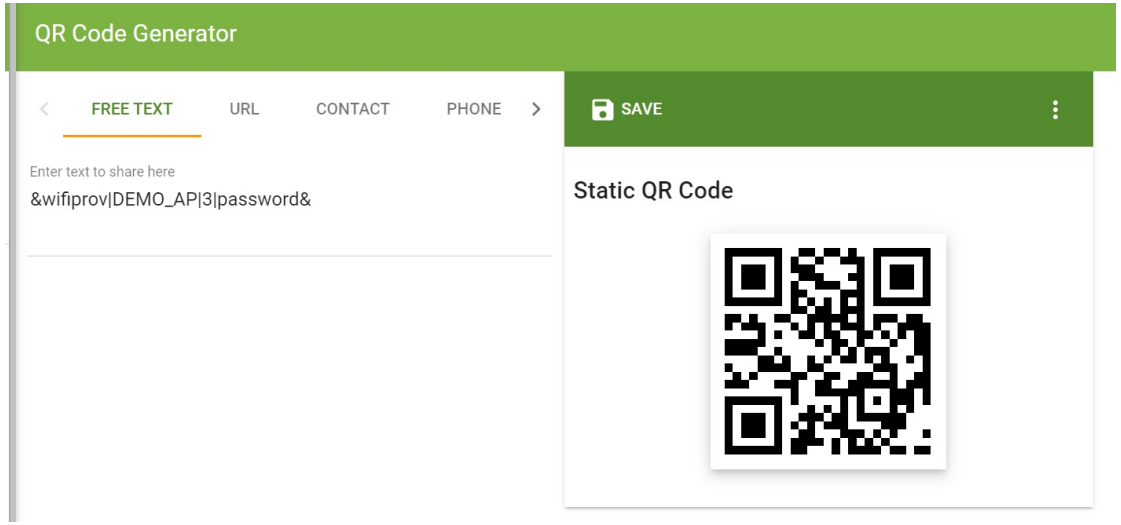
https://github.com/MicrochipTech/PIC32MZW1_Workshop/tree/master/07_projects#wi-fi-provisioning-over-ble

Wi-Fi Provisioning over BLE

Generate QR code for Wi-Fi provisioning

- A QR code is used in the demo to provision the Wi-Fi configuration over BLE.
- **Frame Format: &wifiprov|<ssid>|<authtype>|<password>&**
  - Where **&** is used to indicate the start and the end of the frame.
  - **wifiprov** is required and used as a command keyword.
  - **|** is required and used as a separator.
  - **<ssid>** is the name of the router / network.
  - Auth type represents the security type:
    - OPEN mode; WPAWPA2 (Mixed) mode; WPA2 mode
    - WPA2WPA3 (Mixed) mode; WPA3 mode
  - password is not required in Open mode
- **e.g.: &wifiprov|DEMO_AP|3|password&**
- Create your own QR code from:

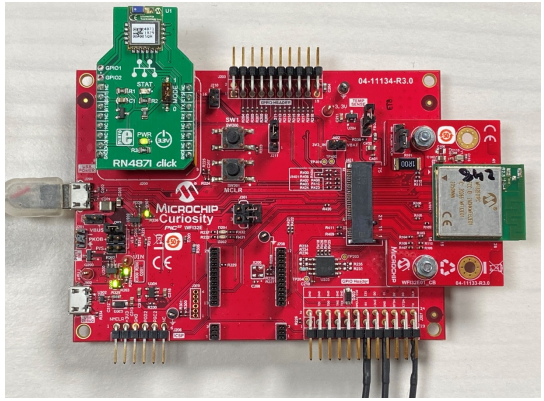
  https://www.the-qrcode-generator.com/



MICROCHIP

Wi-Fi Provisioning over BLE

Download from PIC32MZW1_Workshop

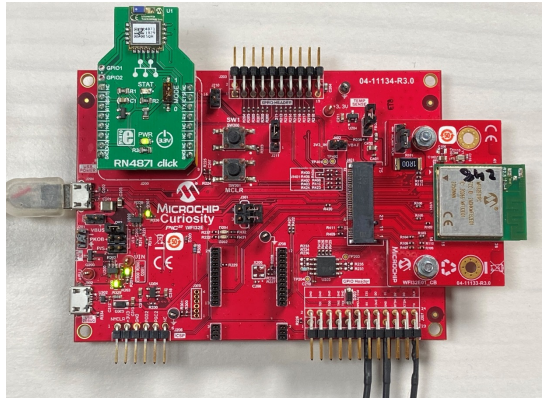


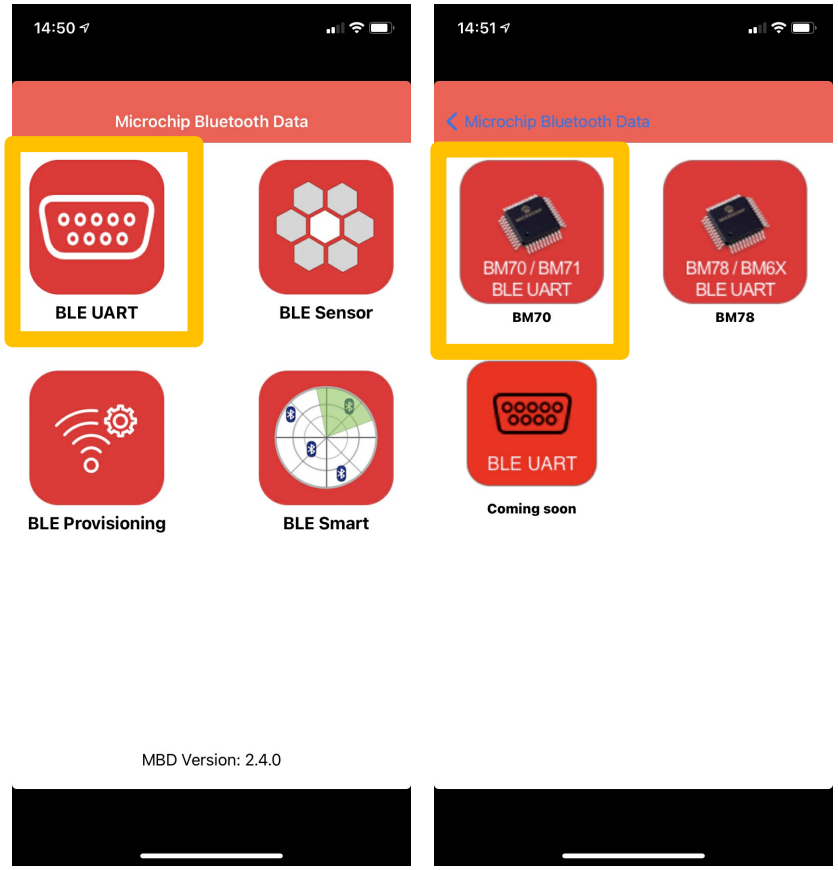
- Go to **PIC32MZW1_Workshop/07_projects/resources/software/**
- Download **ble_provisioning.zip**
- Build and program the code
- Open Tera Term to observe console logs
- Application starts in AP mode

```
TCP/IP Stack: Initialization Started
TCP/IP Stack: Initialization Ended - success

 mode=1 (0-STA,1-AP) saveConfig=1

 AP Configuration :
 channel=1
 ssidVisibility=1
 ssid=DEMO_AP_SOFTAP
 passphase=password
 authentication type=4 (1-Open,2-WEP,3-Mixed mode(WPA/WPA2),4-WPA2,5-Mixed mode(WPA2/WPA3),6-WPA3)
PIC32MZW1 AP Mode IP Address: 192.168.1.1
[APP_BLE] Init.
[APP_BLE] Configuration done.
Open Microchip Bluetooth Data App
- Select BLE UART and BM70
- Connect to your device WFI32_xxxx
- Select Transparent
- Frame format for Wi-Fi provisioning over BLE:
&wifiprov|<ssid>|<authtype>|<password>&
1: Open, 3: WPAWPA2, 4: WPA2, 5: WPA2WPA3, 6: WPA3
e.g. &wifiprov|DEMO_AP|3|password&
```

Wi-Fi Provisioning over BLE

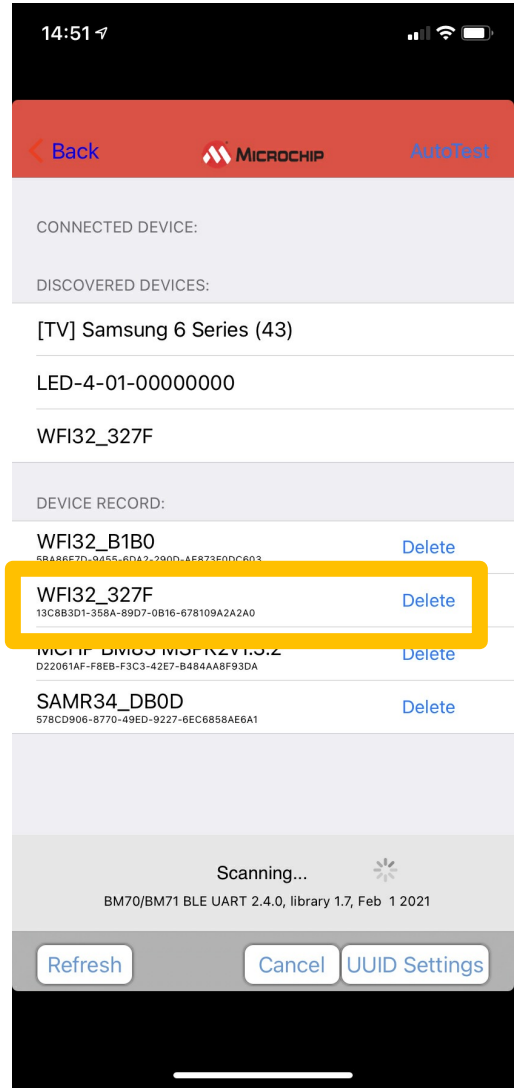
- Scan the QR code from the smartphone
- Copy your own Wi-Fi provisioning frame
- Open Microchip Bluetooth Data App
- Select BLE UART then BM70

