SAMD21 ARM Cortex-M0+ Microcontroller & Harmony v3

SAM2002 v1.01 Appendix

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

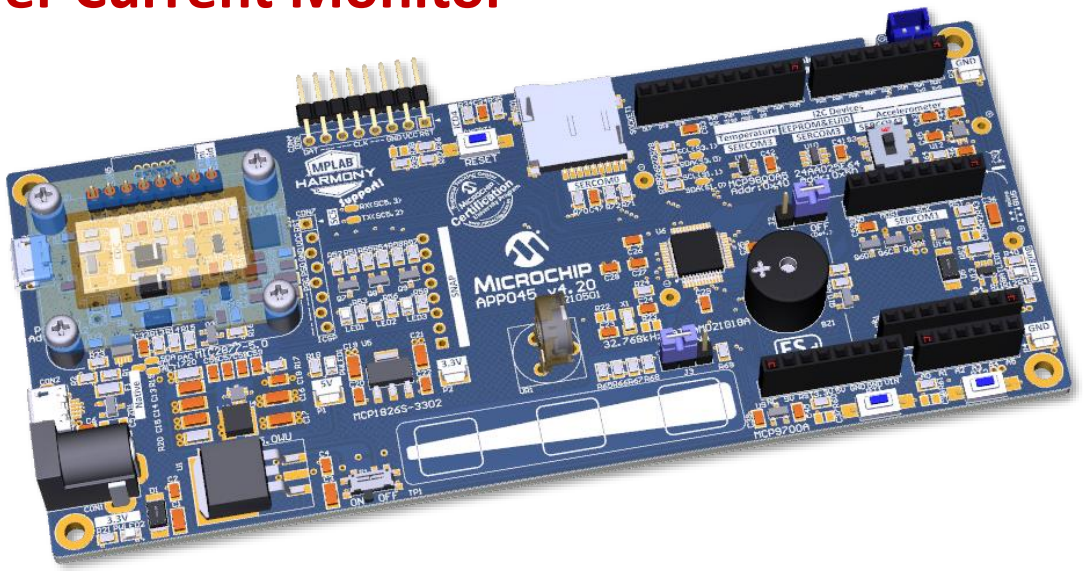
CAE Taiwan Team
Microchip Technology Inc.

2022 March

SAMD21 EVB APP045 v4
Introduction

APP045 v4 Features

- On board SAMD21G18A 32Bit ARM Cortex M0+ Microcontroller
- Support plugged MPLAB SNAP external programmer/debugger
- Onboard USB CDC Virtual COM Port and Power Current Monitor
- Multiple Power Supply Source
- Support Li-on Battery, boost and charger
- 2 x Buttons, 3 x LEDs
- 1 x I2C Temperature Sensor
- 1 x I2C EEPROM with Unique ID
- 1 x I2C Accelerometer
- 1 x MicroSD Socket (SPI interface)
- 1 x SPI OLED (128 x 64, SSD1306 Compliant)
- 1 x Potentiometer, Analog Temperature Sensor and Buzzer
- 1 x Capacitive QTouch® Slider & Buttons with Driven Shield
- 1 x mikroBUS™ Click Board Socket
- 1 x Arduino® Shield Socket (Arduino M0 Pro board Compliant)



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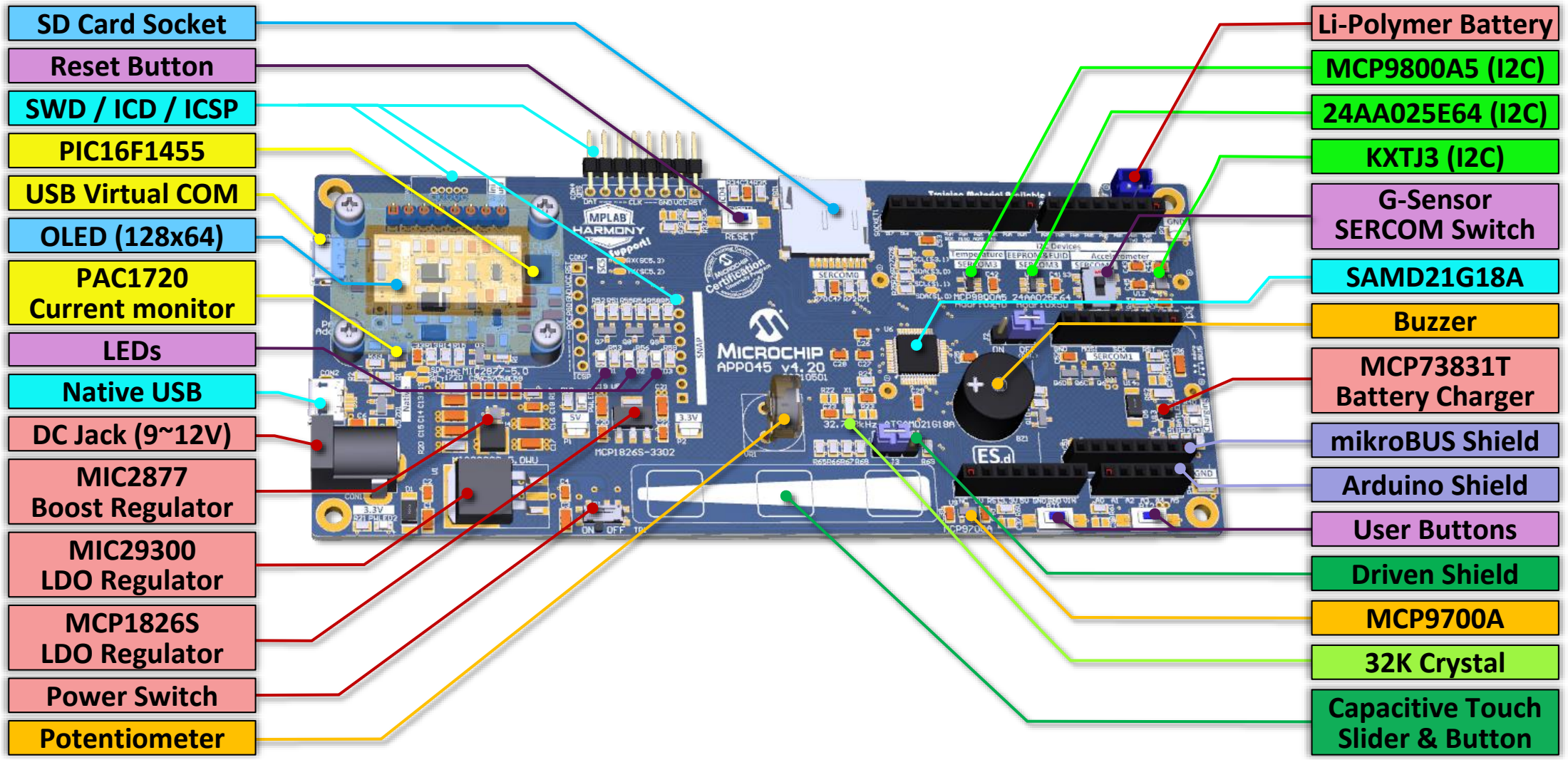
APP045 v4 Overview



