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#4



Data Acquisition Concepts

- **Analog to Digital Conversion (ADC)**
- **Digital to Analog Conversion (DAC)**
- **Digital Input/Output (DIO)**



Data Acquisition Concepts

ADC : Once data has been converted from **analog to digital**, the digital information can then be processed by the computer, or transferred to memory.

DAC : converts stored data back to a continuous signal (analog voltage) for display or control purposes. Output from the D/A converter can be used to drive external devices which require an analog input



Data Acquisition Concepts

Analog signals are “**continuous**” signals Represented by continuously changing physical quantities Level of signal can be increased or decreased indefinitely Ex. temperature, pressure, light, strain, voltage.

Digital signals are “**discrete**” signals represented by separate, individual units Units are represented by “bits” (binary digit).



Data Acquisition Concepts

- Converts analog data into digital data which can be processed,
- Typical components:
 - Multiplexers
 - Amplifiers
 - Sample and hold circuits
 - A/D converters





Data Acquisition Concepts

- Input and output (I/O)
 - Analog input is converted into a digital number, by comparing the voltage with its position within the **Full Scale Range**
 - With an n-bit A/D converter the number of output levels equals 2^n – e.g. **12-bit** converter = **$2^{12} = 4096$**
 - Full scale range refers to the largest voltage range which can be input into the A/D converter



Data Acquisition Concepts

- Range is an input span for an A/D and D/A system
- Typical ranges are based on available sensors

Uni-polar (positive)	Bipolar
0 to 5 volts	-5 to +5 volts
0 to 10 volts	-10 to +10 volts



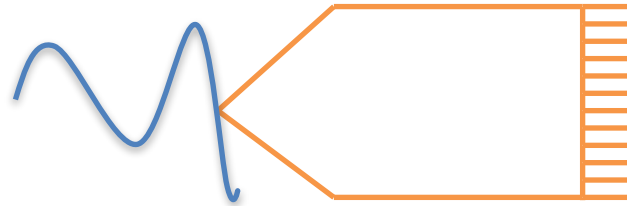
Data Acquisition Concepts





Data Acquisition Concepts

Analog



Digital

(101110010011)

- Resolution determines the smallest change that can be detected
- Specified in bits. Determines number of output levels, or steps
 - 8 bits = 256 steps
 - 10 bits = 1024 steps
 - 12 bits = 4096 steps
 - 16 bits = 65,536 steps

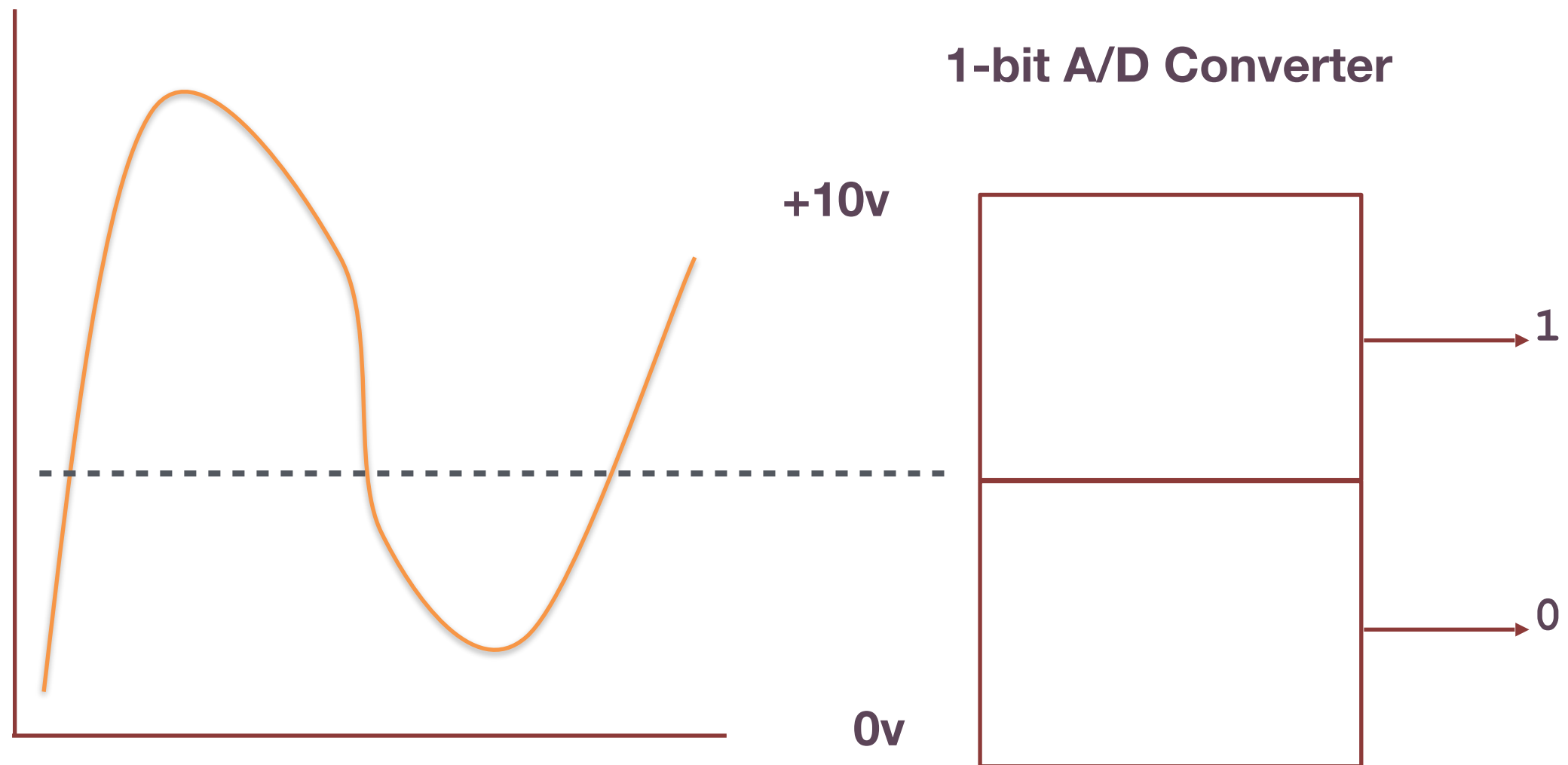


Data Acquisition Concepts

- **8-bit** – common for image capture
- **10-bit** – general analog acquisition
- **12-bit** – general analog acquisition
- **16-bit** – precision analog acquisition
- **24-bit** – high-accuracy analog acquisition