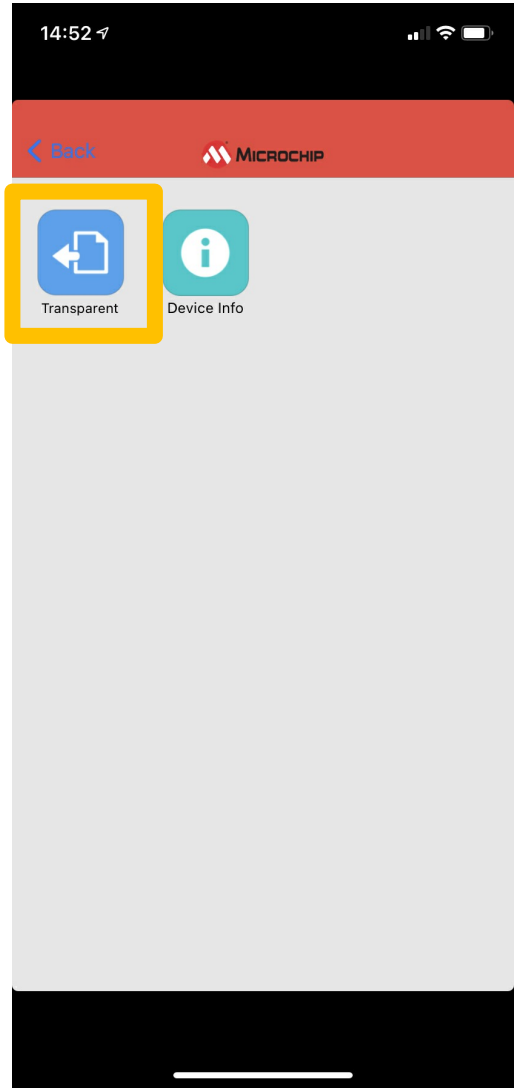




Wi-Fi Provisioning over BLE

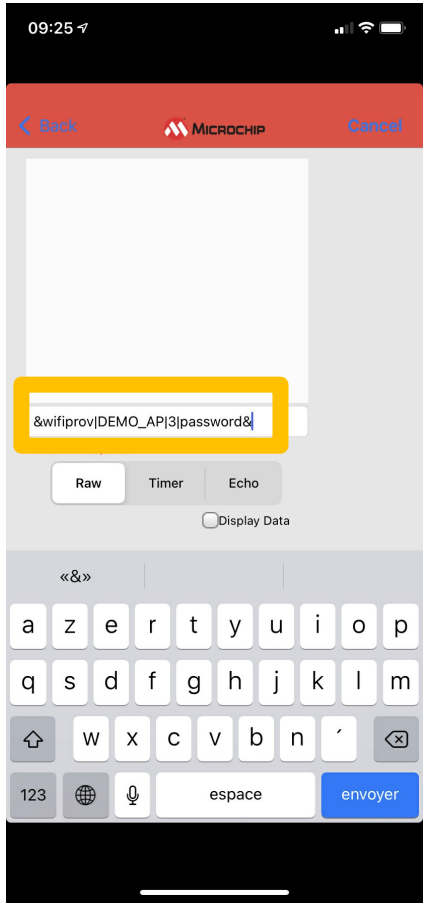
- Connect and select your WFI32_xxxx device
  - [APP_BLE] Connected
- Select Transparent option
  - [APP_BLE] Transparent stream opened





Wi-Fi Provisioning over BLE

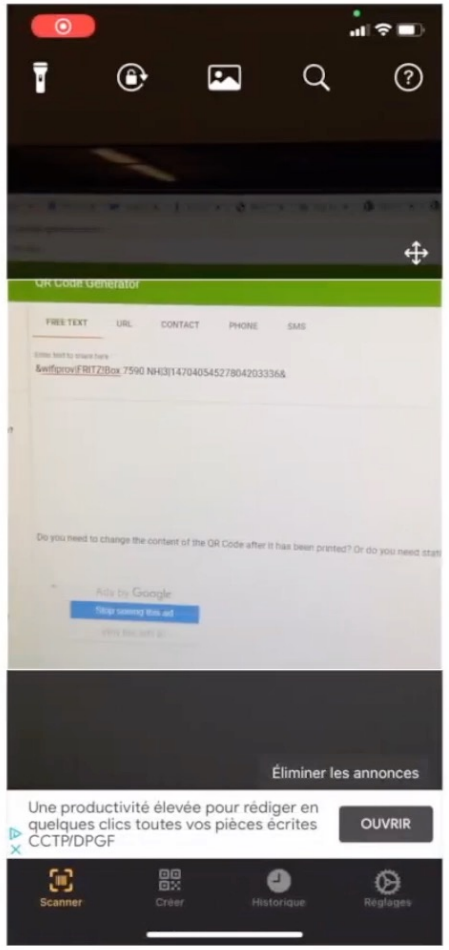
- Paste (or enter the data manually) and send the Wi-Fi provisioning frame
- Application restarts in STA mode using the new Wi-Fi configuration
- Application gets and IP address from the network




```
[APP_BLE] Frame received
SSID: DEMO_AP - AUTH: 3 - PASS: password
Wi-Fi Configuration done.ðTCP/IP Stack: Initialization Started
TCP/IP Stack: Initialization Ended - success

 mode=0 (0-STA,1-AP) saveConfig=1

 STA Configuration :
 channel=0
 autoConnect=1
 ssid=DEMO_AP
 passphase=password
 authentication type=3 (1-Open,2-WEP,3-Mixed mode(WPA/WPA2),4-WPA2,5-Mixed mode(WPA2/WPA3),6-WPA3)
[APP_BLE] Init.
[APP_BLE] Configuration done.
Open Microchip Bluetooth Data App
- Select BLE UART and BM70
- Connect to your device WFI32_xxxx
- Select Transparent
- Frame format for Wi-Fi provisioning over BLE:
&wifiprov|<ssid>|<authtype>|<password>&
1: Open, 3: WPAWPA2, 4: WPA2, 5: WPA2WPA3, 6: WPA3
e.g. &wifiprov|DEMO_AP|3|password&
 Trying to connect to SSID : DEMO_AP
 STA Connection failed.

 Trying to connect to SSID : DEMO_AP
 STA Connection failed.

IP address obtained = 192.168.1.149
Gateway IP address = 192.168.1.1
```

Wi-Fi Provisioning over BLE

Demo



Agenda

eLearning

- **Reference Example Codes**
  - Develop a Secured Smart Home Application from scratch
  - Wi-Fi ® Touch and OLED Display
  - Wi-Fi Provisioning over BLE
  - Wi-Fi to CAN Bus Bridge