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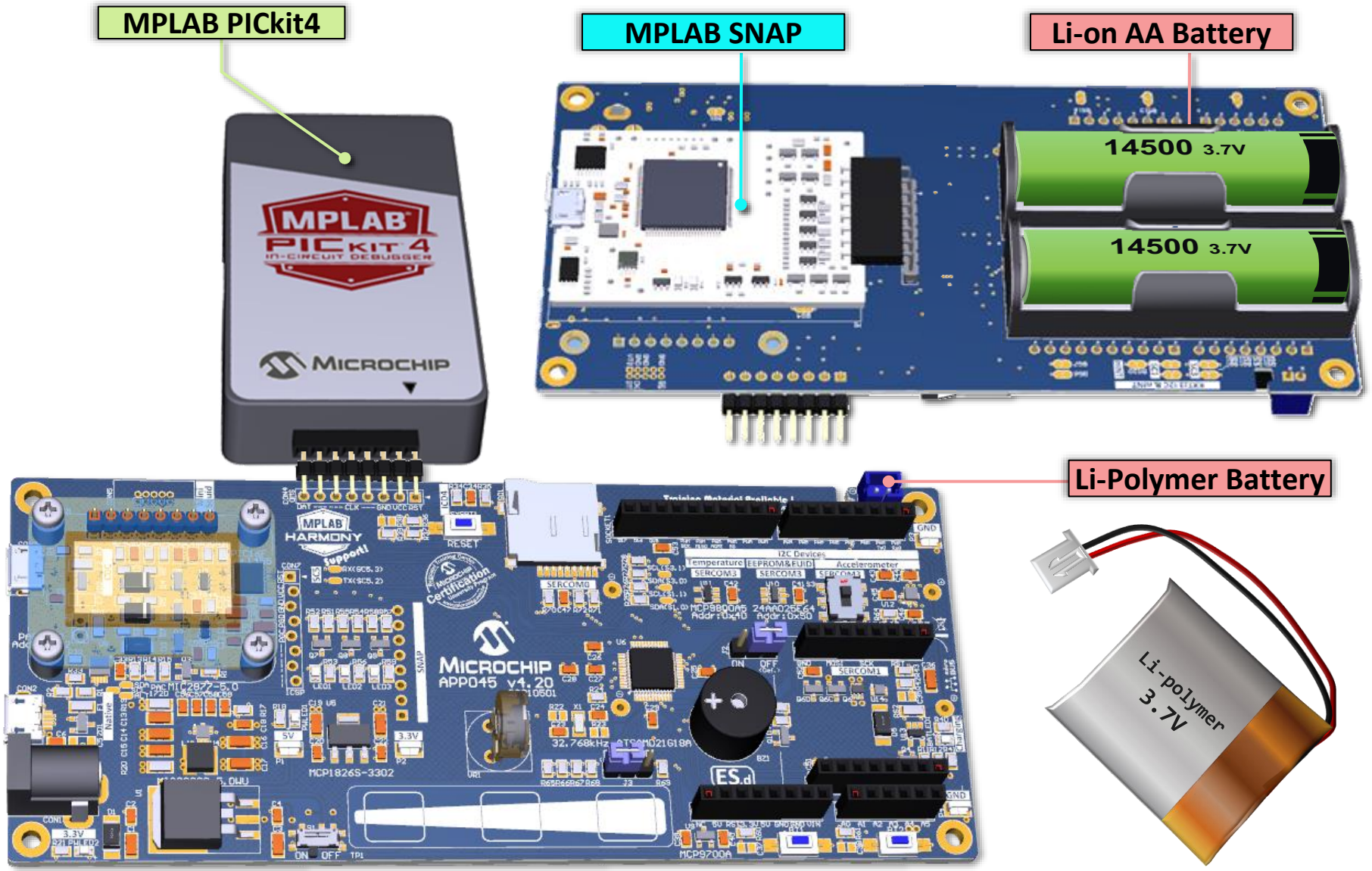
APP045 v4 Programmer and Debugger



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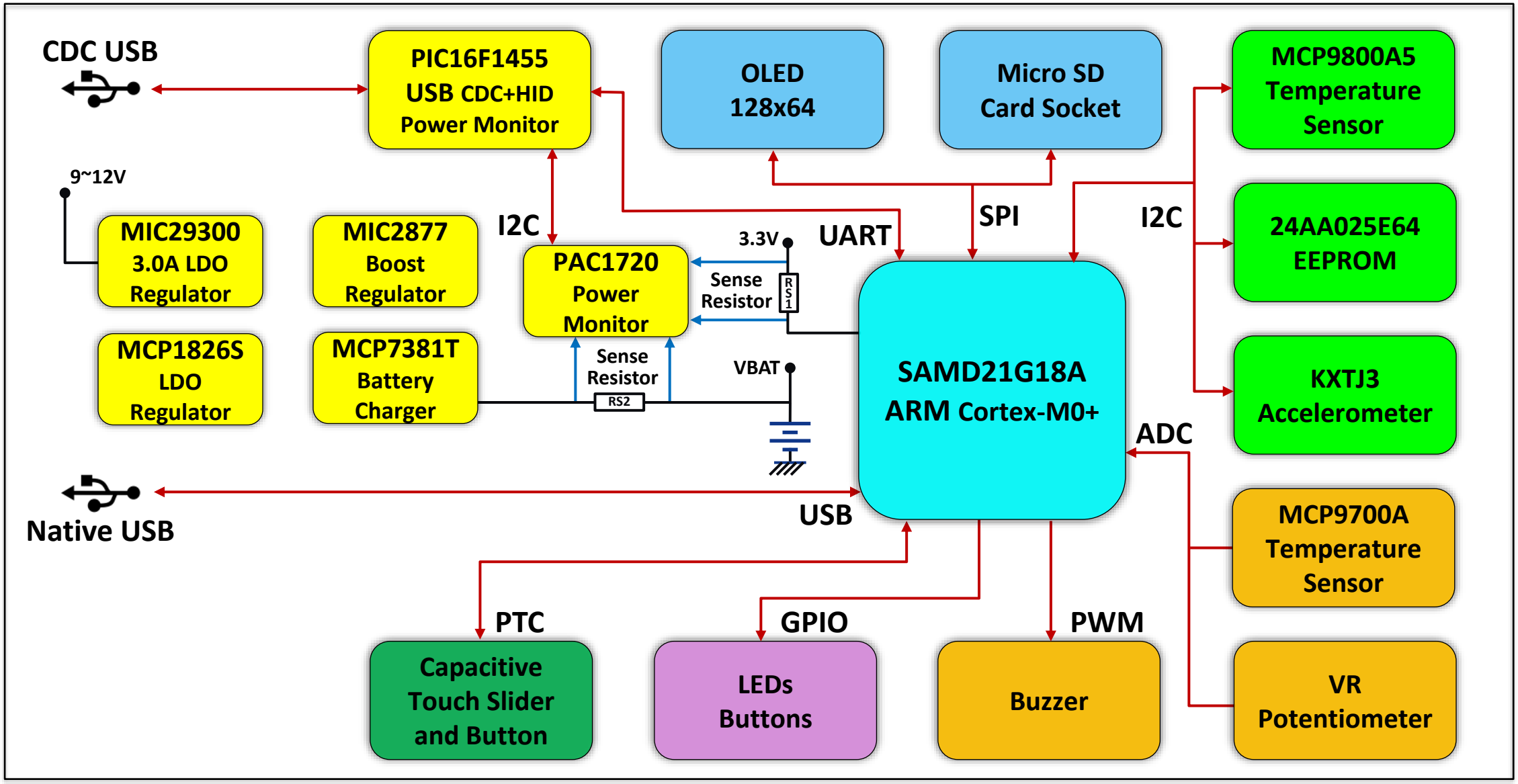
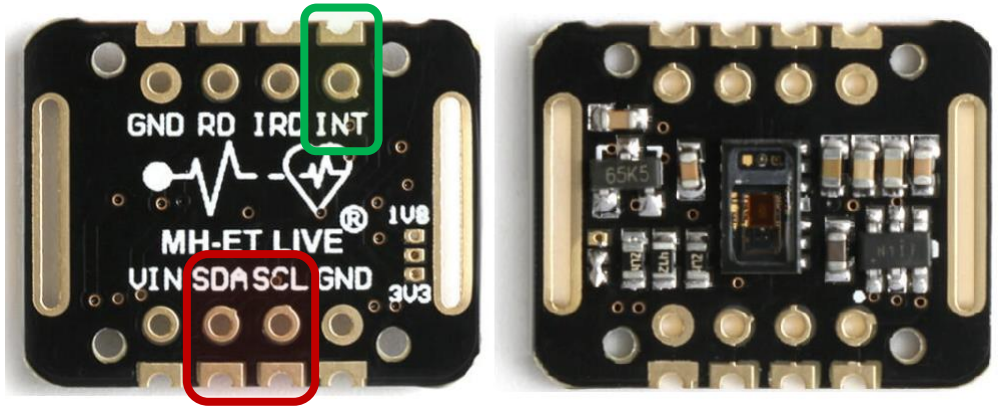
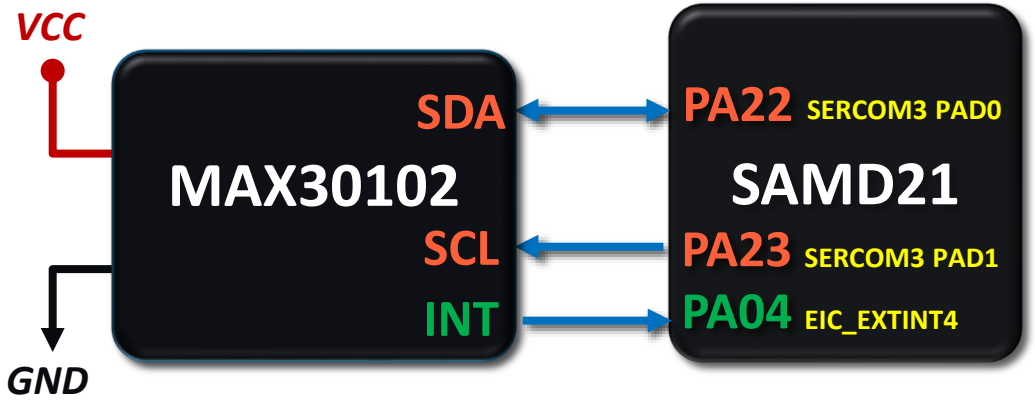
APP045 v4 Block Diagram

