IC231 Spring 2022 – Lab 5 – Digital Potentiometers I

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In this lab you will work with a digital potentiometer, which will be used in later labs.

Learning outcomes

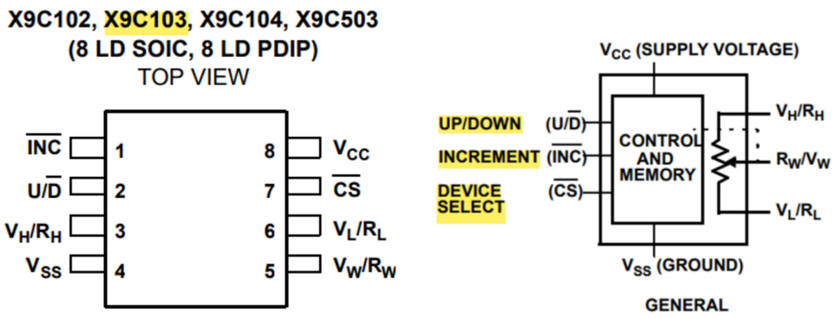
In this lab, you will learn

- How to connect the X90C103 digital potentiometer to the Raspberry Pi and control it with Python routines
- Use the X90C103 as a variable resistor, adjusting it to pre-specified resistance values
- Use the X90C103 to realize a variable voltage source using the voltage pin of the Raspberry Pi

Instructions

The digital potentiometer breakout and schematic representation is shown below. The objective is to send digital signals from the Raspberry Pi to move the 'wiper' of the potentiometer to a desired level, or 'sweep' the wiper through the whole range of the potentiometer.

For this you will have to connect the INC, UD, and CS pins to the RPi's GPIO pins, and of course connect the VCC and VSS to a source (3.3 V) and ground pin on the RPi. You will then use one more voltage source pin (3.3 V) to connect to the VH pin, and draw VL to ground. Then, you can connect an oscilloscope between VW and ground to measure the output voltage. Note that the bars on the pinout names indicate that the logic is inverted.

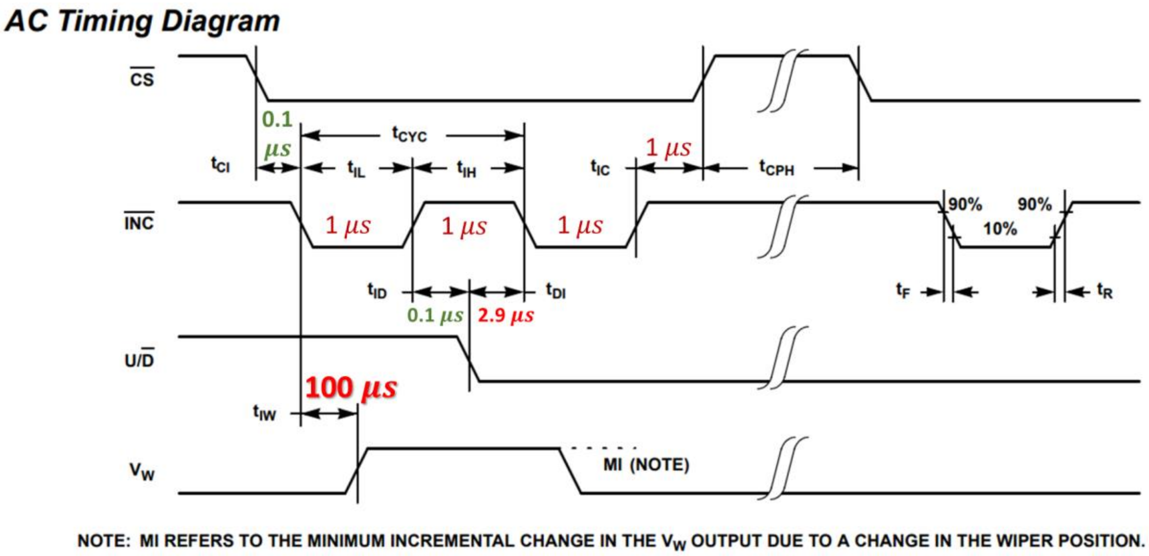


You can modify and use the provided Python source codes and modules to move the wiper position. To get a better understanding of how the code works, I advise you to read the datasheet of the potentiometer as provided on the Moodle page, especially the timing diagram. This is reproduced below with some additional information for a better understanding.

The pseudo-code/algorithm for setting the wiper position is as follows –

1. CS is high, INC is high.
2. Select chip by setting CS to low.
3. Sleep 1 μs. (As tCI - 0.1 μs).
4. Set U/D level to indicate whether to move the wiper up or down.

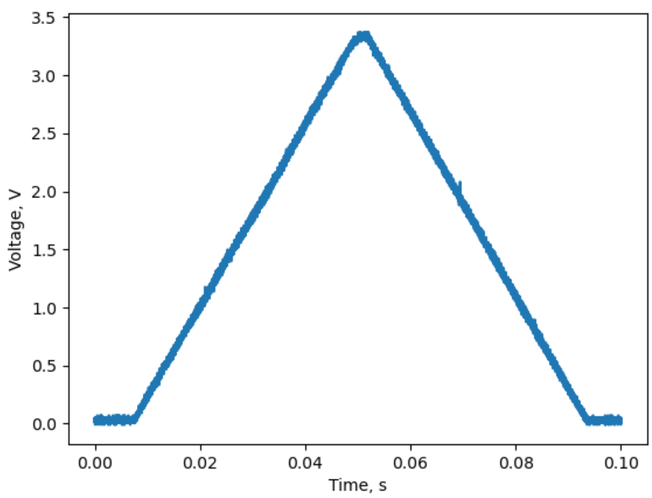
5. Sleep 4 μs. (As tDI - 2.9 us).
6. Toggle INC from high to low. This moves the wiper
7. Sleep for 100 μs. (As tIW is 100 us)
8. Return INC to high.
9. Sleep 4 μs (As tIC - 1 us).
10. Set CS high to store the wiper position/resistance value in the internal register.



Tasks

- **Task 1** – Calculate the number of steps required for setting the potentiometer resistance to values of 100Ω, 1000Ω, 5000Ω, 10KΩ. Verify the values of the resistances using a multimeter.

- **Task 2** – Generate a triangular voltage sweep at the output of the potentiometer by connecting it to a fixed voltage source, and sweeping the wiper position from its minimum to the maximum position and back. Record the output using an oscilloscope, and confirm your observations quantitatively (you will need to use the methods of Task 1). You should get a plot which looks something like the one below.



Do this task for four sweep periods ~ 4 s, 1 s, 500ms, 100 ms.

- **Task 3** – Check the repeatability of your results for the different times indicated in Task 2. You are advised to use statistical measures for quantifying your observations.

General Instructions

1. After connecting the potentiometer to the RPi, call your TA to verify the signal connection.
2. Use the 3.3 V pins for both powering the potentiometer, and for the external voltage source (VH).
3. If you run into any issues, ask your TA/Instructor.

Task completion criteria

1. You are able to match the estimate value to the actual value achieved on the potentiometer, and give a plausible interpretation for the observed errors.
2. You are able to set the oscilloscope setting correctly for measuring the swept signals.
3. You are able to match the resistance values to the voltage levels obtained, and give plausible interpretation for the observed errors.
4. Answering the MCQs.