

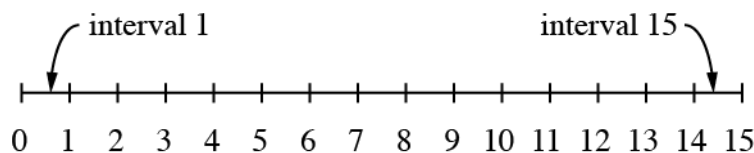
Scaling of Arduino Analog Input Readings

The Arduino Uno can read voltages on one of six analog input pins. The maximum input voltage is 5V, and the analog input readings are returned as 10-bit integer values. The maximum numerical value for a (unsigned) 10-bit number is 1023. Therefore, when the maximum input of 5 V is applied to one of the input pins, the maximum numerical value for an analog reading is 1023.

On a 10-bit scale there are 1024 numbers starting with 0 and ending with 1023. To convert a numerical value returned by the `analogRead` function to a voltage, should the scaling be $5V/1023$ or $5V/1024$?

Answer: The correct scaling is $5V/1023$.

Consider a 4-bit analog to digital converter. An unsigned 4-bit number can have the values 0, 1, 2, ... 15 as depicted by the following number line.



Although there are 16 numbers that label points on the line, there are only 15 equal-length segments. Therefore, the scale factor for a 4-bit analog-to-digital converter is $5V/15$ because the 5V range is divided into 15 intervals. By analogy, the correct scaling for a 10-bit analog to digital converter having a maximum input range of 5V is $5V/1023$.

There are 16 values on the 4-bit number line, but the first value, 0, just marks the beginning of the line. The other values, 1, 2, 3, ... 15 are labels for the right hand endpoints of the intervals.

Yet another way to think about this is to consider the question: How many years have you lived when you reach your *n*th birthday? For example, on your twenty-first birthday, you have lived 21 years. The day you were born is birthday 0.