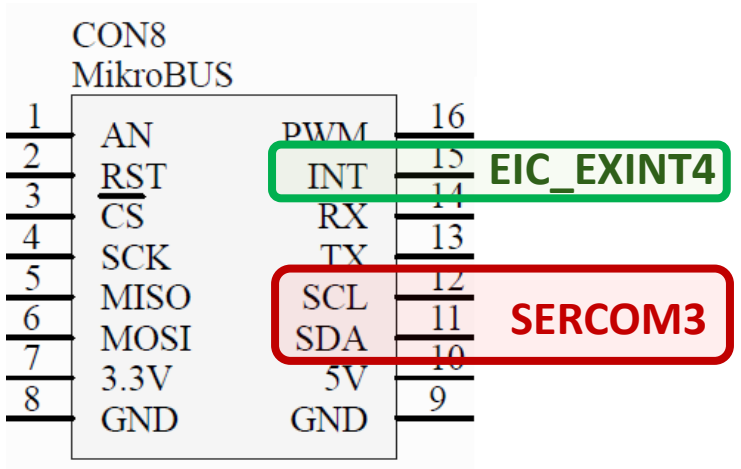


🛠 LabX Heart Rate and Oximeter

- The Sensor we to use is MAX30102 (Pulse Oximeter and Heart-Rate Sensor).
  You can use keyword “MAX30102 module” to find the module for this Lab.
- Please wire MAX30102 module SDA/SCL to APP045v4 mikroBUS SCL(PA22)/SDA(PA23), and optional wire module’s INT to mikroBUS INT(PA04).
- The module needs supply 5V. (Depend module)
- MAX30102 configuration:
  - SDA connect to PA22 (SERCOM3 PAD0)
  - SCL connect to PA23 (SERCOM3 PAD1)
  - INT connect to PA04 (EIC_EXTINT4) Optional
  - Slave address is 0x57.







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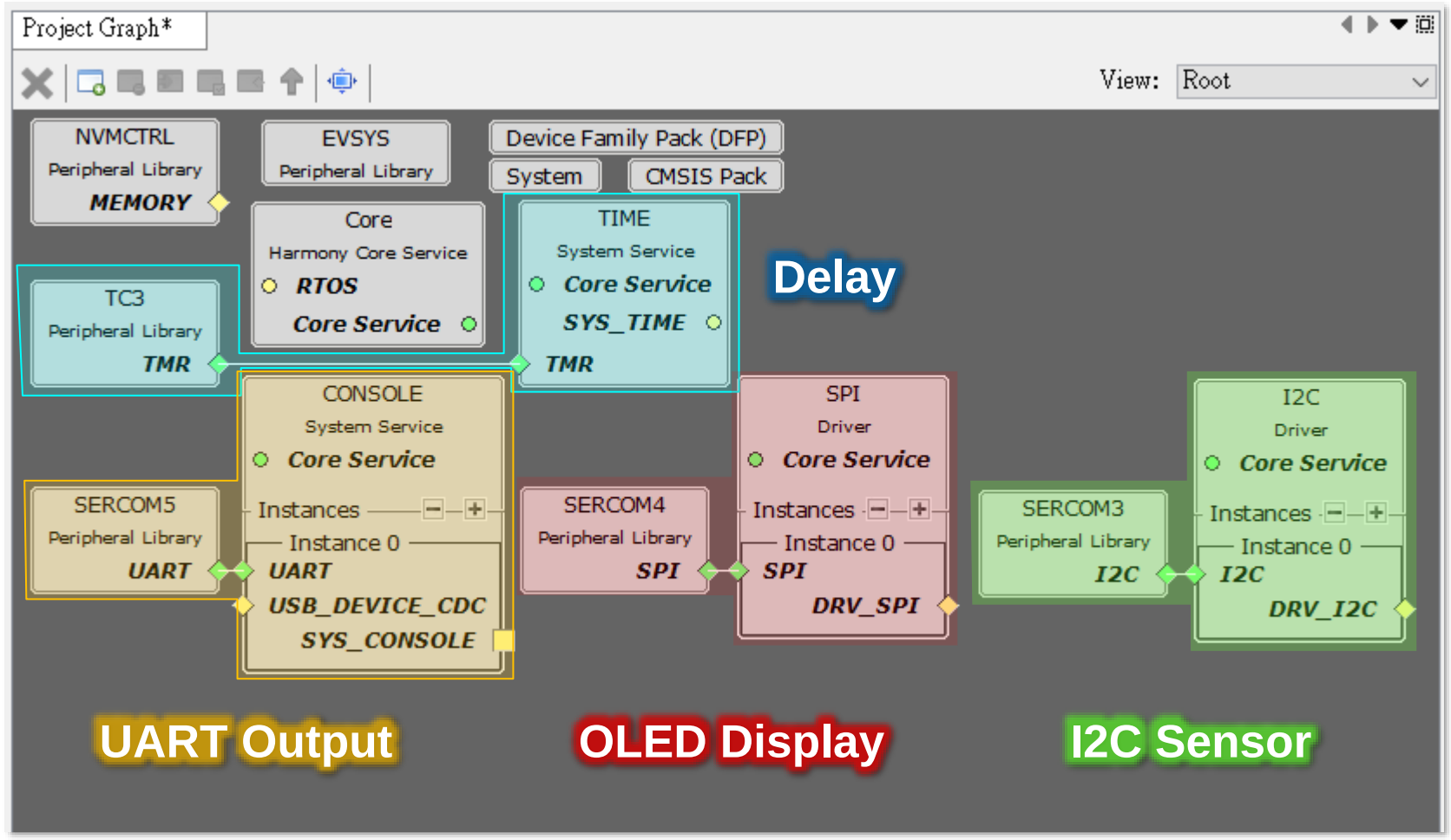
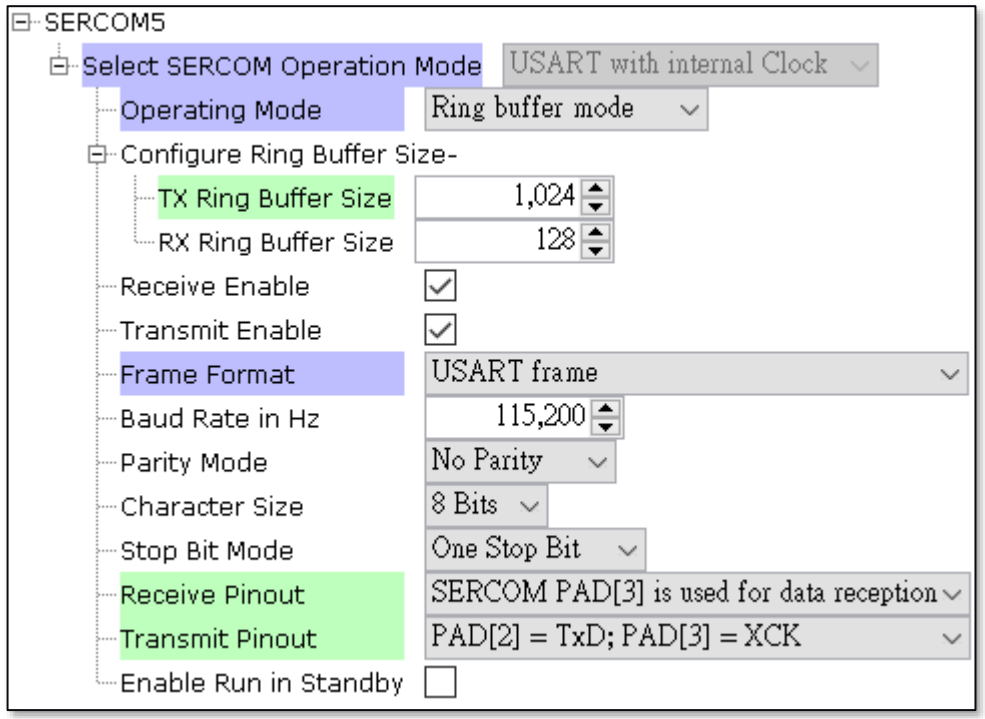
LabX Heart Rate and Oximeter