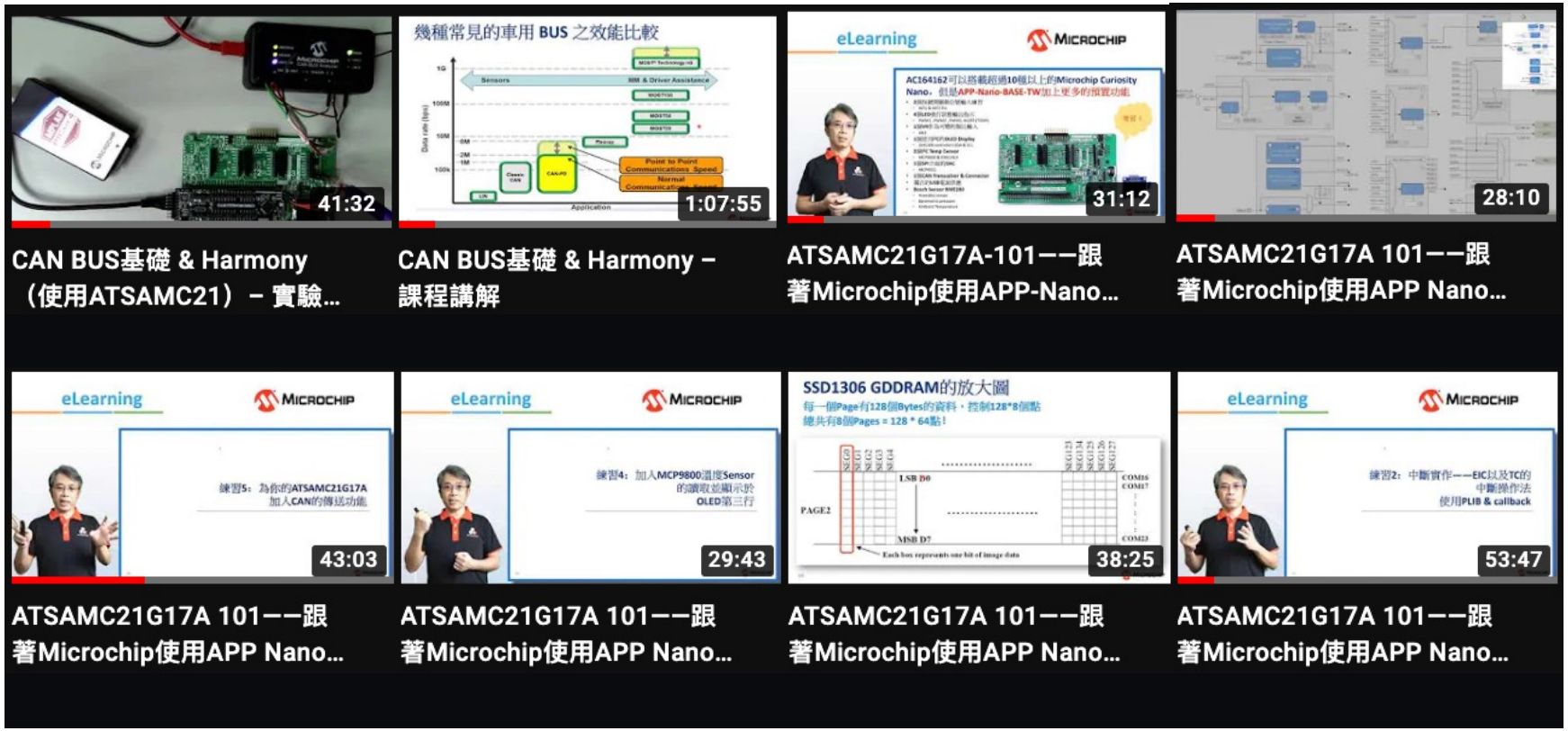
MICROCHIP

Wi-Fi to CAN Bus Bridge

Review APP-Nano-C21-D21-TW of eLearning Classes

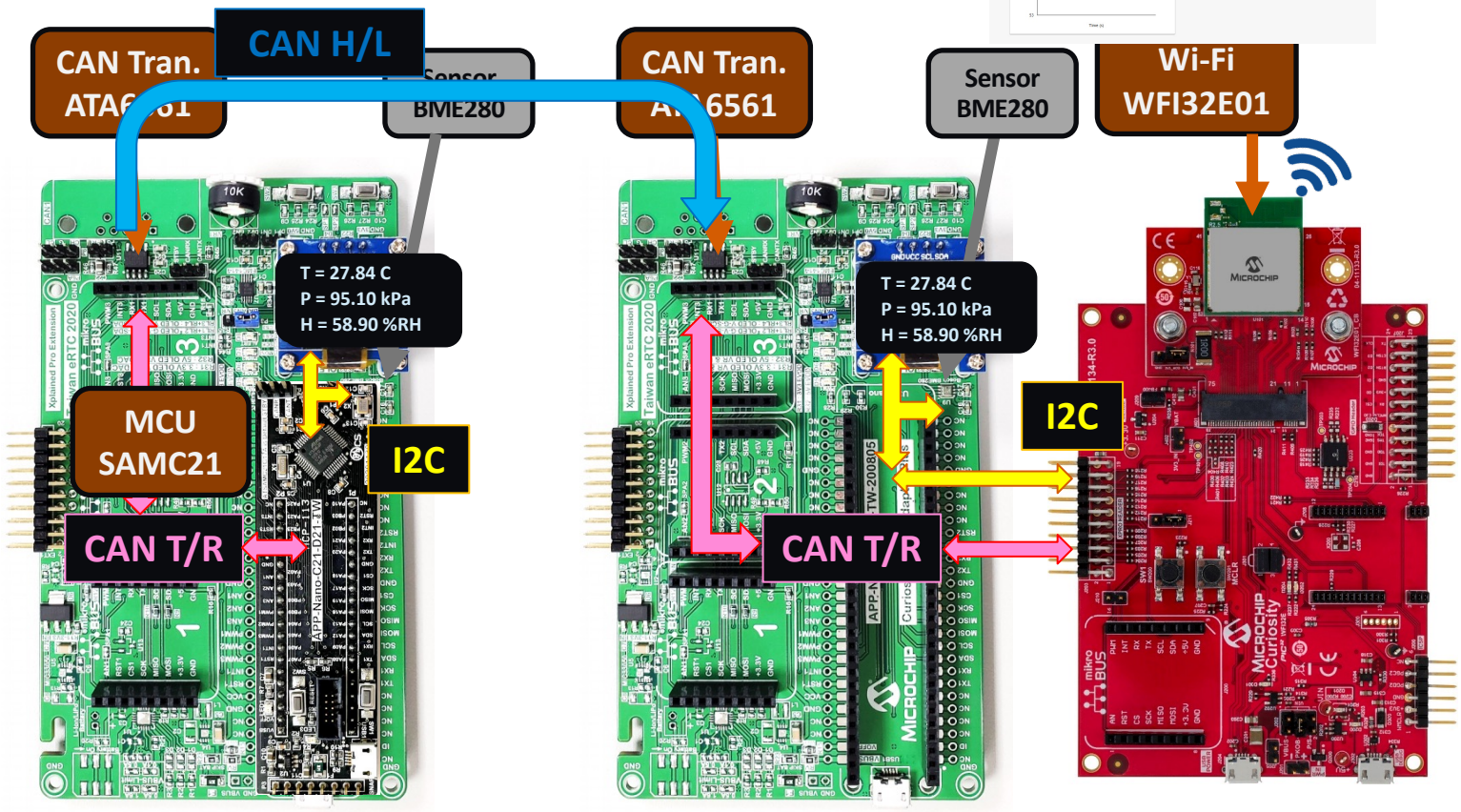
- CAN BUS基礎 & Harmony – 課程講解
- CAN BUS基礎 & Harmony (使用ATSAMC21) – 實驗講解
- ATSAMC21G17A-101 跟著Microchip使用APP-Nano-C21-D21-TW 為這個世界帶來更多的樂趣**1 ~ 6**

https://youtu.be/z3wg4OjW0Vs



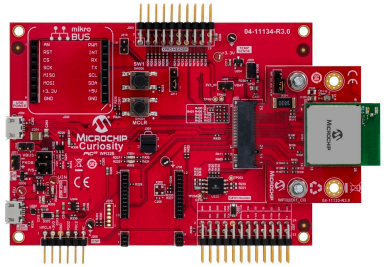
Wi-Fi to CAN Bus Bridge

Application & System Block Diagram

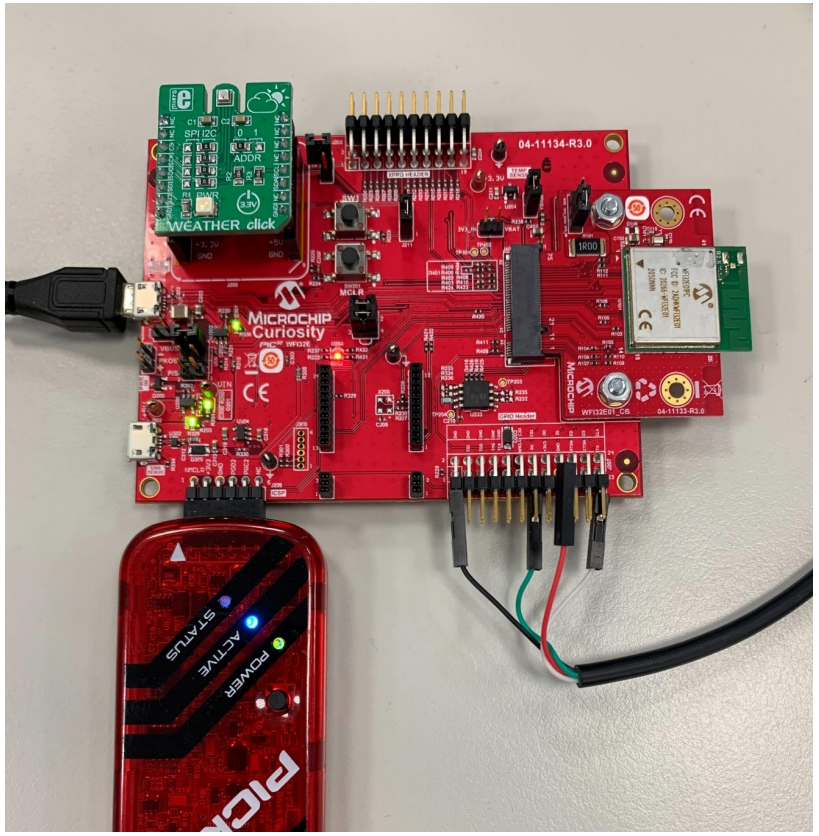


Wi-Fi to CAN Bus Bridge

PIC32WFI32E Curiosity Board - Environment Setup

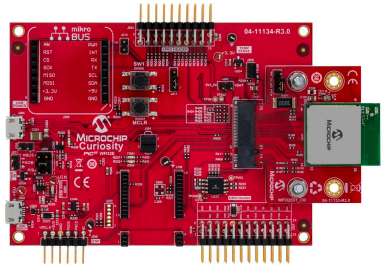


- **Visit https://github.com/MicrochipTech/PIC32MZW1_Workshop/tree/master/03_setup**
- **Follow the instructions to setup the PIC32MZW1 curiosity board and setup your development environment.**
- **Please install MPLAB® X IDE v5.45 or above, otherwise you might not able to open MPLAB® Harmony 3 Configurator in PIC32MZW1_Curiosity_OOB.**



Wi-Fi to CAN Bus Bridge

PIC32WFI32E Curiosity Board - Environment Setup



- **Download PIC32MZW1_Curiosity_OOB Example**
  - Visit https://github.com/MicrochipTech/PIC32MZW1_Curiosity_OOB

master · 2 branches · 7 tags · Go to file · Code

Vysakh Pillai Upgrade to latest H3 version ...

doc	Create .dummy	
resources/media	Upgrade to latest H3 version	
src/firmware	Upgrade to latest H3 version	
.gitignore	update U2TX PPS for v2.3 boards	
README.md	Upgrade to latest H3 version	
faq.md	Update faq.md	4 months ago

Clone

HTTPS GitHub CLI

https://github.com/MicrochipTech/PIC32

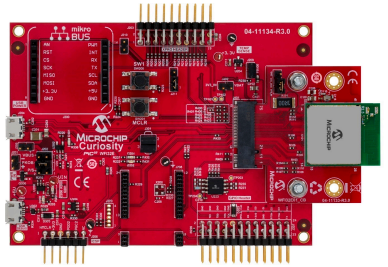
Use Git or checkout with SVN using the web URL.

