San Jose State University
Department of Electrical Engineering
EE104, Fall 2023, Pham

Laboratory Assignment 5

Objectives

This lab gives you opportunities to explore the medical technology via a creation of a heart rate diagnostic program, social technology via the COVID-19 modeling using the full SIDARTHE mathematical model, design a simple EMS Vehicle lighting controlling system, and further in game development with the program Red Alerts.

Grading

Refer to the section **Python Programming** for grading criteria.

Bibliography

Refer to the lecture notes for sample programs.

Requirements

1 - Heart Rate Analysis – Time Domain Measurements – Biotechnology

Download a WAV file from the heartbeat sound bank website https://www.kaggle.com/kinguistics/heartbeat-sounds by selecting a wave file that shows at the minimum 30 beats in the preview waveform. Using WAV to CSV conversion tool and write a Python program to plot the heart rate signal and find the time-domain measurements for that WAV file. See a sample below.

Note: CSV data has to be normalized to 0.xxx format. For example, if your converted data is 95, then normalize by dividing the number by 1000 to get 0.095. You must attend the class lecture to know how to do the data conversion if you are not already knowing how to do it.

```
bpm: 252.758989
ibi: 237.380282
sdnn: 205.684865
sdsd: 178.894568
rmssd: 306.362338
pnn20: 0.794118
pnn50: 0.764706
hr_mad: 46.000000
sd1: 214.754515
sd2: 182.818533
s: 123342.400111
sd1/sd2: 1.174687
breathingrate: 0.682331
```

2 – COVID-19 Modeling

What is Epidemiology?

Epidemiology is the method used to find the causes of health outcomes and diseases in populations. In epidemiology, the patient is the community and individuals are viewed collectively. By definition, epidemiology is the study (scientific, systematic, and data-driven) of the distribution (frequency, pattern) and determinants (causes, risk factors) of health-related states and events (not just diseases) in specified populations (neighborhood, school, city, state, country, global). It is also the application of this study to the control of health problems (Source: *Principles of Epidemiology, 3rd Edition*).

SIDARTHE mathematical model is presented in this paper: https://www.nature.com/articles/s41591-020-0883-7

Methods

SIDARTHE mathematical model

The SIDARTHE dynamical system consists of eight ordinary differential equations, describing the evolution of the population in each stage over time:

$$\dot{S}(t) = -S(t)\left(\alpha I(t) + \beta D(t) + \gamma A(t) + \delta R(t)\right) \tag{1}$$

$$\dot{I}(t) = S(t)\left(\alpha I(t) + \beta D(t) + \gamma A(t) + \delta R(t)\right) - (\varepsilon + \zeta + \lambda) I(t) \tag{2}$$

$$\dot{D}(t) = \varepsilon I(t) - (\eta + \rho) D(t) \tag{3}$$

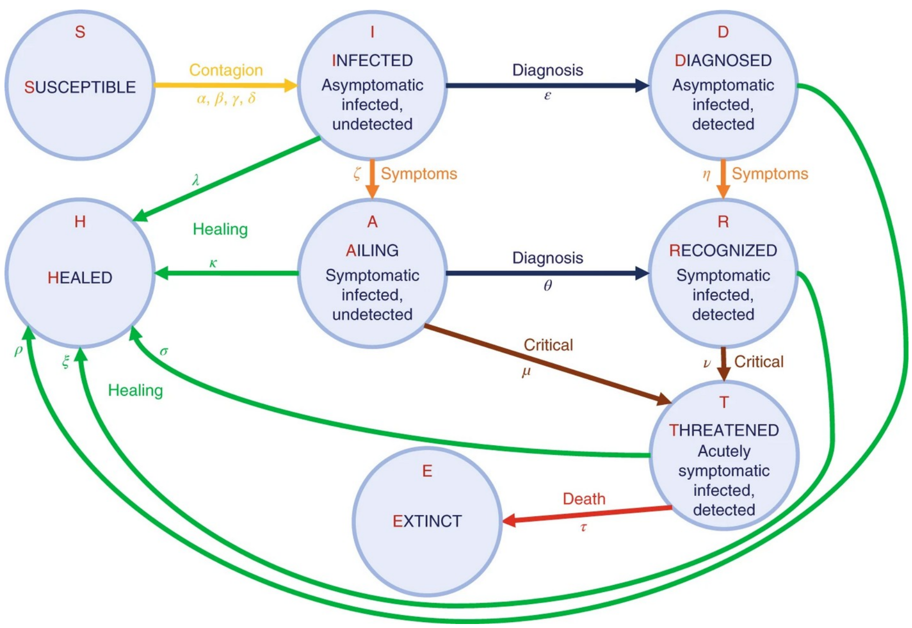
$$\dot{A}(t) = \zeta I(t) - (\theta + \mu + \kappa) A(t) \tag{4}$$