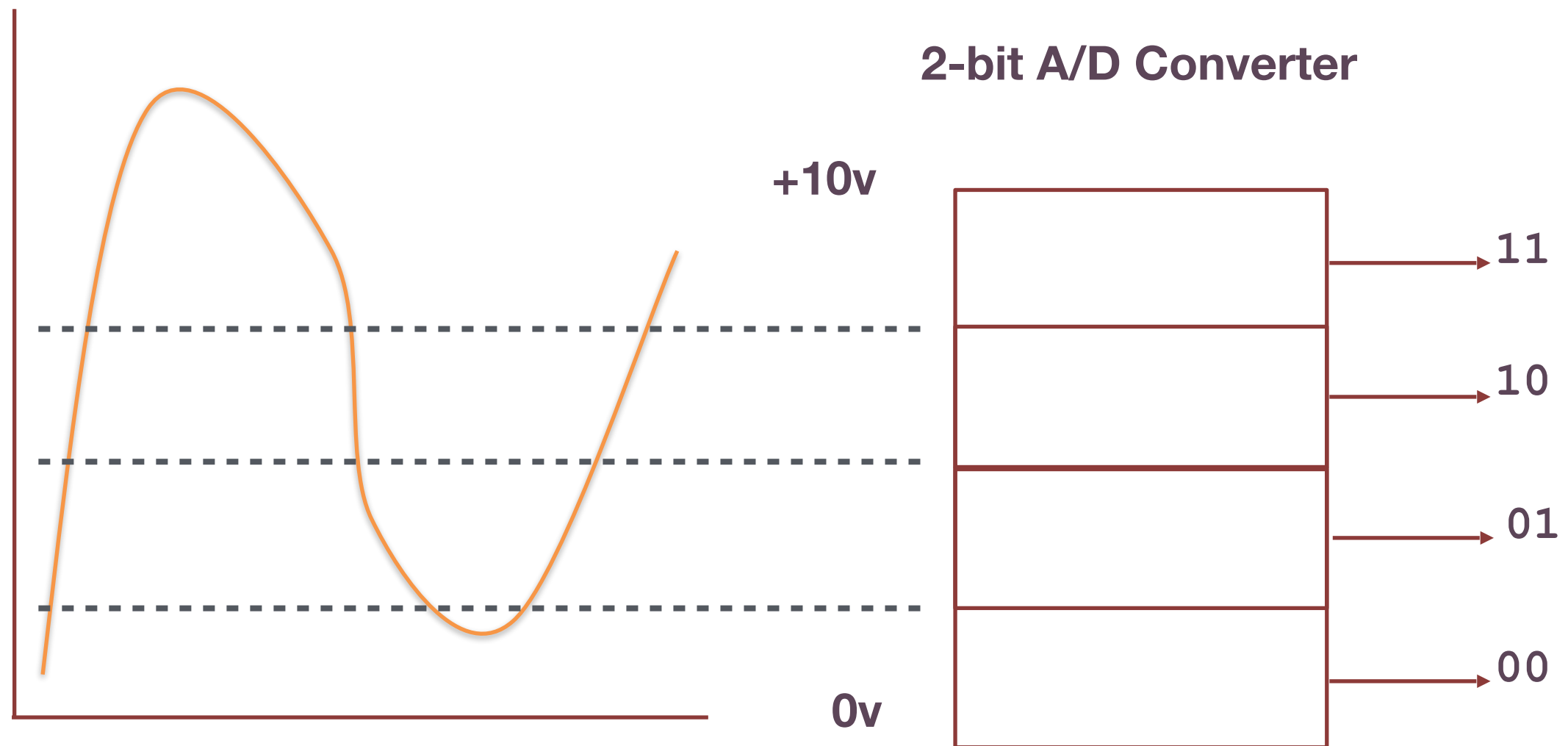


Data Acquisition Concepts



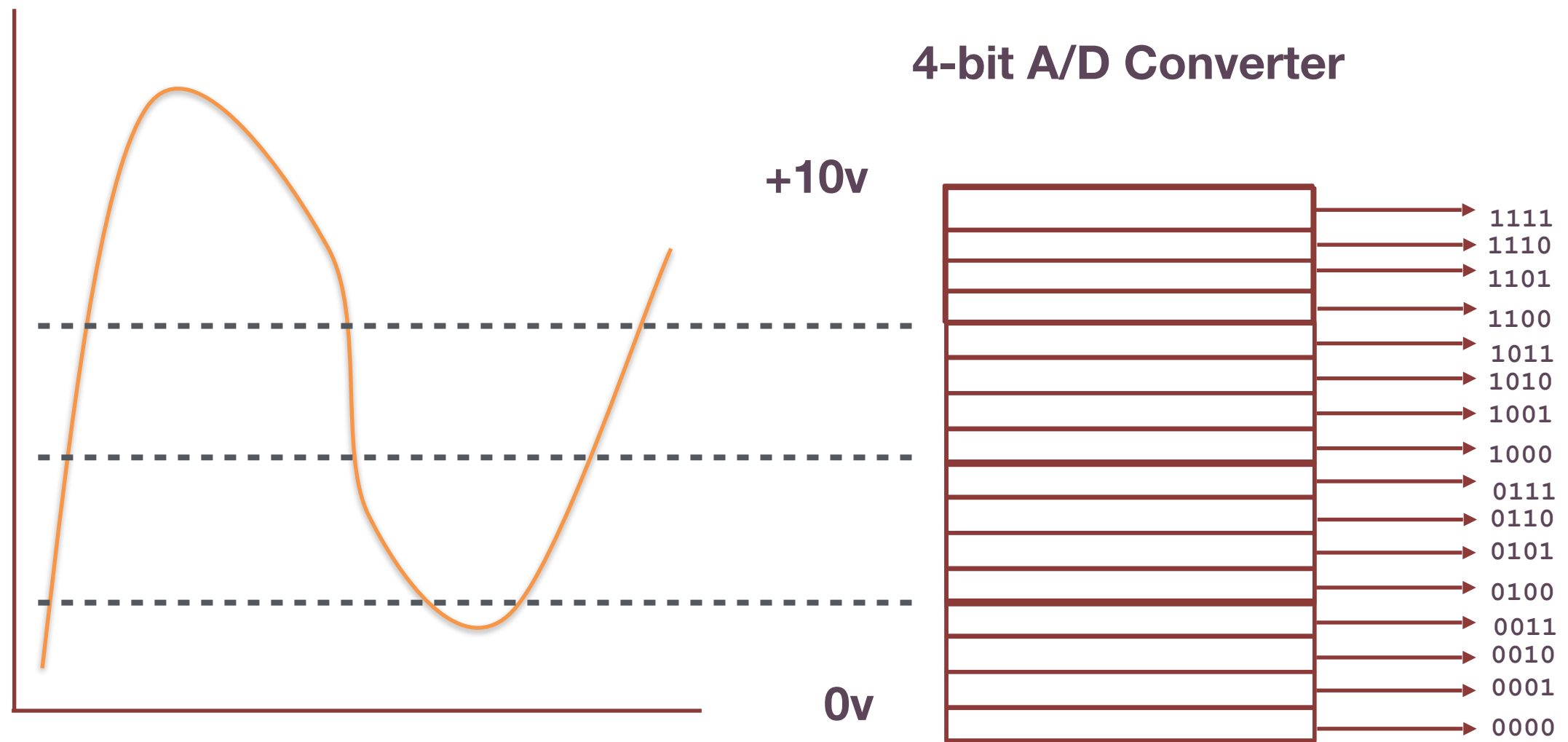


Data Acquisition Concepts



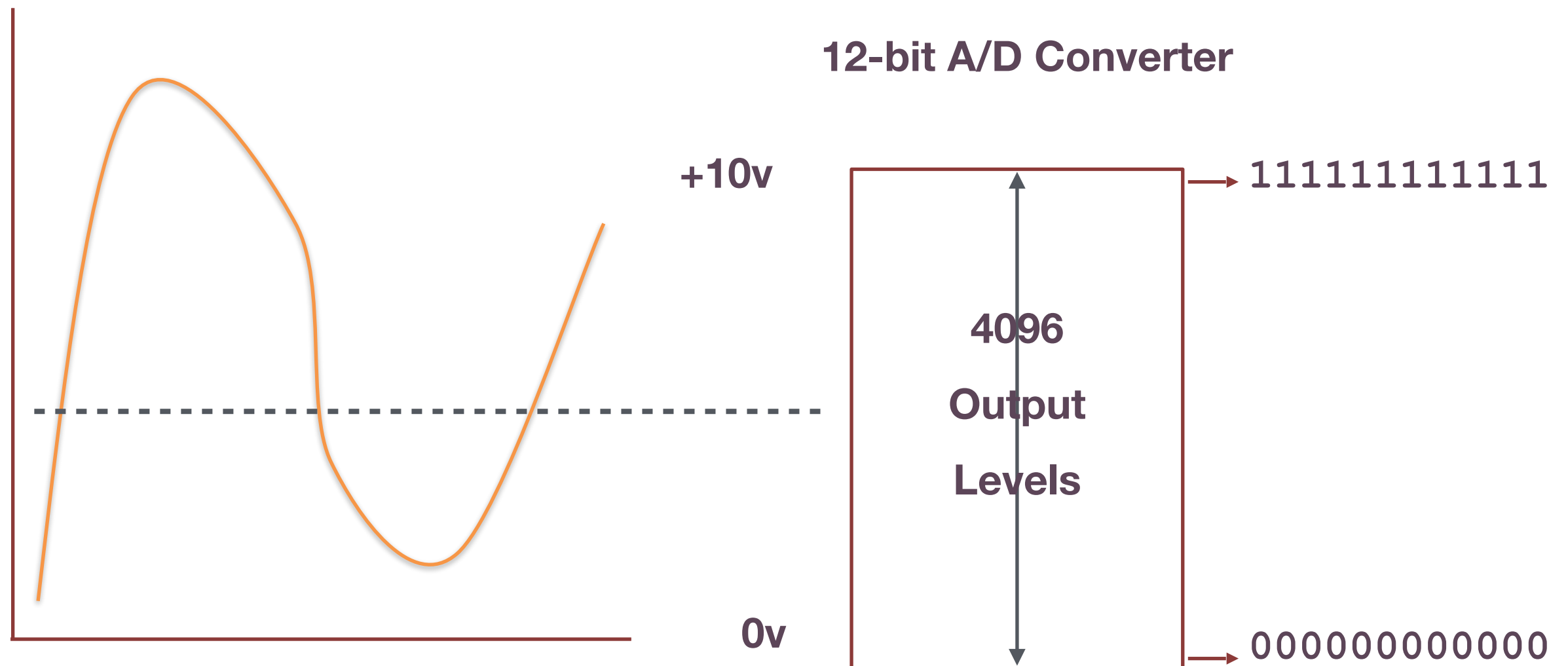


Data Acquisition Concepts





Data Acquisition Concepts





Data Acquisition Concepts

- **LSB** stands for “least significant bit”
- An **LSB** represents the smallest change that can be resolved by the A/D converter
- An **LSB** carries the smallest value or weight
- An **LSB** is the rightmost bit
- **LSB** = Full Scale Range (FSR) $\div 2^n$



Data Acquisition Concepts

The time required to perform a complete conversion from the analog signal to digital