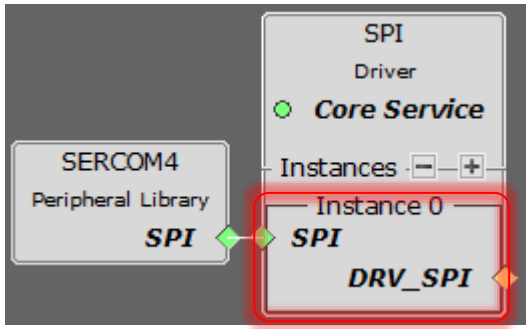
- **The Harmony Configuration.**

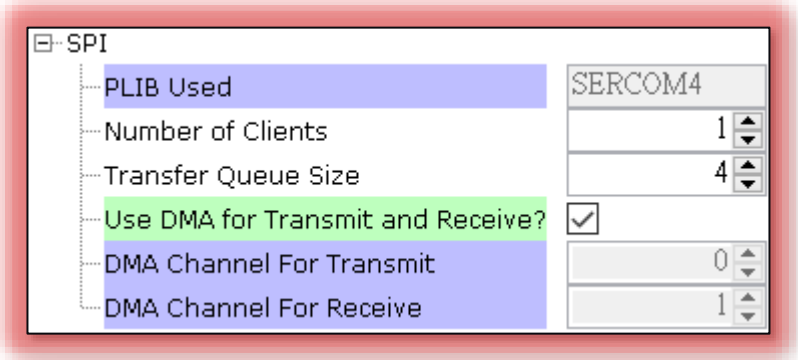


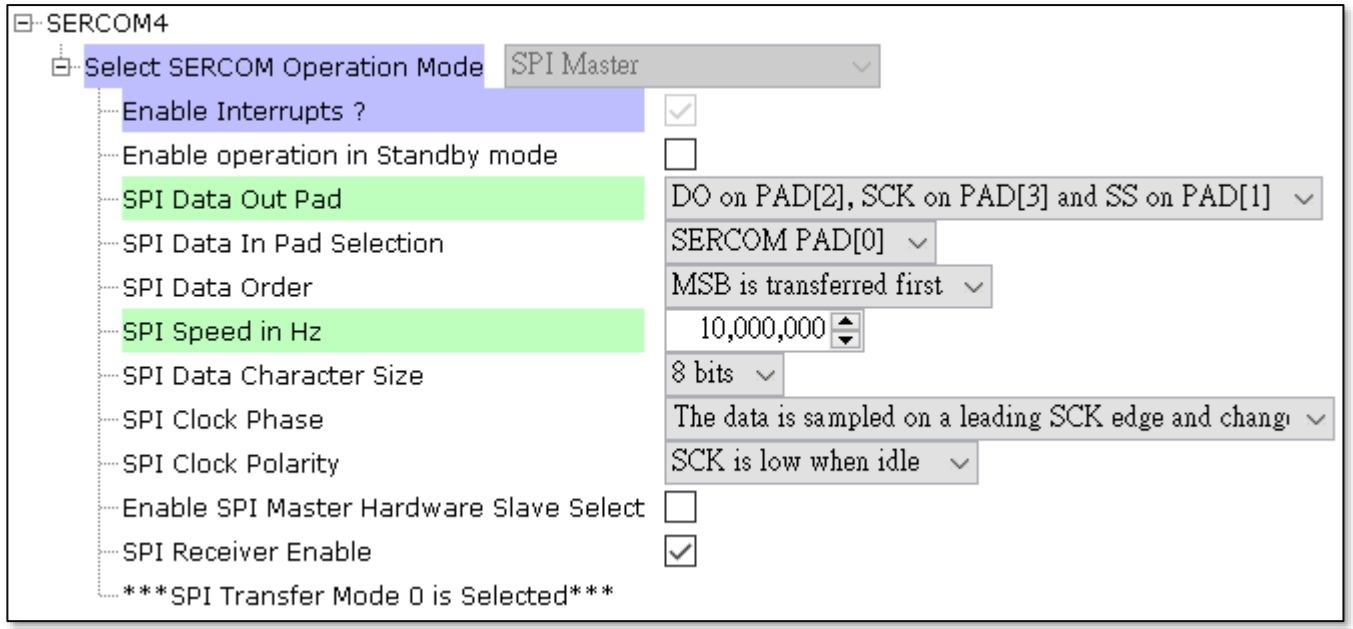
LabX Heart Rate and Oximeter

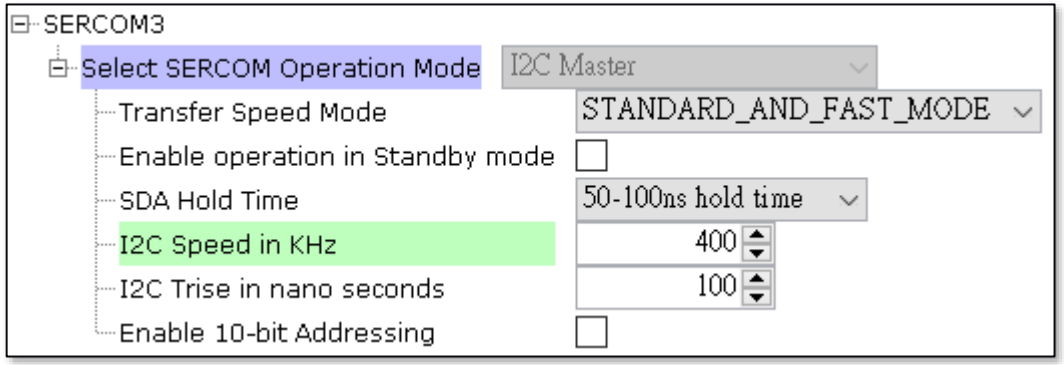
- **The Harmony Configuration.**











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LabX Heart Rate and Oximeter