Open with GitHub Desktop

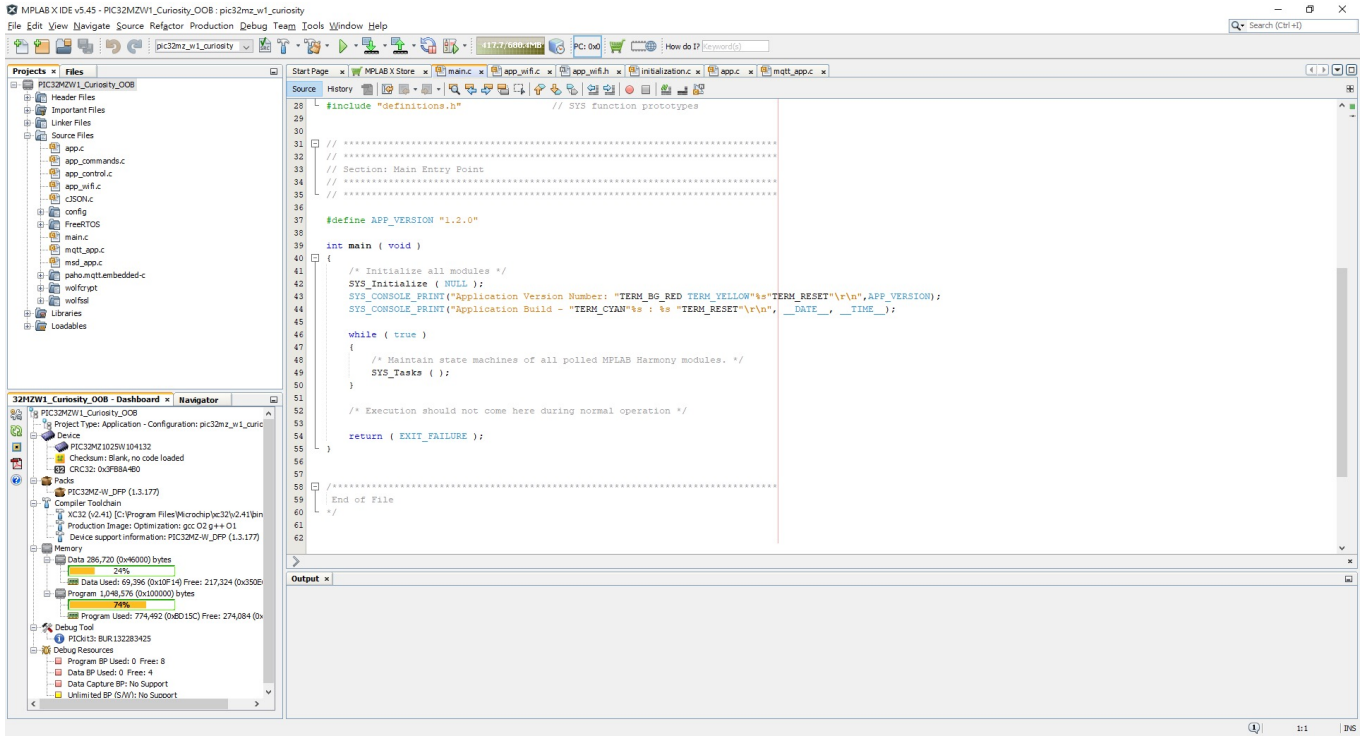
Download ZIP

Wi-Fi to CAN Bus Bridge

PIC32WFI32E Curiosity Board - Environment Setup

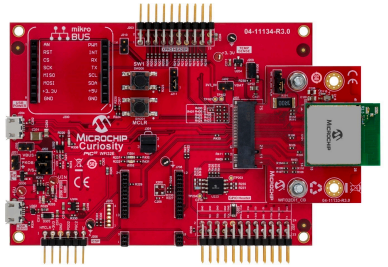


- **Open the project by MPLAB X IDE v5.45 or above**
  - The project is located at …\PIC32MZW1_Curiosity_OOB-master\src\firmware\PIC32MZW1_Curiosity_OOB.X

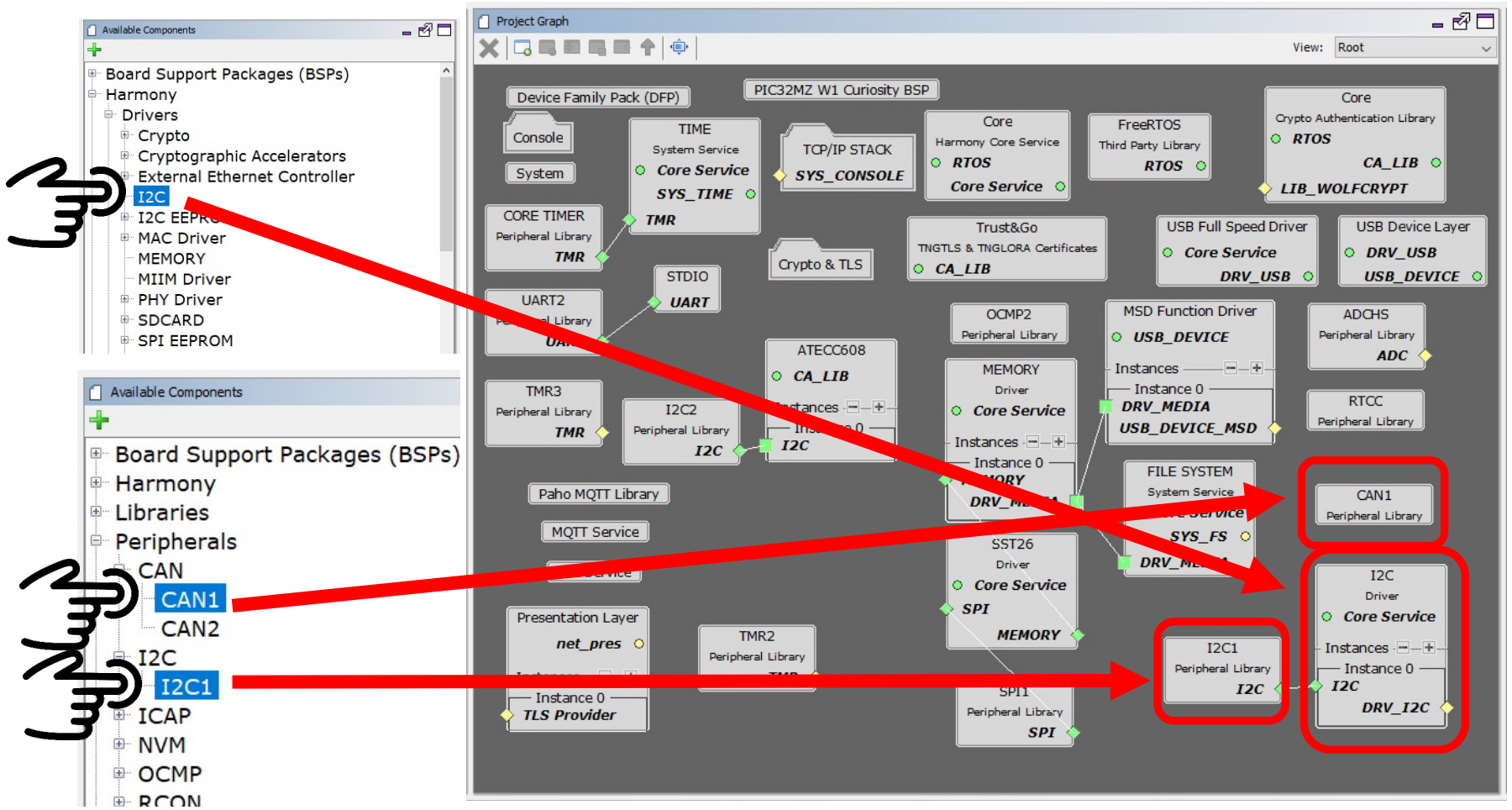


Wi-Fi to CAN Bus Bridge

PIC32WFI32E Curiosity Board - Harmony 3 Configurator

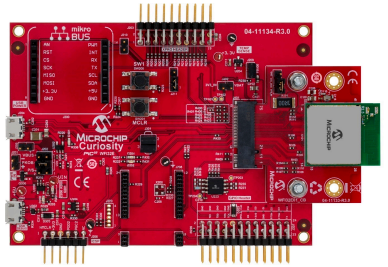


- **Add I2C and CAN interfaces**

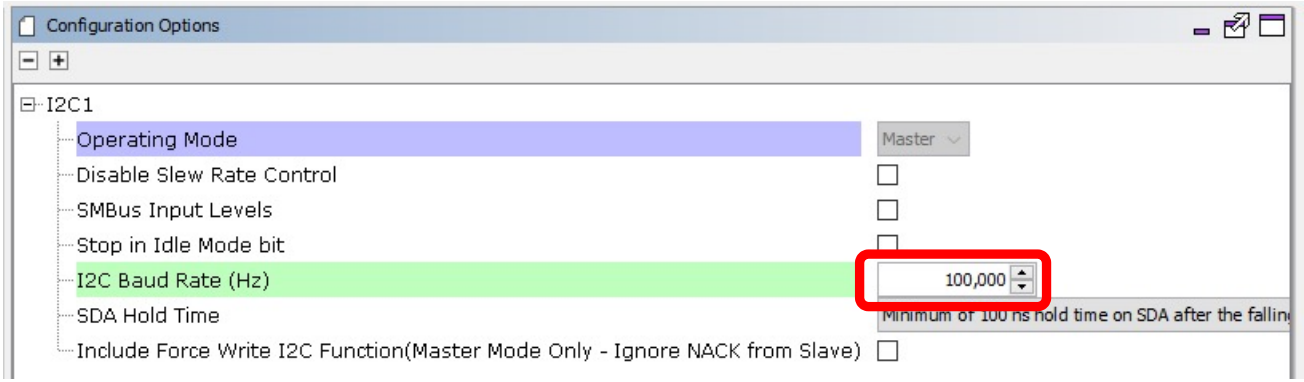


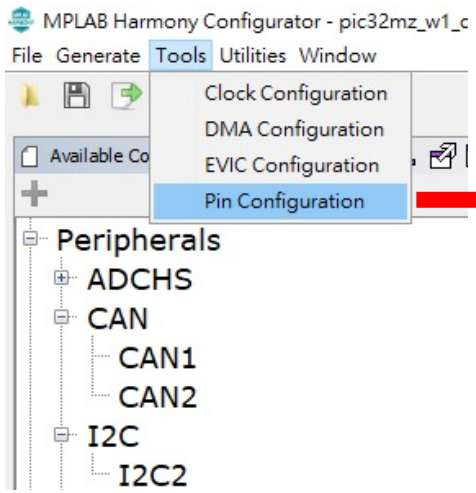
Wi-Fi to CAN Bus Bridge

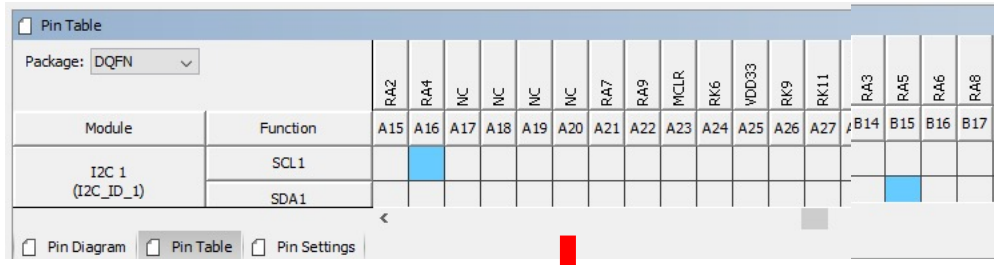
PIC32WFI32E Curiosity Board - Harmony 3 Configurator