$$\dot{R}(t) = \eta D(t) + \theta A(t) - (\nu + \xi) R(t) \tag{5}$$

$$\dot{T}(t) = \mu A(t) + \nu R(t) - (\sigma + \tau) T(t) \tag{6}$$

$$\dot{H}(t) = \lambda I(t) + \rho D(t) + \kappa A(t) + \xi R(t) + \sigma T(t) \tag{7}$$

$$\dot{E}(t) = \tau T(t) \tag{8}$$

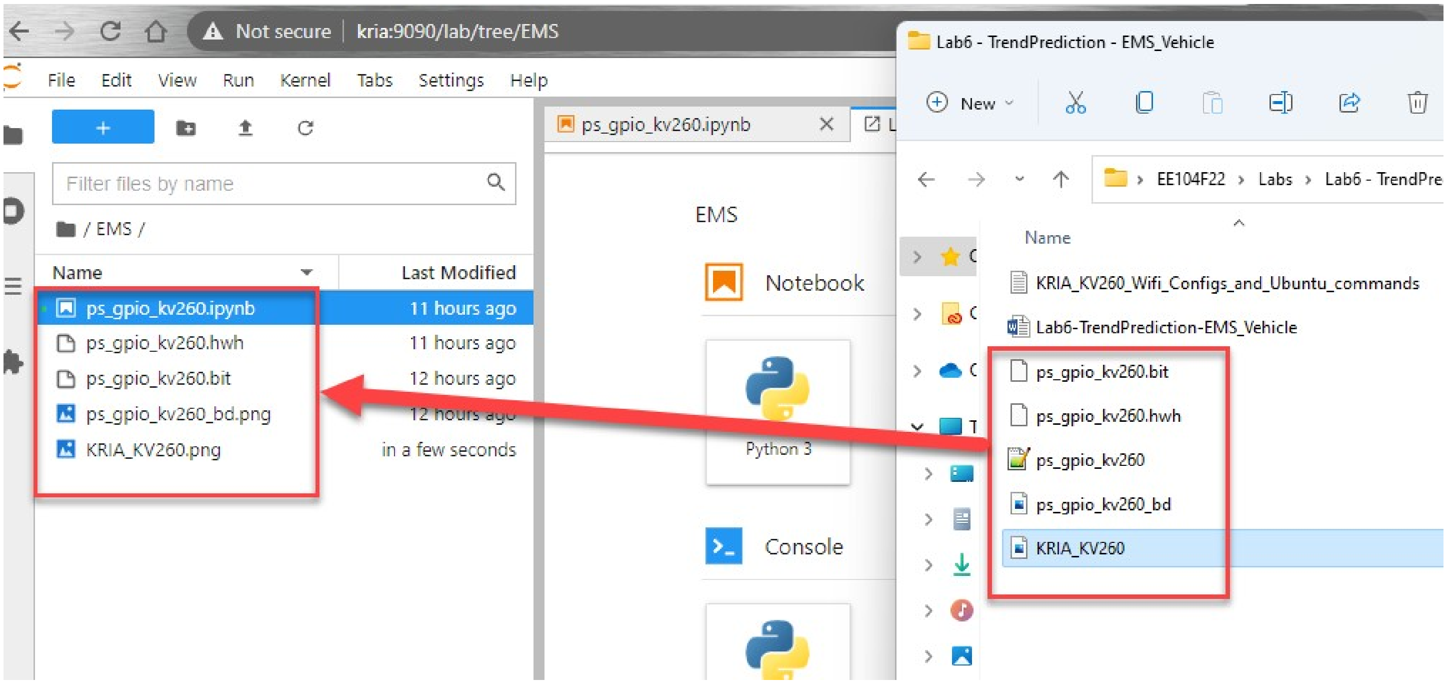


3 – Python Hardware Programming: Design the Light Controller for an EMS Vehicle

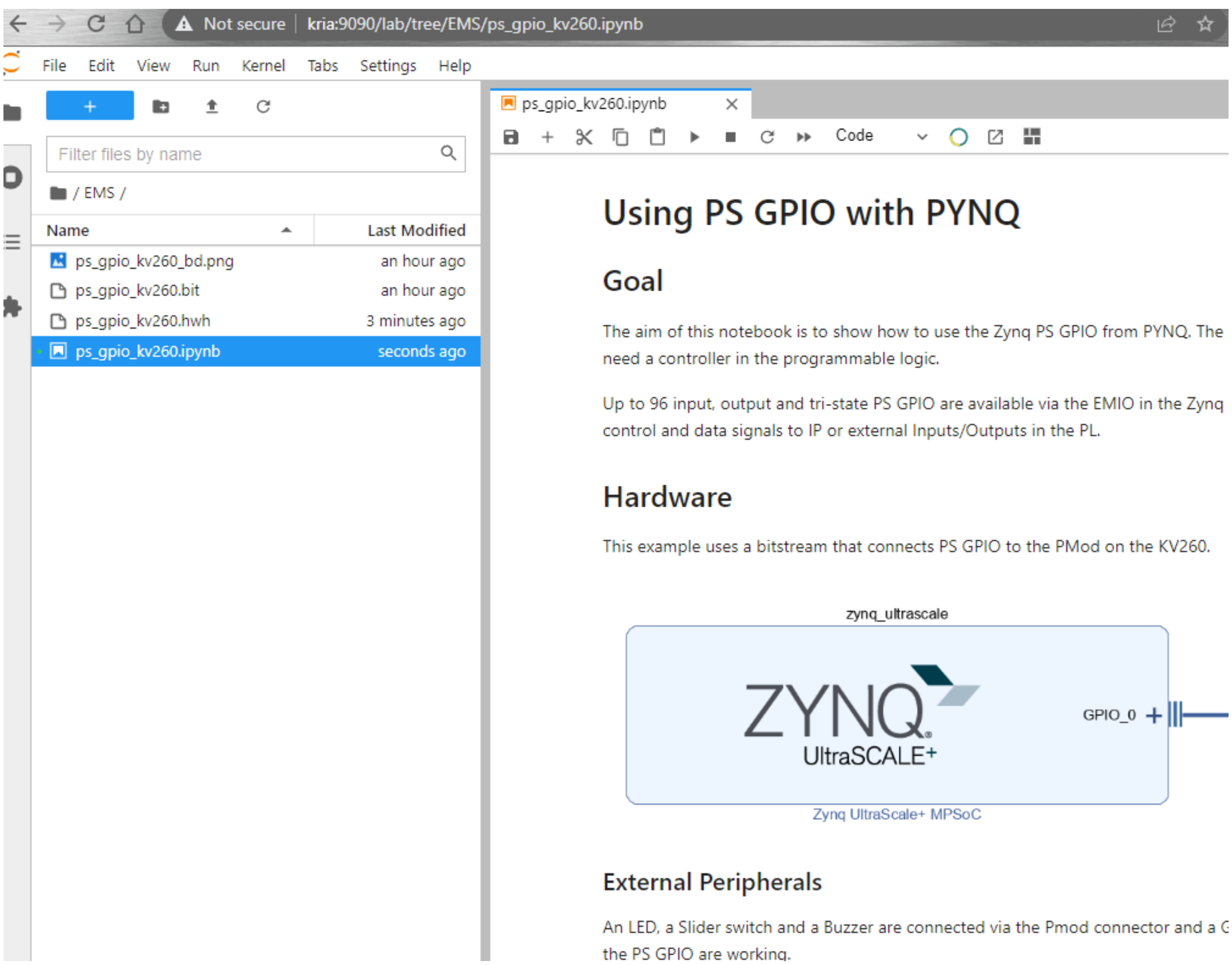
Python hardware programming
Reference: https://github.com/cathalmccabe/PYNQ_tutorials/tree/master/ps_gpio/kria_kv260_example