- **The Harmony Configuration.**

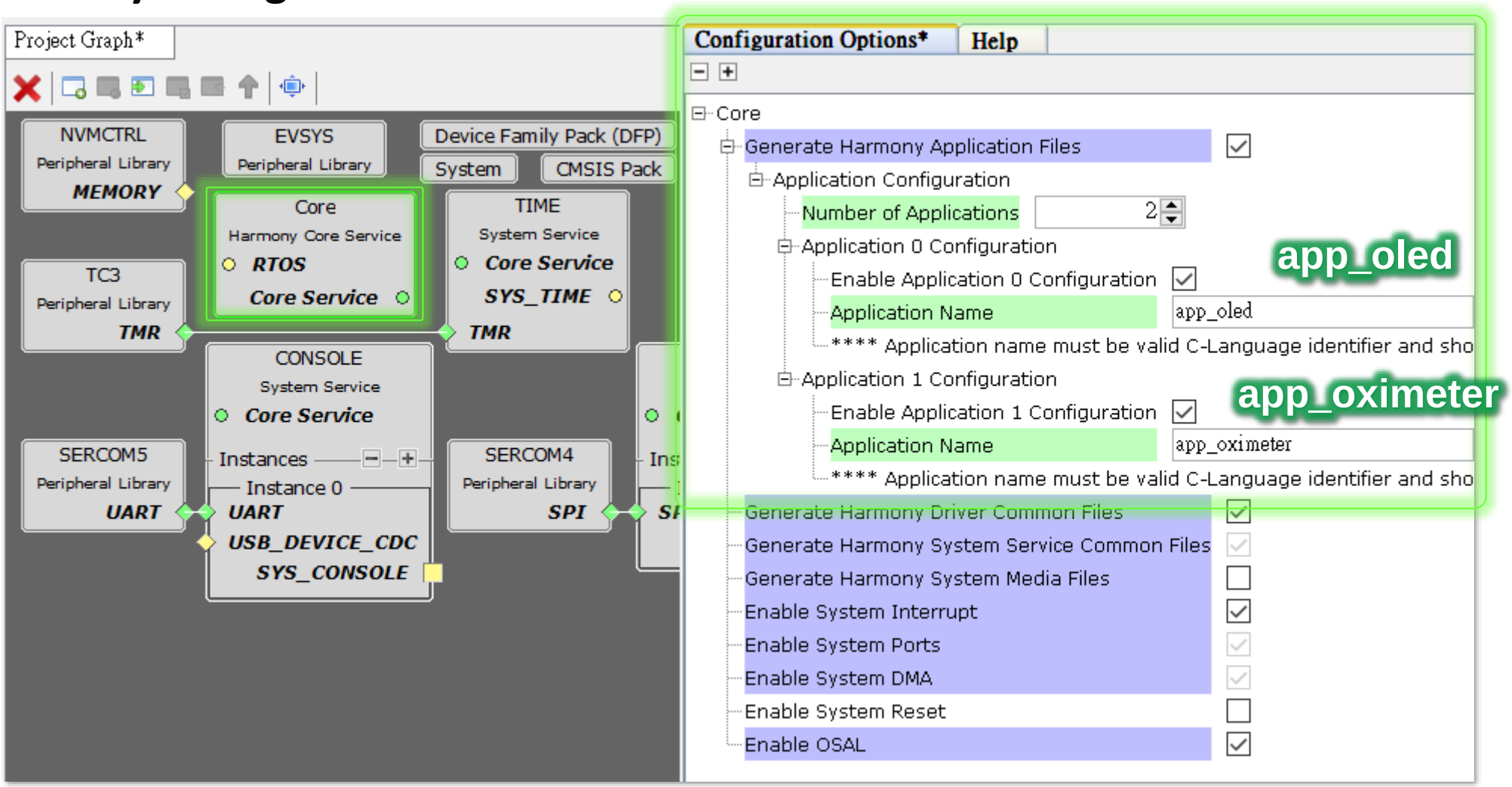
Pin Settings

Order: Ports | Table View | Easy View

Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch	Pull Up	Pull Down	Drive Strength
SSD1306_RS	PA03	SSD1306_RS	GPIO	Digital	Out	High			NORMAL
SSD1306_CS	PA08	SSD1306_CS	GPIO	Digital	Out	High			NORMAL
14	PA09	LED2	GPIO	Digital	Out	High			NORMAL
22	PA13		SERCOM4_PAD1	Digital	Out	n/a			NORMAL
23	PA14	BT1	GPIO	Digital	In	Low	☐	☐	NORMAL
24	PA15	BT2	GPIO	Digital	In	Low	☐	☐	NORMAL
26	PA17	LED3	GPIO	Digital	Out	Low			NORMAL
29	PA20	LED1	GPIO	Digital	Out	High			NORMAL
31	PA22		SERCOM3_PAD0	Digital	High Impedance	n/a	☐	☐	NORMAL
32	PA23		SERCOM3_PAD1	Digital	High Impedance	n/a	☐	☐	NORMAL
19	PB10		SERCOM4_PAD2	Digital	High Impedance	n/a	☐	☐	NORMAL
20	PB11		SERCOM4_PAD3	Digital	High Impedance	n/a	☐	☐	NORMAL
37	PB22		SERCOM5_PAD2	Digital	High Impedance	n/a	☐	☐	NORMAL
38	PB23		SERCOM5_PAD3	Digital	High Impedance	n/a	☐	☐	NORMAL

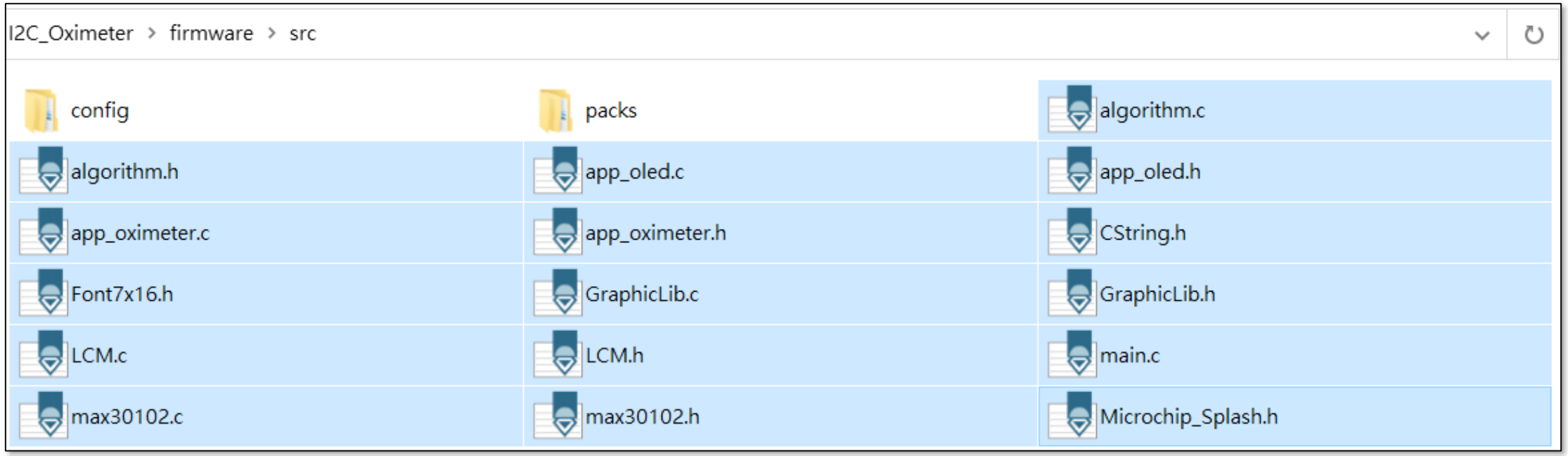
LabX Heart Rate and Oximeter

- **The Harmony Configuration.**



🛠 LabX Heart Rate and Oximeter

- **Copy files and overwrite all in your project \src folder.**
  - Graphic library : GraphicLib.c and GraphicLib.h
  - OLED display driver : LCM.c and LCM.h
  - Bitmap and Font pictures : Microchip_Splash.h, Font7x16.h and CString.h
  - MAX30102 driver : max30102.c and max30102.h
  - Oximeter algorithm : algorithm.c and algorithm.h (MAXIM to provided)
  - Main and App state machine : main.c , app_oximeter.c and app_oximeter.h