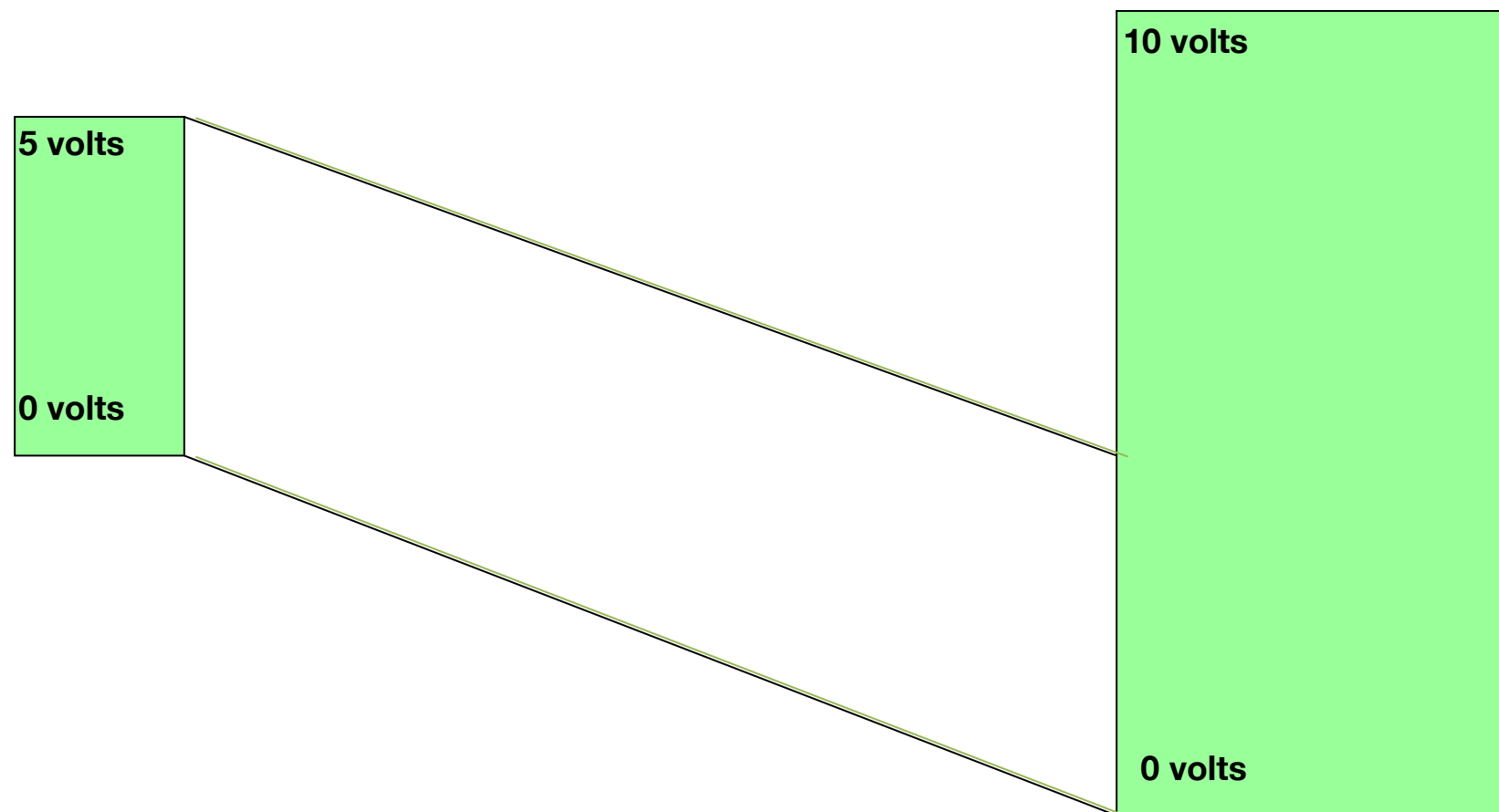
- The time required after receipt of “**start digitizing**” command until the A/D converter has finished digitizing
- Time it takes to switch to a new channel
- Each time a user switches between channels, there is a delay, referred to as **settling time**



Data Acquisition Concepts

User Input

Selected Range (uni-polar)



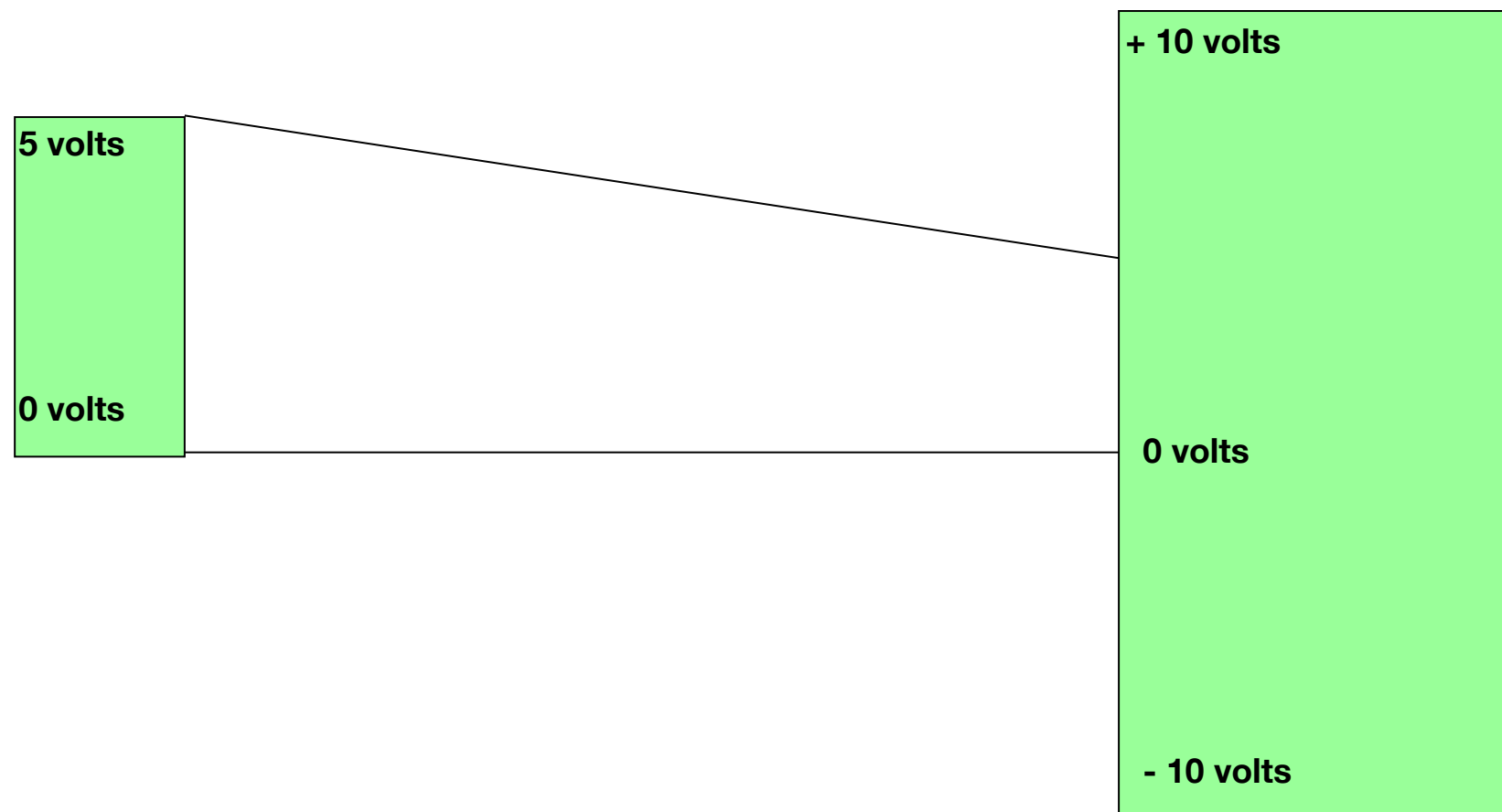
Only 50% of the available A/D range is used.