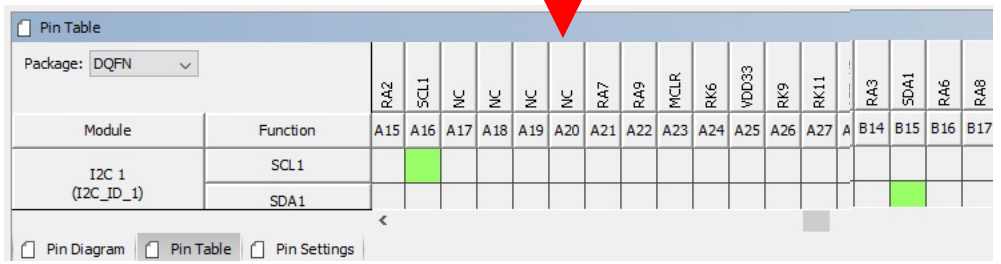


- **Change I2C1 Baud Rate (Hz) to 100,000 and set I2C1 pins**



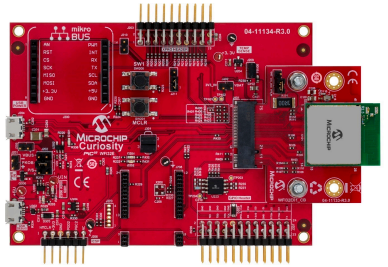




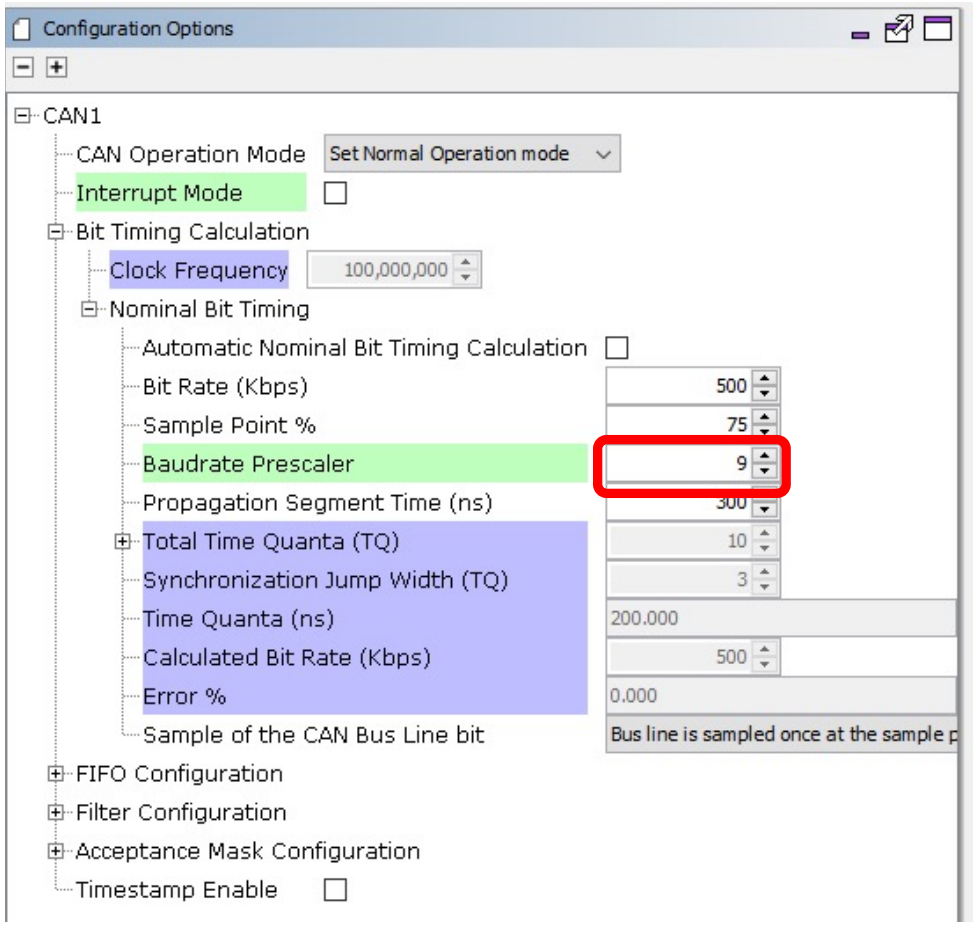


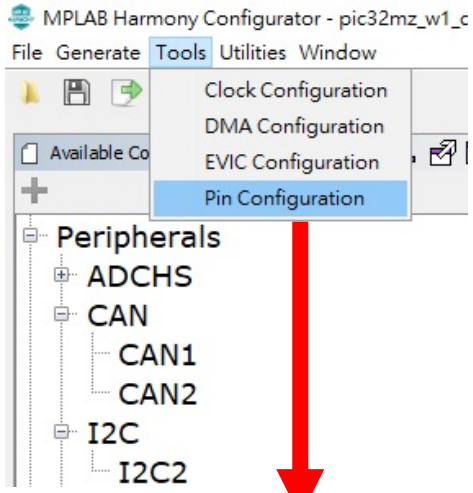
Wi-Fi to CAN Bus Bridge

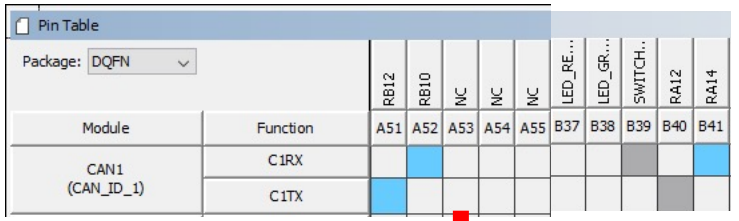
PIC32WFI32E Curiosity Board - Harmony 3 Configurator

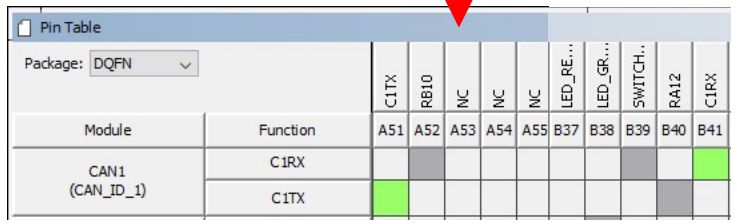


- **Change CAN1 Baudrate Prescaler to 9 and set CAN1 pins**



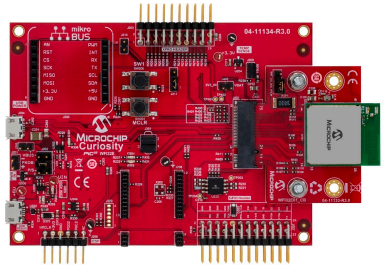




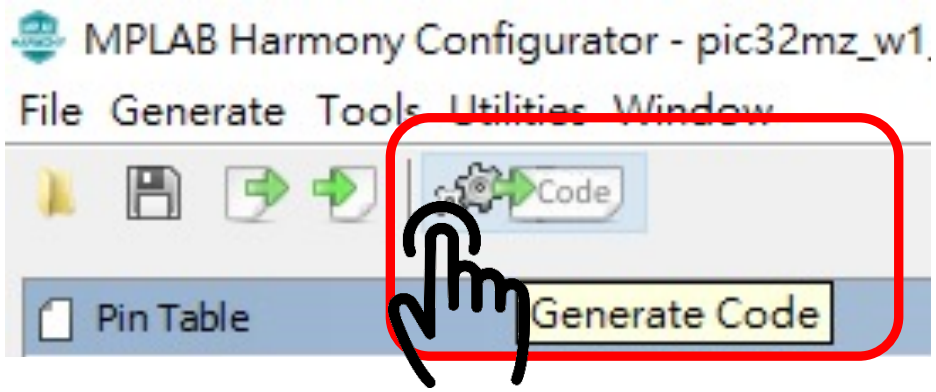


Wi-Fi to CAN Bus Bridge

PIC32WFI32E Curiosity Board - Harmony 3 Configurator

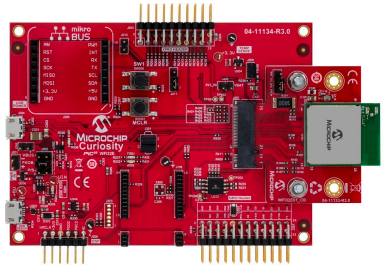


- **Generate Code**
  - Please make sure to Generate Code whenever you do any modification, otherwise, the code will not be generated!