Download the following files from Canvas to you local drive.
Now, create a new folder EMS from the KRIA JupyterLab environment, and copy these 5 files by drag-and-drop method to the new EMS folder:

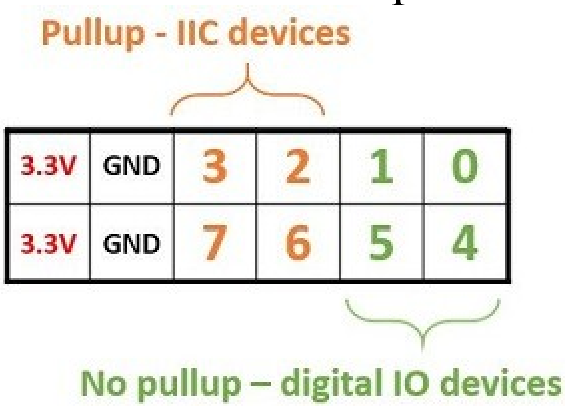
ps_gpio_kv260.bit
ps_gpio_kv260.ipynb
ps_gpio_kv260_bd.png
ps_gpio_kv260.hwh
KRIA_KV260.png

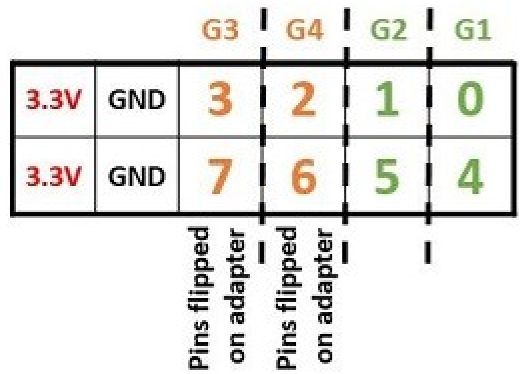


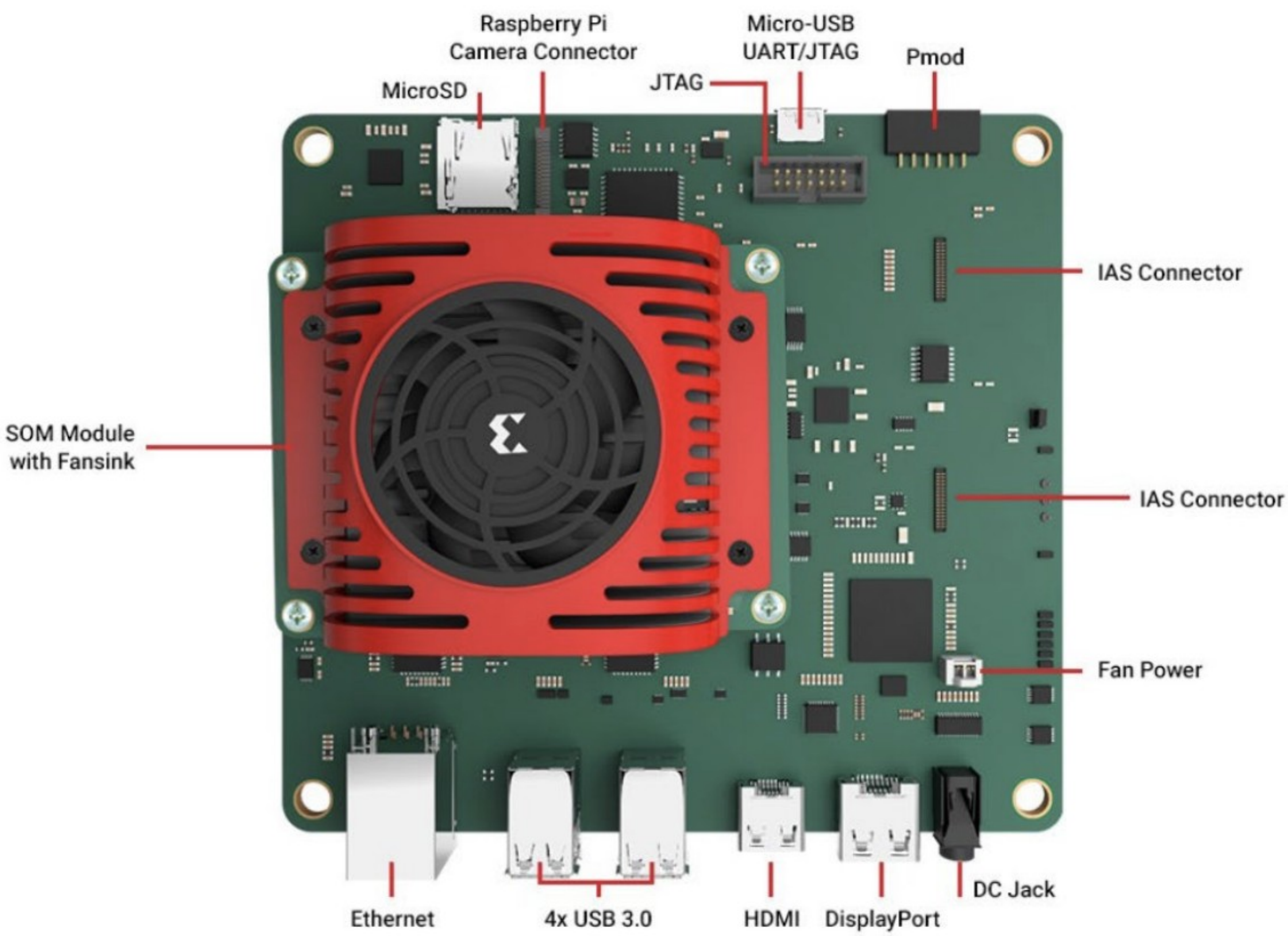
In the Jupyter directory, double click on the file ps_gpio_kv260.ipynb
You will open the Jupyter Editor:



This is the PMOD pinouts







According to the code below, connect the PMOD pins to the LED, Buzzer, and the Slider.

PYNQ GPIO class

The PYNQ GPIO class will be used to access the PS GPIO.

```
[ ]: from pynq import GPIO
```

GPIO help

```
[ ]:
```

```
### Create Python GPIO objects for the led, slider and buzzer and set the direction:
```

```
[ ]: led =        GPIO(GPIO.get_gpio_pin(6), 'out')

     buzzer =     GPIO(GPIO.get_gpio_pin(0), 'out')

     slider =     GPIO(GPIO.get_gpio_pin(1), 'in')
     slider_led = GPIO(GPIO.get_gpio_pin(5), 'out')
```

PMOD pins

Wiring:

LED1: Positive terminal connects to PMOD pin 6. Negative terminal connects to a 1K-Ohm resistor then to GRD.