Data Acquisition Concepts

User Input

Selected Range (bi-polar)



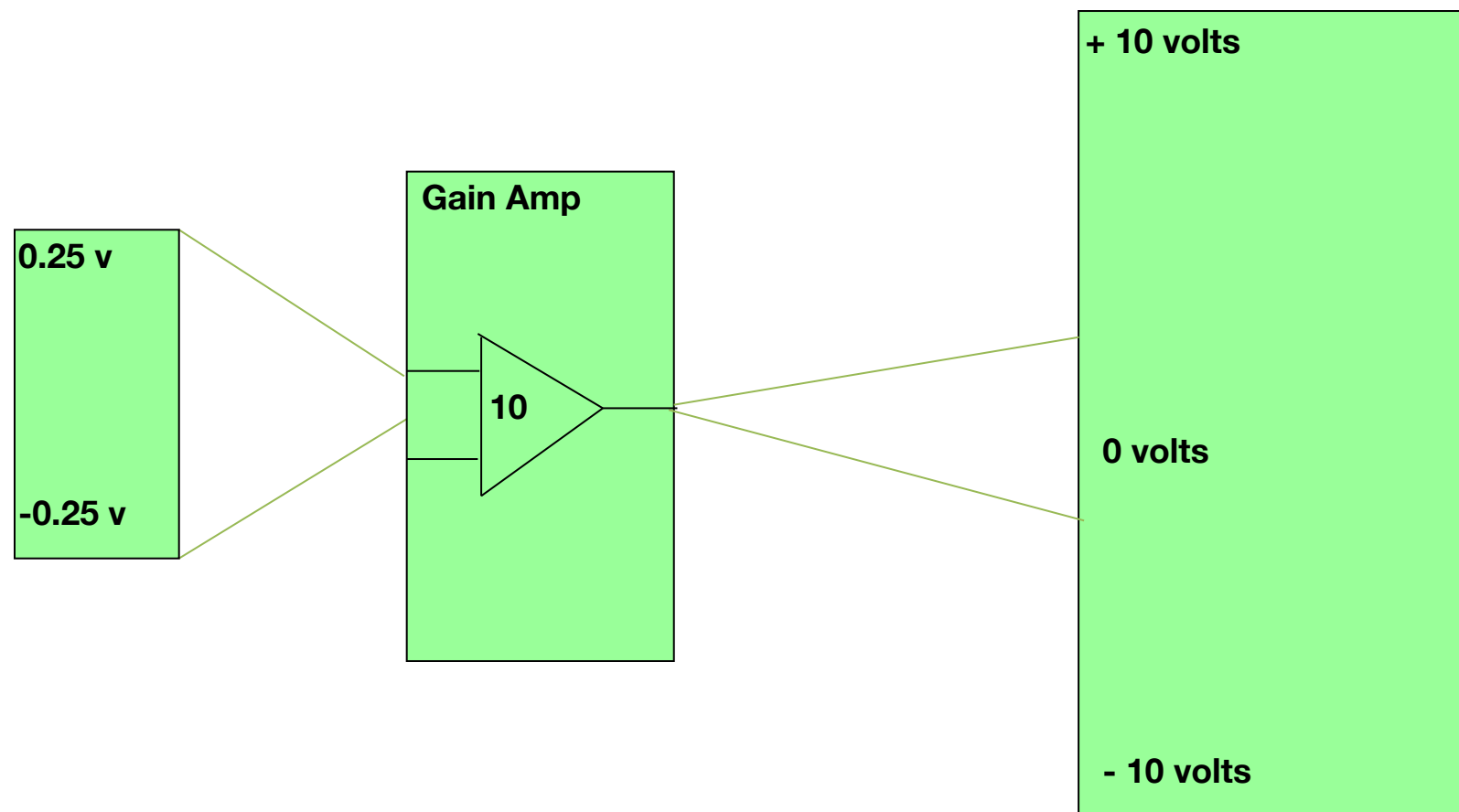
Only 25% of the available A/D range is used.



Data Acquisition Concepts

User Input

Selected Range (bi-polar)



Only 25% of the available A/D range is used.