Wi-Fi to CAN Bus Bridge

PIC32WFI32E Curiosity Board - Add Application Code



MPLAB X IDE v5.45 - PIC32MZW1_Curiosity_OOB : pic32mz_w1_curiosity

File Edit View Navigate Source Refactor Production Debug Team Tools Window Help

Projects × Files

PIC32MZW1_Curiosity_OOB
- Header Files
- Important Files
- Linker Files
- Source Files
  - app.c
  - app_commands.c
  - app_control.c
  - app_wifi.c
  - cJSON.c
  - config
  - FreeRTOS
  - main.c
  - mqtt_app.c
  - msd_app.c
  - paho.mqtt.embedded-c
  - wolfcrypt
  - wolfssl
- Libraries
- Loadables

app_control.c ×

Source History

```
447  void APP_CONTROL_Tasks(void) {
448      uint32_t status = 0;
449      uint16_t tempValue = 0;
450      uint8_t rx_message[8];
451      uint32_t rx_messageID = 0;
452      uint8_t rx_messageLength = 0;
453      //uint8_t length = 0;
454      CAN_MSG_RX_ATTRIBUTE msgAttr = CAN_MSG_RX_DATA_FRAME;
455      static int counter = 0;
456
457      WDT_Clear();
458      switch (app_controlData.state) {
459          case APP_CONTROL_STATE_INIT:
460          {
461              ADCHS_CallbackRegister(ADCHS_CH15, ADC_ResultHandler, (uintptr_t) NULL);
462              TMR3_Start(); /*TMR3 is used for ADC trigger*/
463
464              RTCC_CallbackRegister(RTCC_Callback, (uintptr_t) NULL);
465              setup_rtcc();
466              indicator_on();
467
468              /* Open I2C driver instance */
469              appData.drvI2CHandle = DRV_I2C_Open( DRV_I2C_INDEX_0, DRV_IO_INTENT_READWRITE);
470
471              OLED_Init();
472              OLED_CLS();
473
474              app_controlData.state = APP_CONTROL_STATE_MONITOR_CONNECTION;
475              break;
476          }
477          case APP_CONTROL_STATE_MONITOR_CONNECTION:
478          {
```

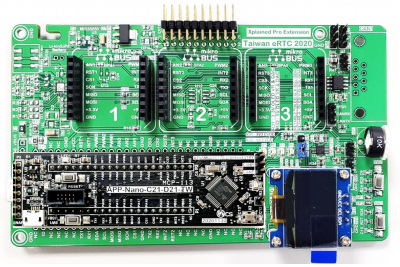
Output × Call Stack

Configuration Loading Error × Atmel-ICE × PIC32MZW1_Curiosity_OOB (Clean, Build, ...) ×

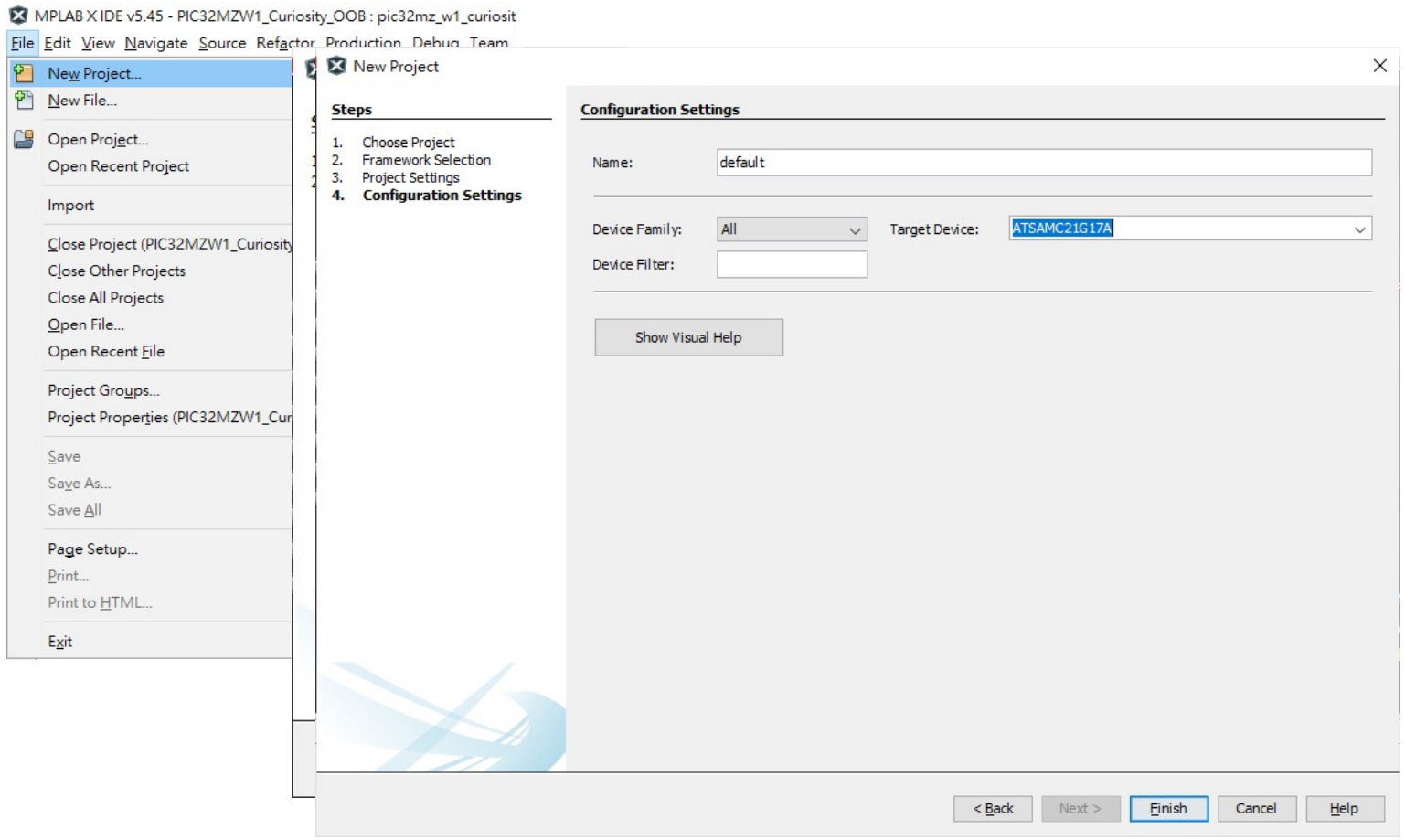
```
BUILD SUCCESSFUL (total time: 1m 19s)
Loading code from C:/Charley/Microchip/Trainings/20210531_WFI32_SAMC21/Demo_OOB_CAN/WFI32_CAN_Rx_OLED/PIC32MZW1_Curiosity_OOB/src/firmware/PIC32MZW1_Curiosity_OOB.X/dist/pic32mz_w1_curiosity/production/PIC32MZW1_Curiosity_OOB.X.production.hex...
Program loaded with pack,PIC32MZ-W_DFP,1.3.177,Microchip
Loading completed
```