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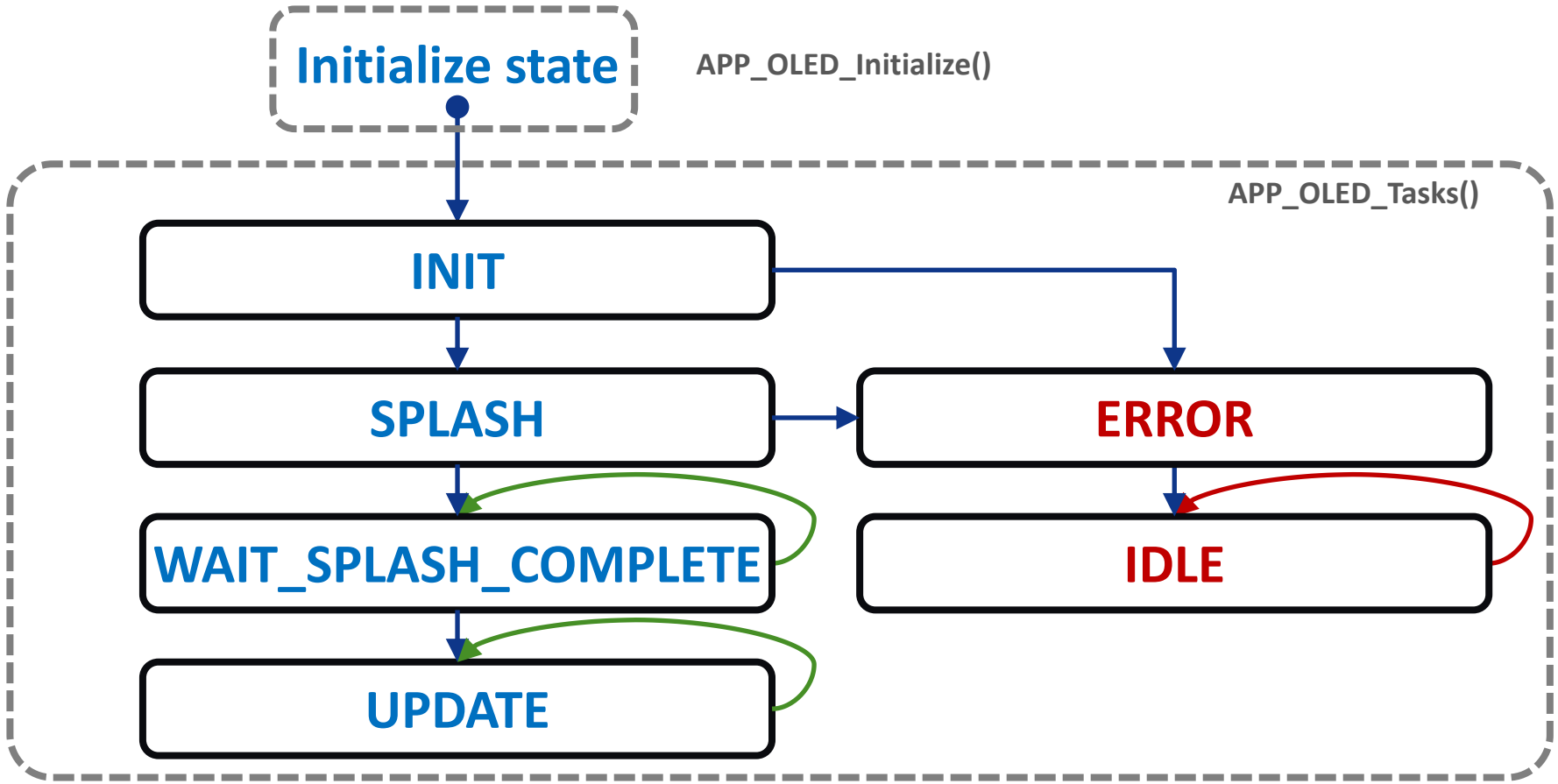
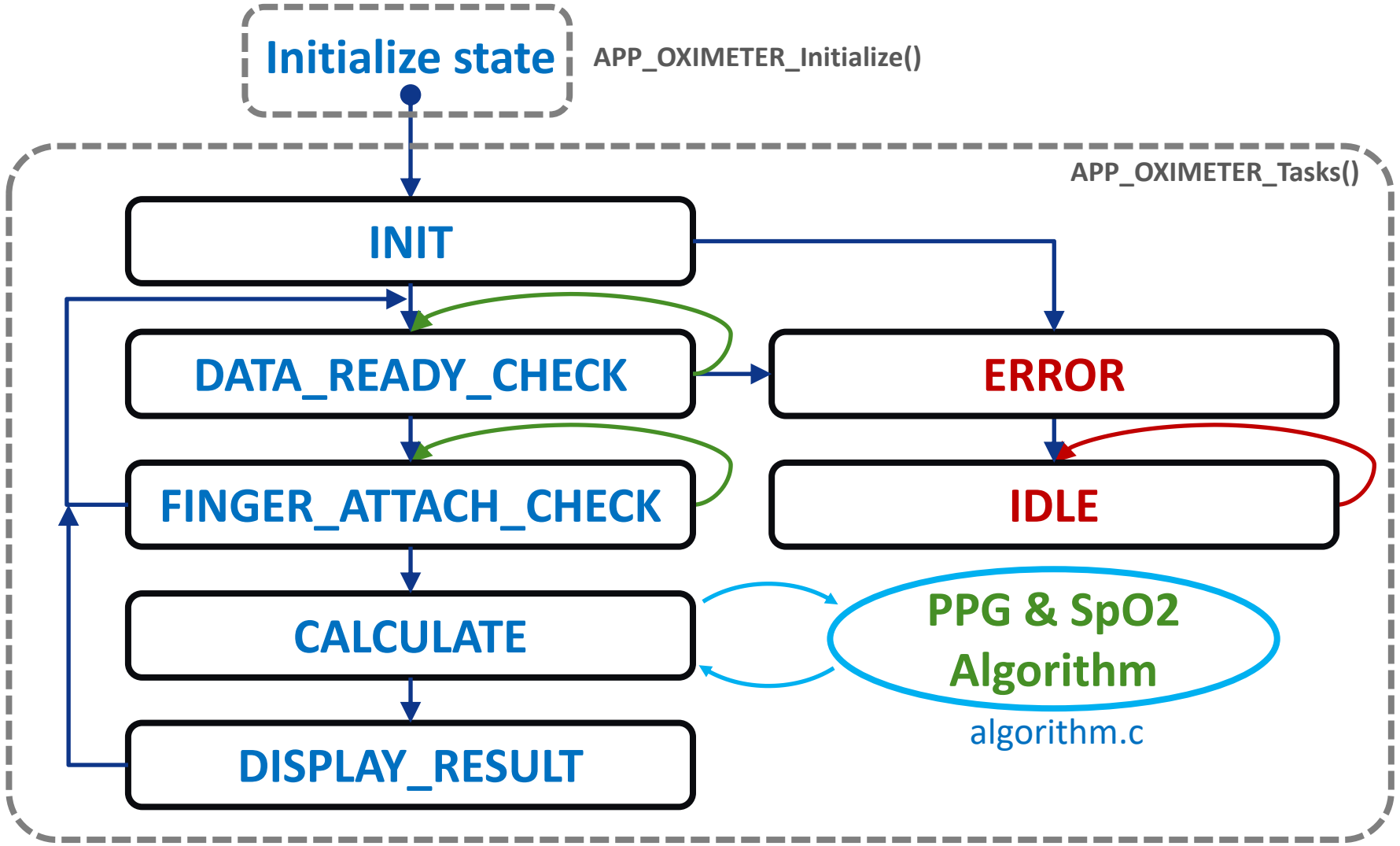
🛠 LabX Heart Rate and Oximeter

