MCP4725 DAC
What is it?

It is a Digital to Analog Converter
Why would you need that?

Analog and Digital signals both carry information... but they use different methods
Analog Signals vs. Digital Signals

- carries information through sin waves
  - continuous electrical signal

- carries information through square waves
  - non-continuous electrical signal
Why would you need that? To convert between signals in your breadboard.
How does it work?

The MCP4725 has a 12 bit resolution, meaning it can specify $2^{12}$ or 4096 different values.

- The reference voltage (5V), is divided into equally spaced parts.
- Based on the digital value received, we can create the analog voltage we want.
- For example, if we wanted an analog output of 2.5V or half of the reference voltage, we would send the digital signal 2048, which is half of 4096.
- This can be done in increments as small as $5V/4096 = 1.22mV$.
- If the reference voltage is 3V, we have even finer voltage output steps ($0.73mV$).
Analog and Digital Signals

- Microcontrollers detect binary signals (digital signals)
  - Press of a button
  - 0V or 5V
- What if we want any other value that is not 0V or 5V?
  - We need analog signals!
Digital-to-Analog Converter (DAC)

- DACs is a data converter which generates an analog output from a digital input.
- There is a source of error in the analog output: digital values are only approximations of real-world analog signals.
- The more digital bits represented by the DAC, the more accurate the analog output signal.
Digital-to-Analog Converter (DAC)

- The conversion produces an analog waveform that is discrete, not continuous.
- Discrete output is then integrated in the DAC.
- Resultant analog waveform is filtered on a low-pass filter to be smoothed out.
Analog-to-Digital Converter (ADC)

- ADCs convert analog voltage on a pin to a digital number
- Not every pin on a microcontroller has the ability to do analog conversions
Analog-to-Digital Converter (ADC)

- The world contains information in continuous values, like temperature and motion
- ADCs convert continuous values to a sequence of discrete values
- The more bits in digital values, the closer it resembles an analog signal!
Connections

The MPC4725 12-bit Digital to Analog Converter is connected via an I2C connection.

- An I2C connection is an inter-integrated circuit. This means that it uses two bi-directional lines for data communication - the SDA and SCL.

- The SCL stands for serial clock pin and SDA for Serial Data Pin.

- The lines are both pulled high, which means they are both at the operating voltage (as opposed to ground) of either 3.3 or 5V.
The I2C connection means the wiring involved in setting up the sensor is incredibly simple:

- One pin goes from the VIN to the 5V or 3V slot, depending on the system.
- Another runs from GND to GND.
- Finally, the last two are connected via the SCL and SDA channels.
- One can also use the A0 pin to connect a second MCP4725 on the same bus.
- Additionally, there is a VOUT which is the output for the I2C signal.
Setup for the MCP4725

The Adafruit_MCP4725 library must be downloaded first and is available through the Arduino Library manager.

Considerations:

- The transfer speed is increased from 100 MHz to 400 MHz in the MCP4725 library versus the Arduino Wire Library.

- The resolution is 12 bit, meaning you can specify values ranging from 1-4095 to control the output of the DAC in high resolution.
Applications

The Adafruit_MCP4725 can be used whenever a digital signal needs to be output as an analog signal.

- Digital to analog converters are commonly used in music players to convert the digital music signal an analog signal that can be played by a speaker.
- They are used on the receiving end of telephone calls to convert the digital signal to something we can hear.
- Finally, they are sometimes used to create analog video from digital signals.
- Data acquired by sensors generate an analog signal.
- This signal is converted to a digital one by the ADC.
- Computers/Arduino store and manipulate data digitally.
- Signal must be reconverted to analog for the output to be continuous.
Why do we need an analog output?

- Physical quantities are continuous (at least on a macroscopic scale)
- Sound waves produced by speakers are analog - so its input must also be
- Controlling Servo Motors: position, speed, and acceleration are continuous quantities, so an analog, smooth signal will offer a higher precision in its control