Wi-Fi to CAN Bus Bridge

SAMC21 Nano Board - Environment Setup

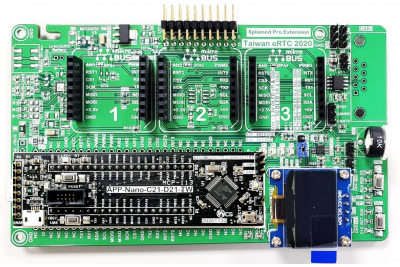


- **Select: ATSAMC21G17A**

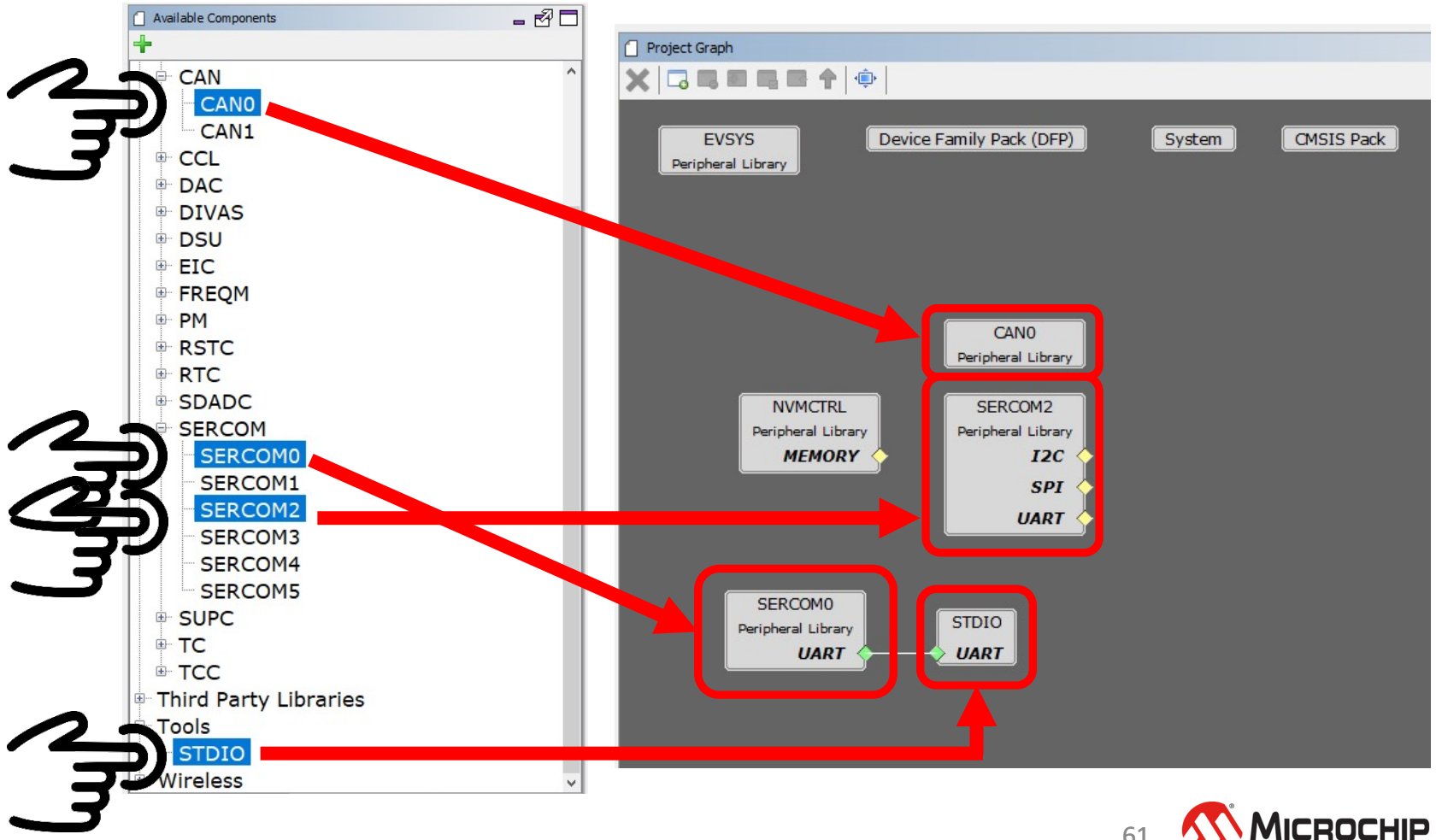


Wi-Fi to CAN Bus Bridge

SAMC21 Nano Board - Harmony 3 Configurator



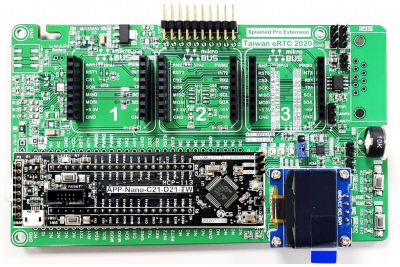
- **Add I2C , UART, and CAN interfaces**



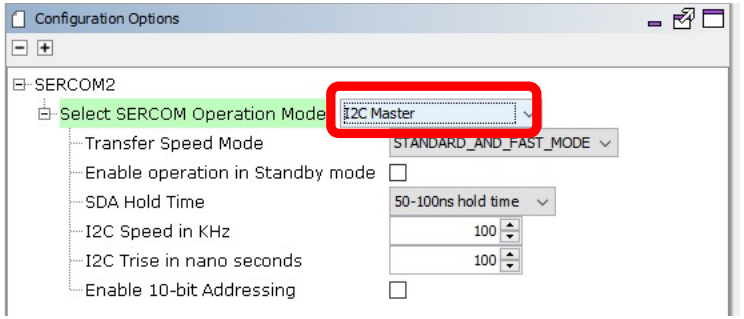
MICROCHIP

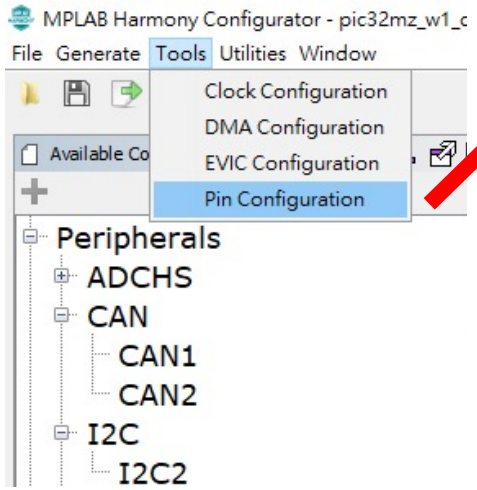
Wi-Fi to CAN Bus Bridge

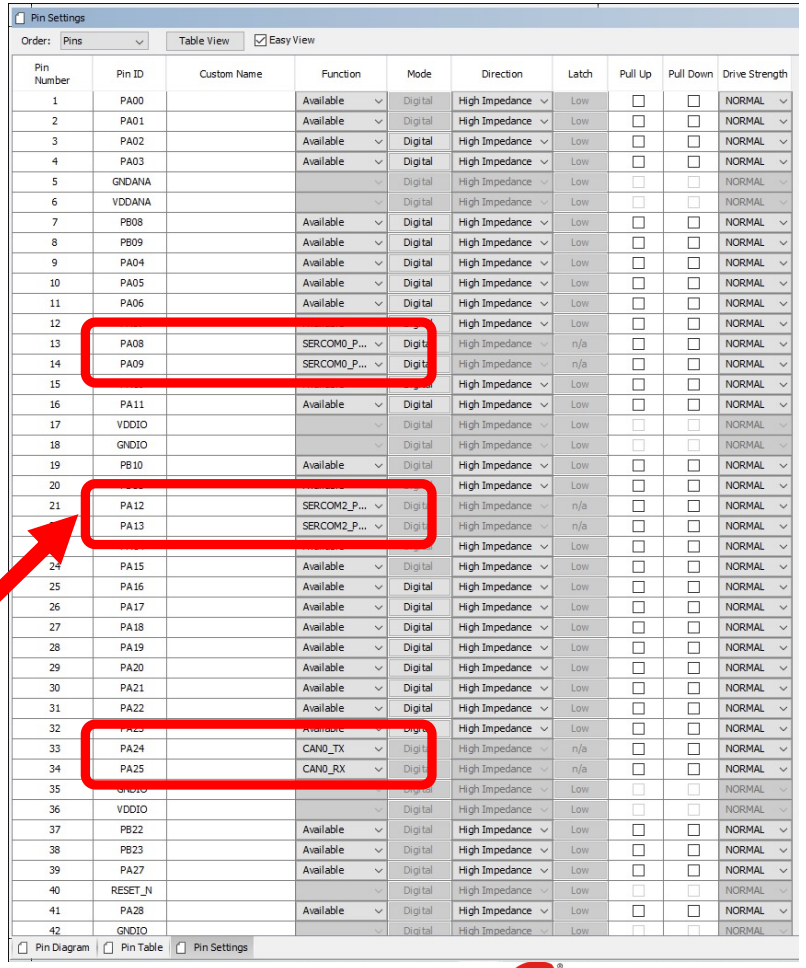
SAMC21 Nano Board - Harmony 3 Configurator



- **Change SERCOM2 to I2C Master, and set SERCOM0, SERCOM2, and CAN0 pins**
  - PA8 & PA9 are SERCOM0
  - PA12 & PA13 are SERCOM2
  - PA24 & PA25 are CAN0

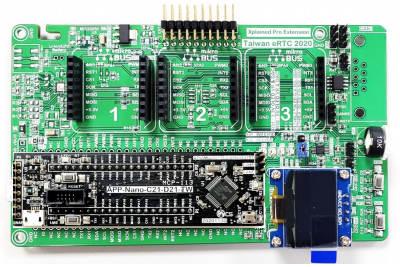




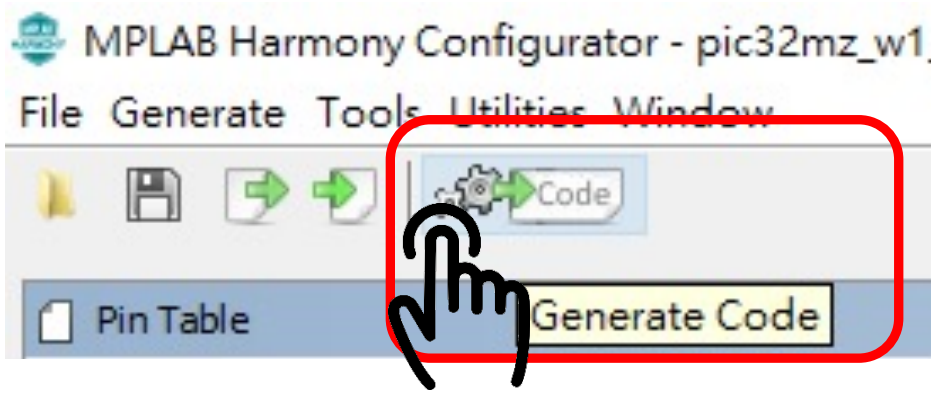


Wi-Fi to CAN Bus Bridge

SAMC21 Nano Board - Harmony 3 Configurator



- **Generate Code**
  - Please make sure to Generate Code whenever you do any modification, otherwise, the code will not be generated!



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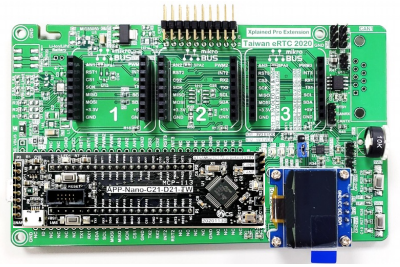
Wi-Fi to CAN Bus Bridge

SAMC21 Nano Board - Add Application Code



MPLAB X IDE v5.45 - can_demo_sam_c21n_xpro : sam_c21n_xpro

File Edit View Navigate Source Refactor Production Debug Team Tools Window Help

Projects × Files

- can_demo_sam_c21n_xpro
  - Header Files
  - Important Files
  - Linker Files
  - Source Files
    - config
    - main.c
  - Libraries
  - Loadables
- PIC32MZW1_Curiosity_OOB

main.c ×

Source History

```
200
201  int main ( void )
202  {
203      uint32_t status = 0;
204      uint16_t bitMask = 0x00FF;
205      uint8_t rx_message[8], tx_message[8];
206      uint32_t rx_messageID = 0, tx_messageID = 123;
207      uint8_t rx_messageLength = 0;
208      CAN_MSG_RX_FRAME_ATTRIBUTE msgFrameAttr = CAN_MSG_RX_DATA_FRAME;
209      uint32_t getDataDelay = 0, resetDelay = 0;
210      CALIBR_BME280_STATES calibStage = CALIBR_BME280_T_P_WRITE;
211      uint8_t tempWrite = 0, writeStage = 0;
212      int tempTemp = 0, tempPress = 0, tempHumid = 0;
213
214      appData.state = APP_BME280_STATE_INIT;
215
216      /* Initialize all modules */
217      SYS_Initialize ( NULL );
218
219      SERCOM2_I2C_CallbackRegister(i2cEventHandler, 0);
220
221      /* Set Message RAM Configuration */
222      CAN0_MessageRAMConfigSet(Can0MessageRAM);
223
224      while ( true )
225      {
226          /* Check the application's current state. */
227          switch(appData.state)
228          {
229              case APP_BME280_STATE_INIT:
230              {
231                  /* Open I2C driver instance */
232                  appData.state = APP_BME280_STATE_READY_WAIT;
```