- **The state machine we want to implement in “app_oled.c“ as below.**



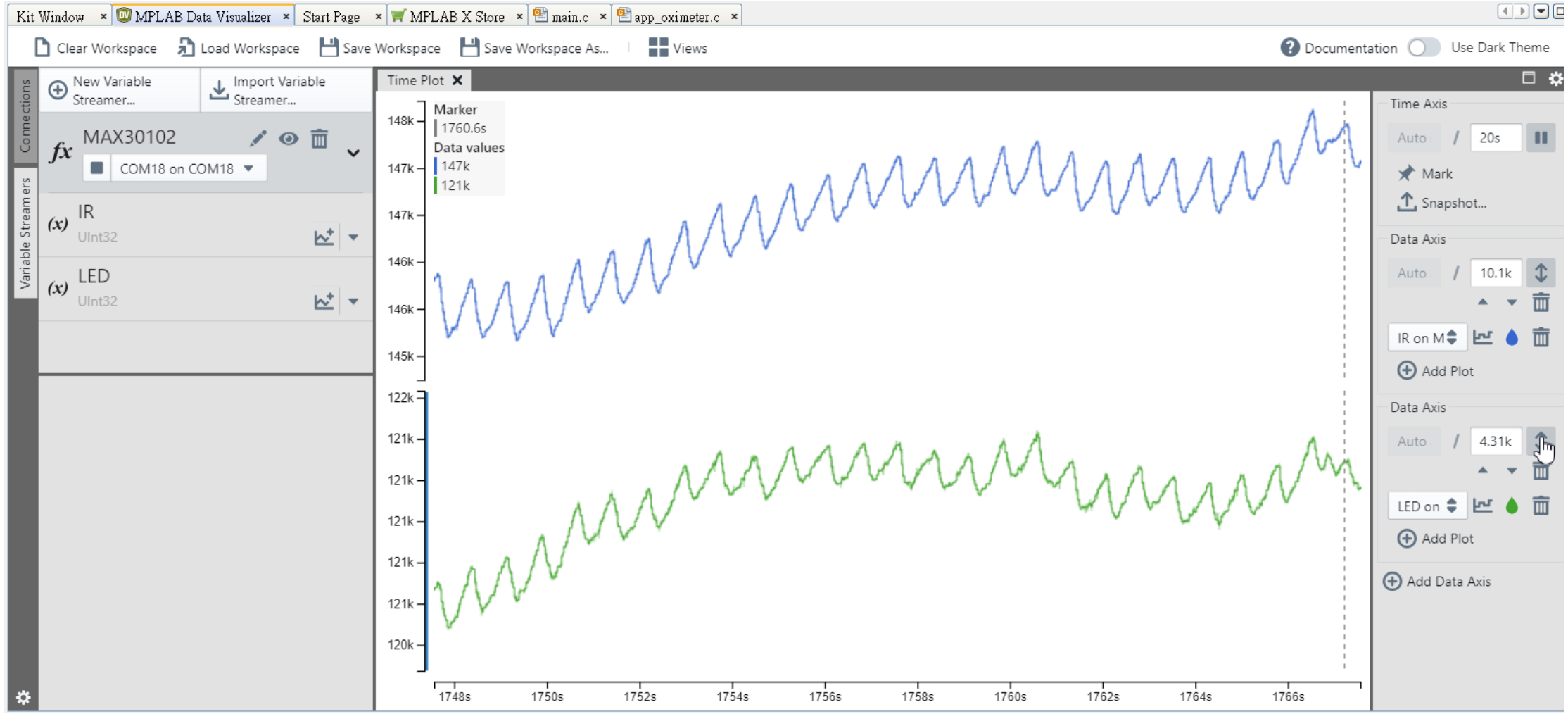
🛠 LabX Heart Rate and Oximeter

- The state machine we want to implement in “app_oximeter.c“ as below.



LabX Heart Rate and Oximeter

- **Raw PPG signal in MPLAB Data Visualizer**



🛠 LabX Heart Rate and Oximeter

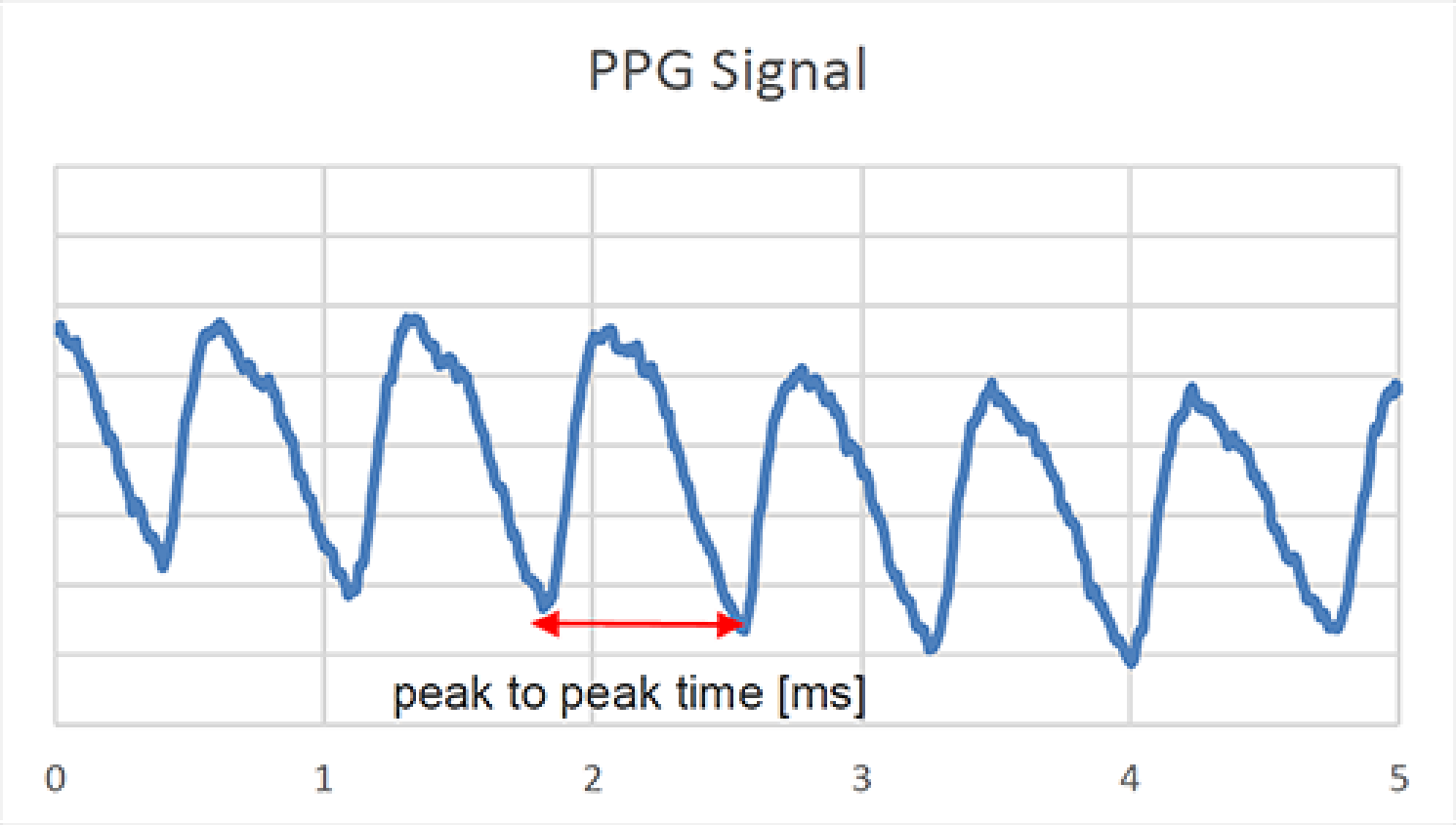
- **PPG Algorithms**

  Time domain :