Buzzer: Make a simple buzzer using a method you learned before. One of the simple method is here:
https://www.youtube.com/watch?v=glu77Fpecxs
Tie one end of the copper wire to GND, and the other end of the wire to PMOD pin 0.

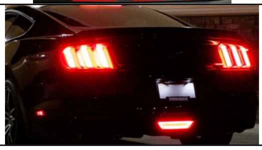
Slider: According to this spec, https://wiki.seeedstudio.com/Grove-Slide_Potentiometer/, connect Red wire to VCC, Black wire to GND, and Yellow wire to PMOD pin 1.

Slider LED2: You can connect the positive terminal of LED2 to PMOD pin 5. Connect negative LED 2 terminal to a 1K-Ohm resistor then to GND.

Code Execution:

Beginning from the first cell of the Jupyter Notebook, click on the PLAY button to execute every single cell from top down.
Experiment by changing the pin out from the 4^{th} cell and re-run that cell. Experiment by changing code from other cells and run it.

Hardware lab requirements: You will design an EMS (Emergency Medical Service) Vehicle, 5 points/each feature.

Inputs	**Responds to signal**	**LED pattern**	**Example**
00	Left turn	LED2 LED1-LED2 LED0-LED1-LED2	
01	Right turn	LED0 LED0-LED1 LED0-LED1-LED2	
10	Break	LED0 –LED1- LED2 are ON Solid	
11	Emergency button	LED0 –LED1- LED2 are flashing	FLASHING
Slider=1	Siren with Roof RGB lights	Play the siren sound along with the Roof RGB lights	 + SIREN
Slider=0	Roof RGB lights only	Roof RGB lights alone with no sound	

Slider specification: https://wiki.seeedstudio.com/Grove-Slide_Potentiometer/

That's all for this lab. Hopefully you found it useful and increase your interest in the Python world! See you in the next lab.

Python Programming

Lab Submission: see Laboratory Hand-In Requirements section below

Once you learn the process and the code associate with each step in the process, you will be able to customize the program to do the followings.

Program or Requirement	Use Case	Earned Score / Max Score
Lab Report	**Turn in lab report (using the group report template) and the video recordings of all your work with your own voice narration for each requirement below and Submit Lab#_TeamName.Zip file on time to Canvas**	_____ / 10
Medical Technology	Heart rate signal analysis for clinical diagnostics	_____ / 25
Social Technology	Covid-19 Modeling Model States S, I, and two states of your choice from the SIDARTHE mathematical model.	_____ / 20
Python Hardware Programming	Design the Light Controller for an EMS Vehicle: Left turn (5 points) Right turn (5 points) Break (5 points) Emergency button (5 points) Siren with Roof RGB lights (5 points) Roof RGB lights only (5 points) Cut out a piece of paper with the picture of the EMS vehicle. Attach your LED lights to the EMS vehicle picture in proper positions. Cycle through your inputs to demonstrate all scenarios with proper LED light display responses.	_____ / 30
Game development and Testing: Red Alerts	Entertaining Industry, Education Add hacks and tweaks: Need for speed, two directions, shuffling (5 points each)	_____ / 15
	TOTAL	**100%**

That's all for this lab. Hopefully you found it useful and increase your interest in the Python world! See you in the next lab.

Laboratory Hand-In Requirements

Once you have completed a working design, prepare for the submission process. **You are required to submit a video to demonstrate the process of data conversion and show that you achieved a working design**. You are also required to submit an archive of your project in the form of a ZIP file. Use 7-Zip option to create the ZIP file. Name the archive lab#_GroupName.zip. Refer to Lab 1 for detail instructions.

You will submit your zip file to the instructor through Canvas by the due date and time. If your program is not completely functional by the due date, you should demonstrate and turn in what you have accomplished to receive partial credit. See the syllabus for the late penalty guideline