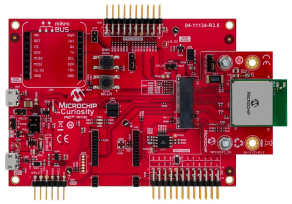
Output × Call Stack

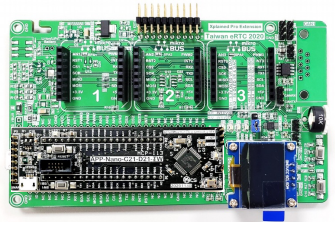
Configuration Loading Error × Atmel-ICE ×

Loading script file C:\Program Files\Microchip\MPLABX\v5.45\packs\Microchip\SAMC21_DFP\3.4.78\samc21\..\scripts\dap_cortex-mOplus.py

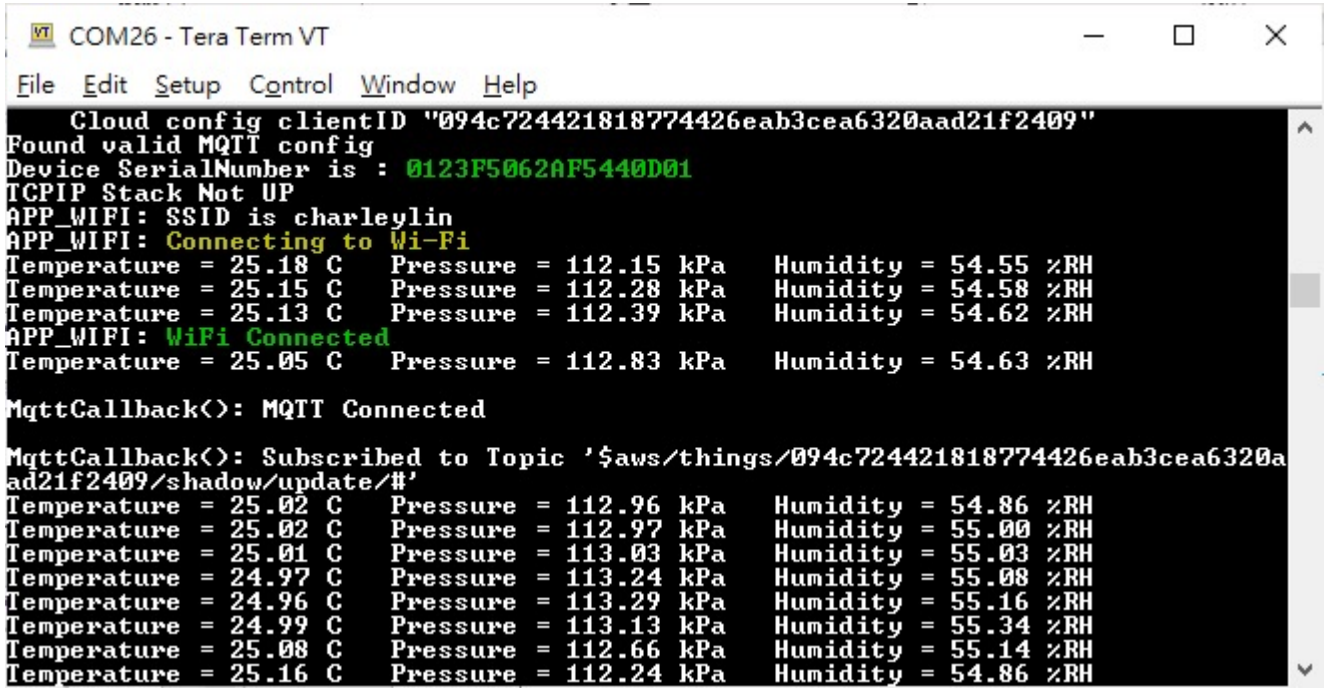
Wi-Fi to CAN Bus Bridge

Demo



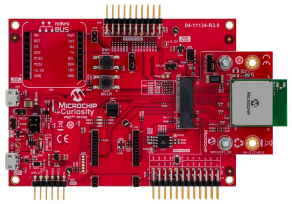


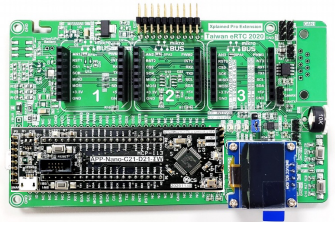
- **Follow the instructions in**
  https://github.com/MicrochipTech/PIC32MZW1_Curiosity_OOB
  You can get the results below:

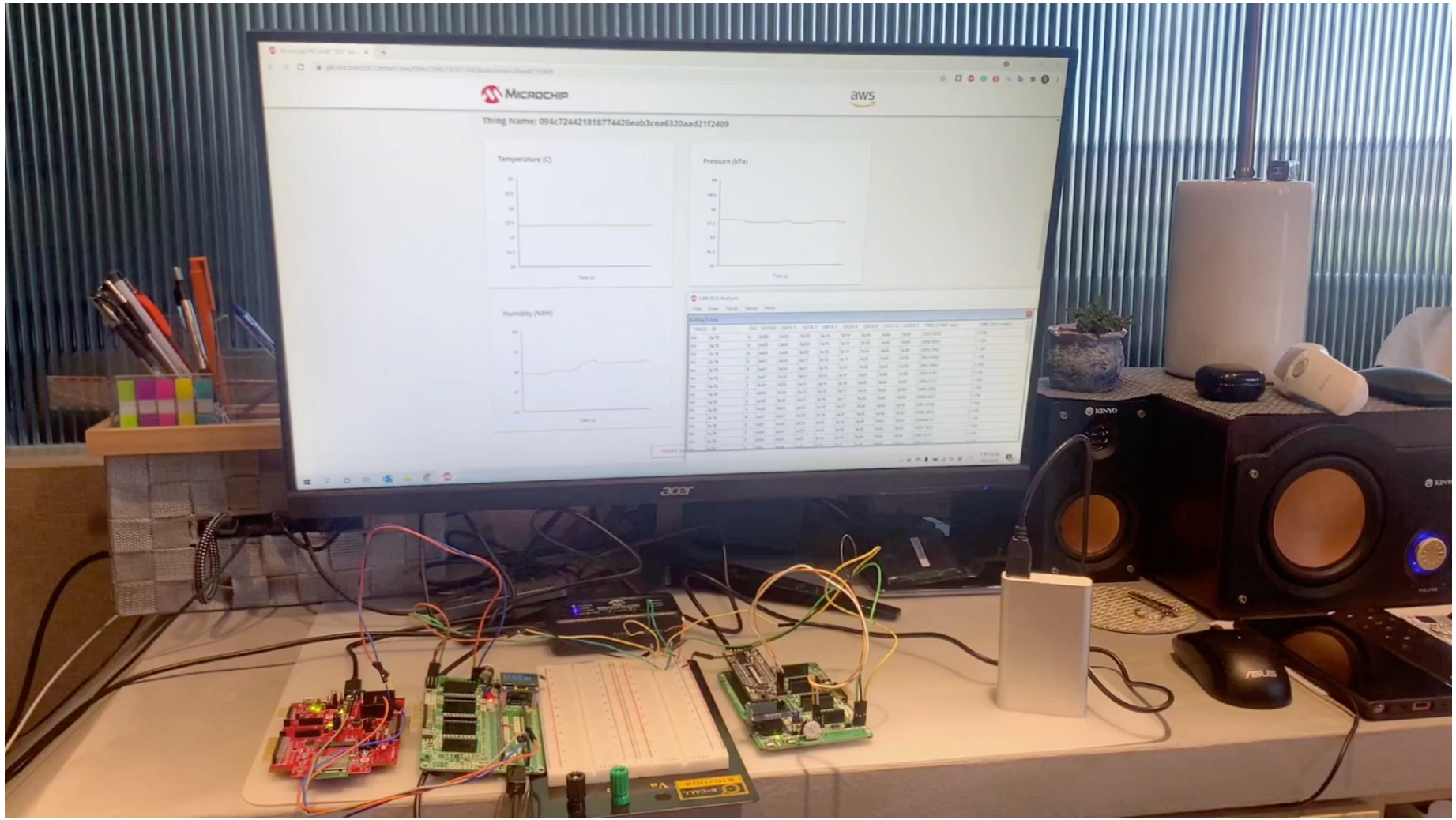


Wi-Fi to CAN Bus Bridge

Demo







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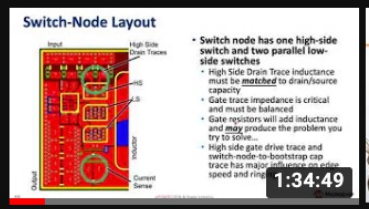

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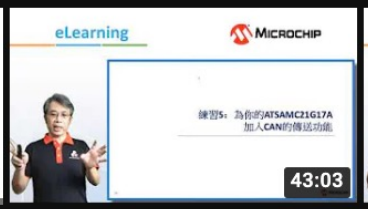

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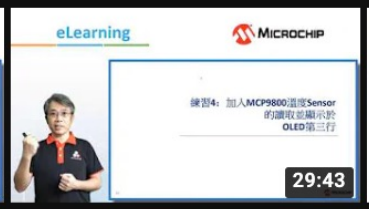

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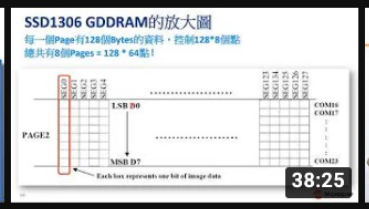

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