  HeartRate = 60 / duration * Number of Peaks

  Frequency domain : Use FFT

  HearRate = Freq * 60



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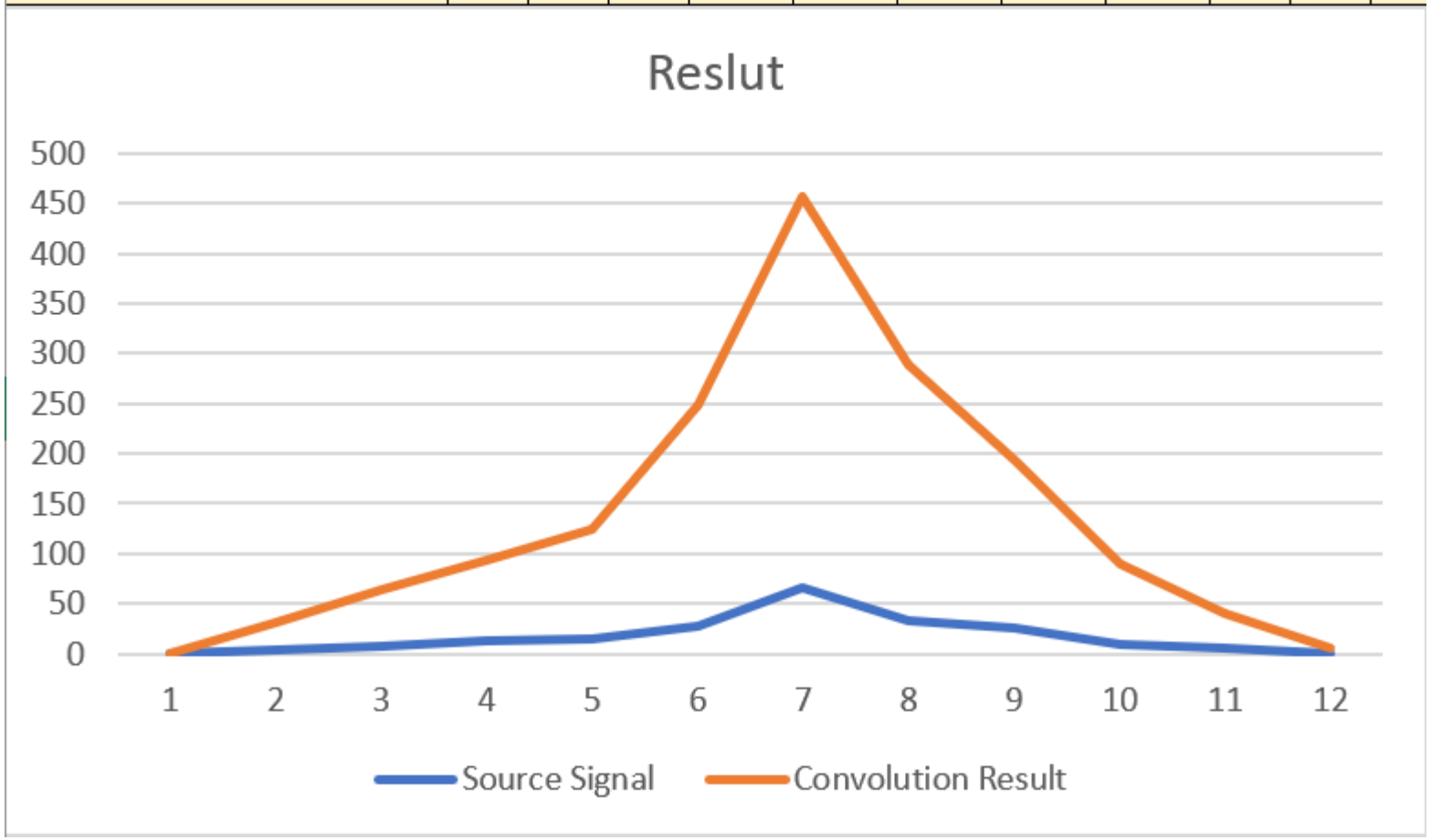
LabX Heart Rate and Oximeter

- **Find Peak Algorithm (Example)**

Convolution Pattern	1	5	1								
Source Signal	4	8	12	14	28	66	33	25	10	5	0
Convolution Result	28	56	82	110	220	391	256	168	80	35	5



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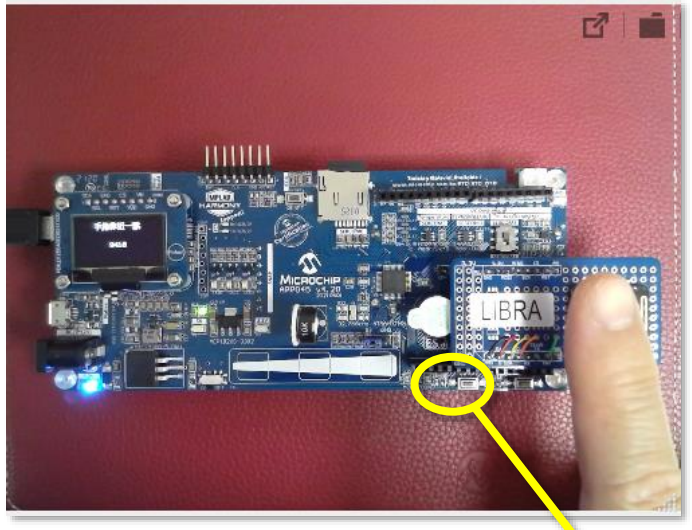
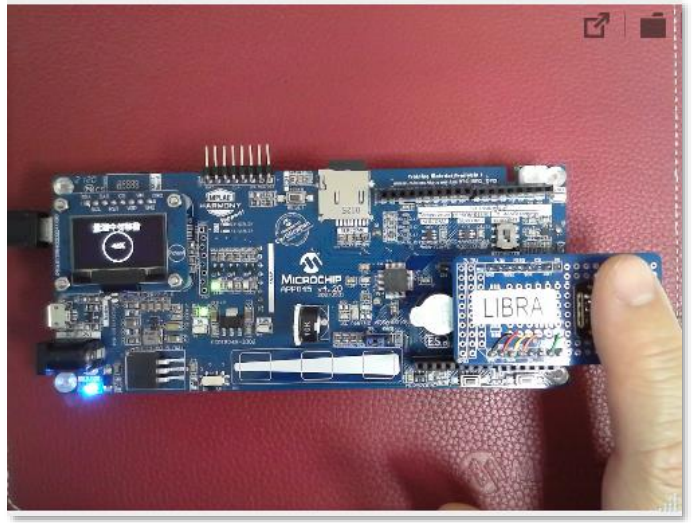
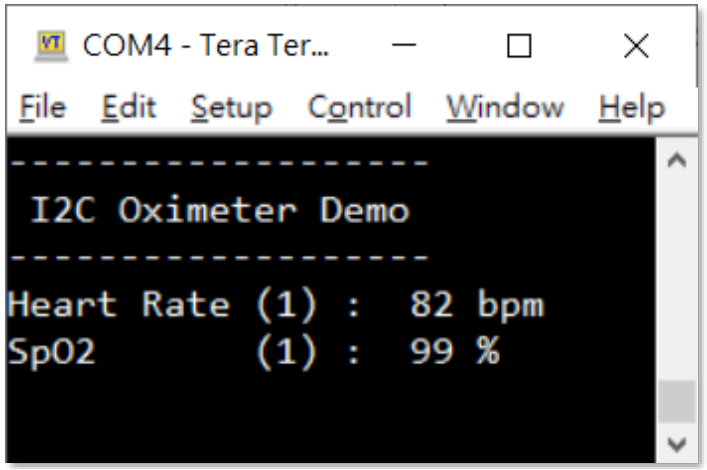
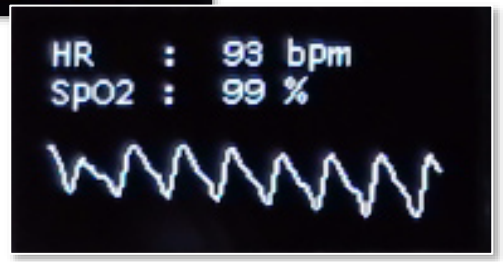
🛠 LabX Heart Rate and Oximeter

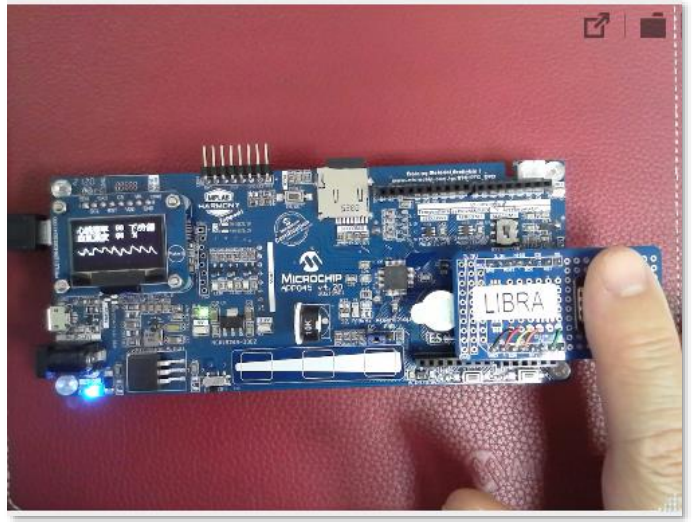
- **Result Demo**











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