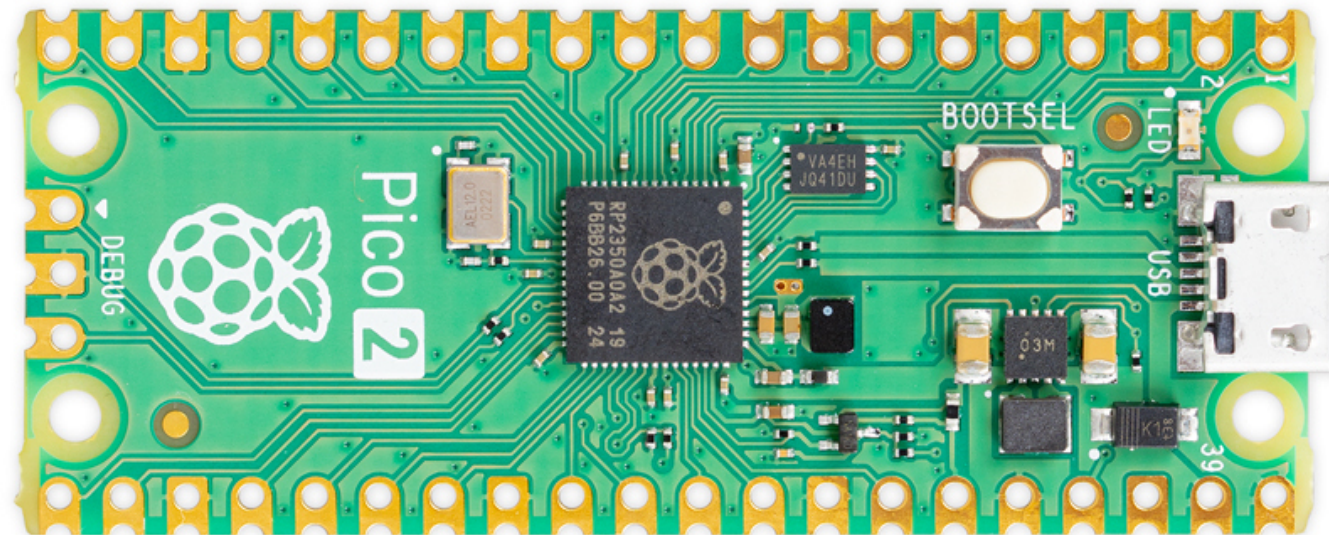


Data Acquisition Concepts

- To get the highest degree of accuracy possible out of an I/O board – try to utilize as much of the available range as possible
- Use internal or external gain selection
- Determine the maximum range that the input signal will use
- Determine if the signal is uni-polar (above zero) or bipolar (above and below zero)
- Evaluate the available gain and range combinations to select the most appropriate product



Data Acquisition Concepts



- 12 PIO (programmable input–output) state machines.
- 24 PWM channels.
- 4/8-channel **12-bit 500-kSPS** SAR ADC, extra channel is connected to internal temperature sensor.



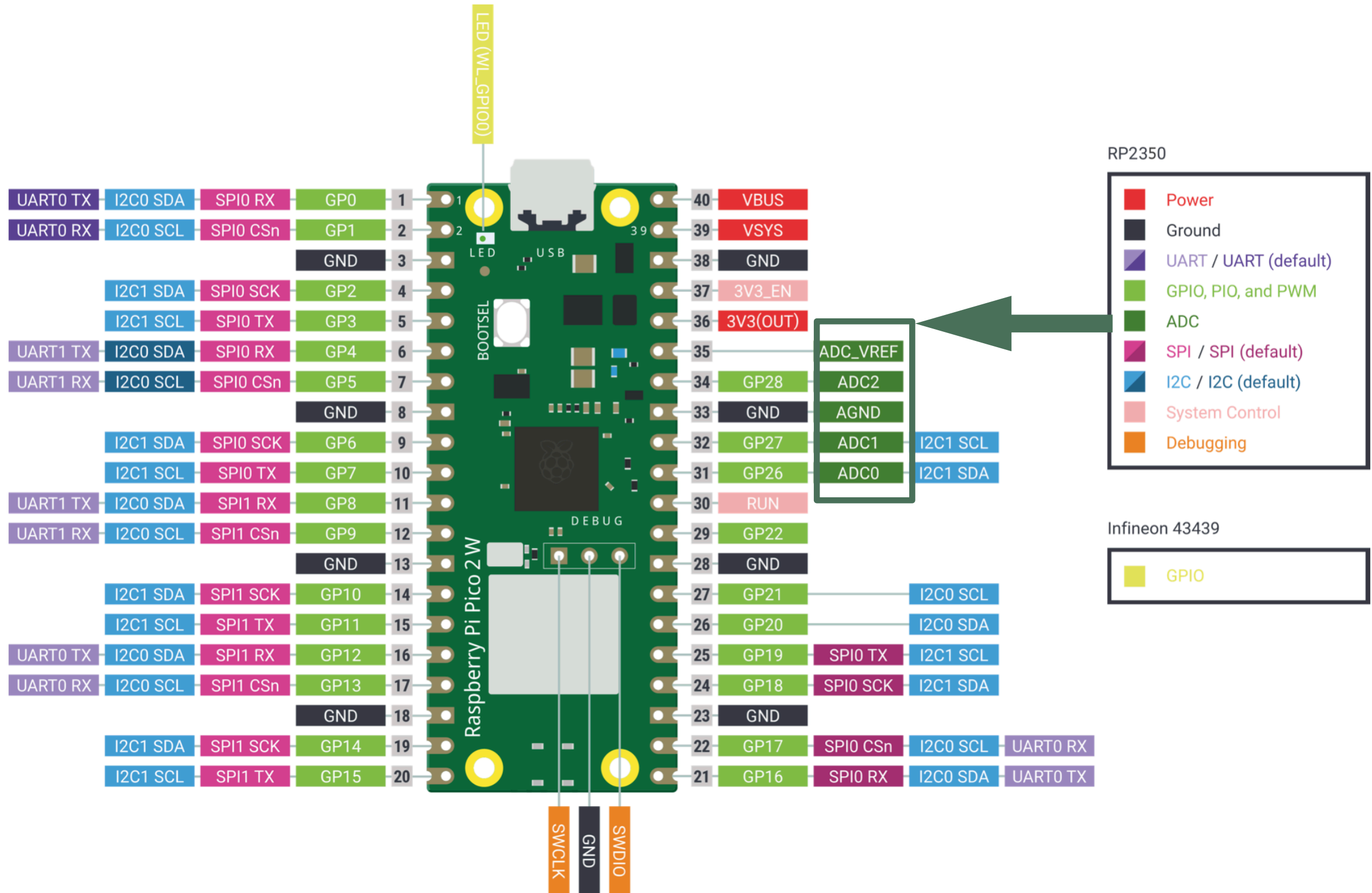
Data Acquisition Concepts

- 4/8-channel **12-bit 500-kSPS** SAR ADC

A **successive-approximation ADC** (or **SAR ADC**) is a type of analog-to-digital converter (ADC) that digitizes each sample from a continuous analog waveform using a **binary search** through all possible quantization levels.

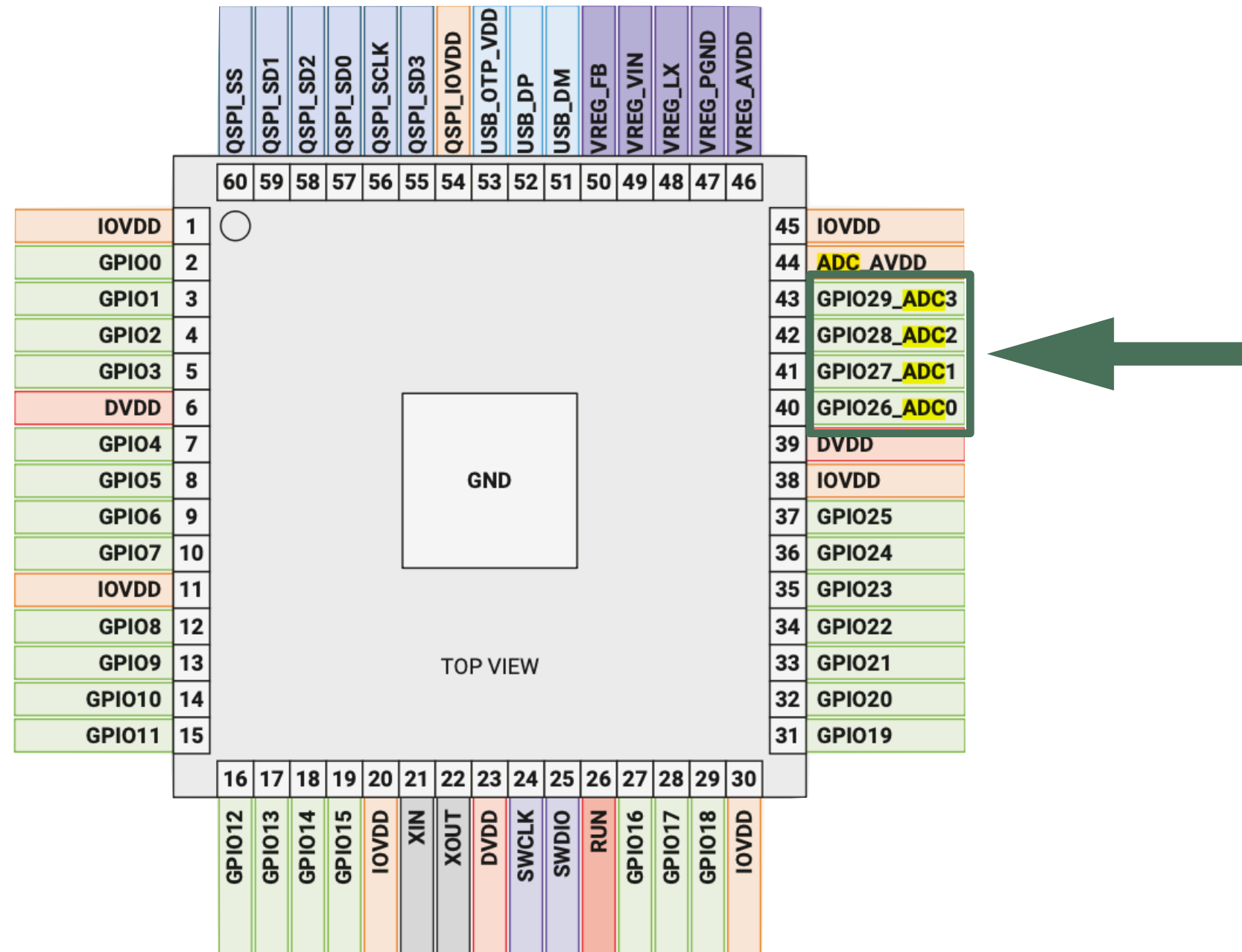


Data Acquisition Concepts



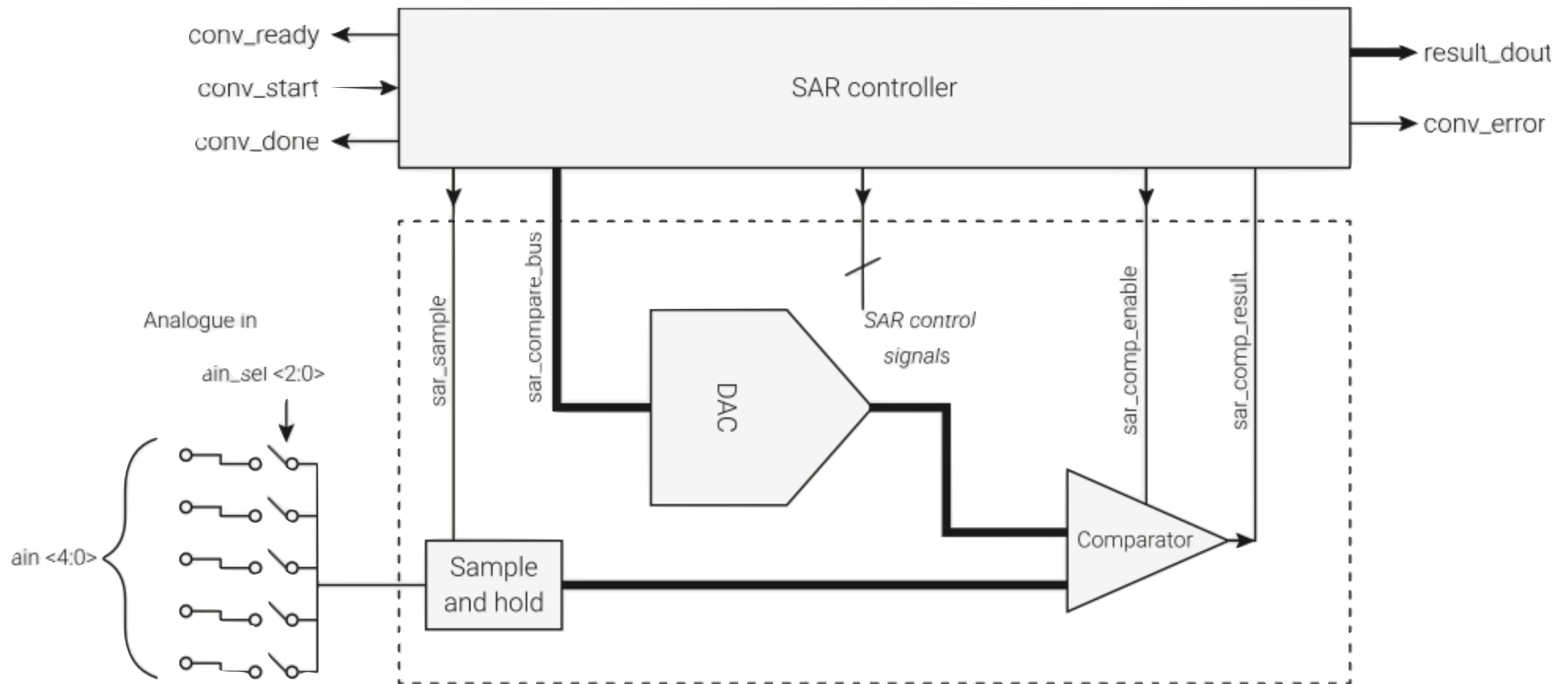


Data Acquisition Concepts





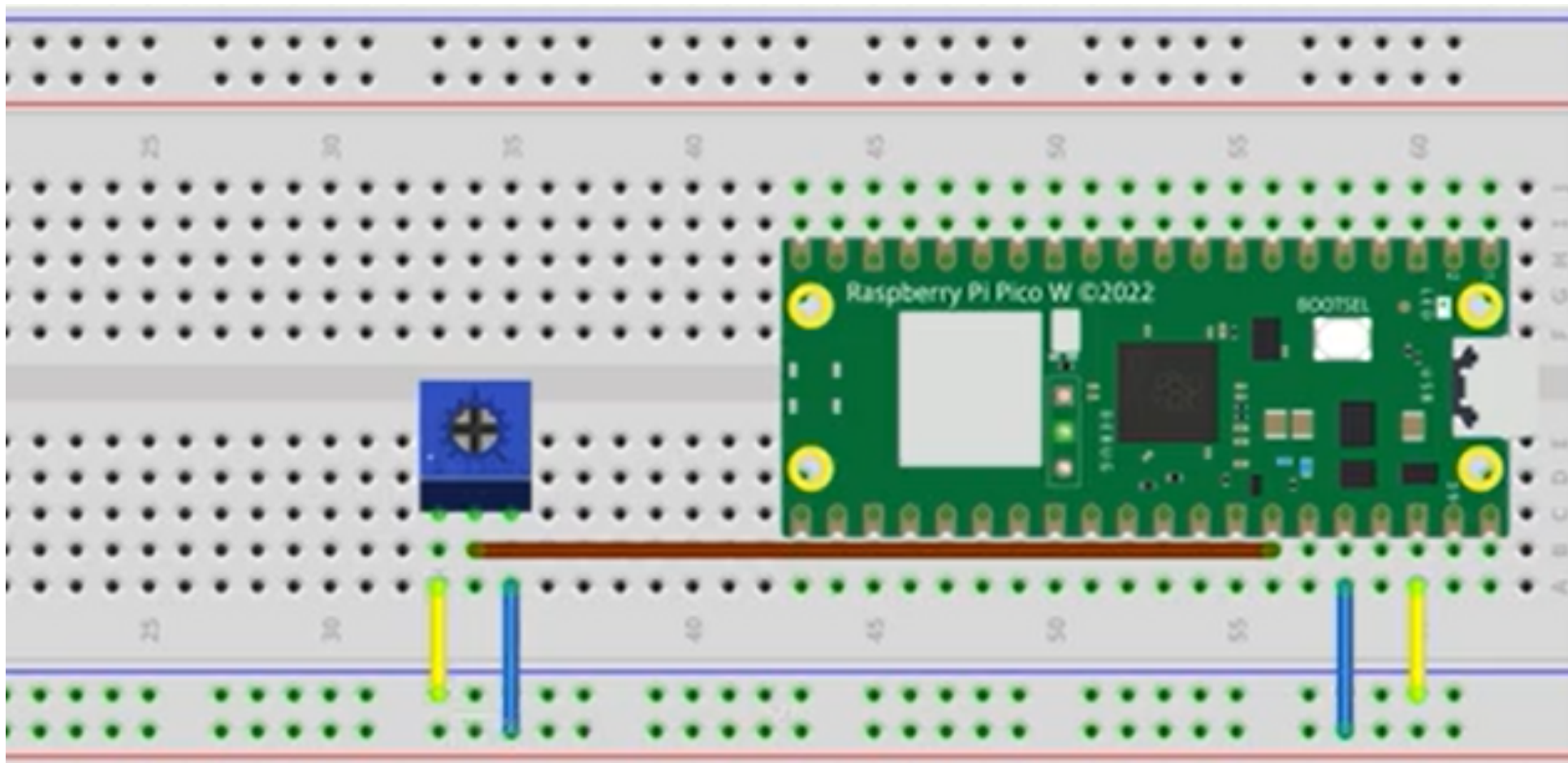
Data Acquisition Concepts



- Multiplexers
- Sample and hold circuits



Data Acquisition Concepts





Data Acquisition Concepts

```
import machine
from time import sleep
potPin=28
myPot = machine.ADC(potPin)

while True:
    potVal = myPot.read_u16()
    print(potVal)
    sleep(.5)
```