Module 15

Introduction: Data Acquisition Systems

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Educational Objectives:

REVIEW periodic interrupts and the Nested Vector Interrupt Controller
UNDERSTAND how to use the ADC to implement real-time data acquisition systems, observing noise, choosing a sampling rate and thinking about aliasing (undesired frequency components)
EXPLORE the world of digital processing by implementing some simple digital filters
LEARN the Nyquist Theorem and the Central Limit Theorem.
DESIGN, BUILD & TEST A SYSTEM
Create a real-time data acquisition system that measures distance from three IR sensors

Prerequisites (Modules 10, and 13)

- SysTick periodic interrupts and arrays (Module 10)
- Timer_A periodic interrupts (Module 13)

Recommended reading materials for students:

- Volume 1 Sections 10.1, 10.4, and 10.5
  Embedded Systems: Introduction to the MSP432 Microcontroller ISBN: 978-1512185676, Jonathan Valvano, copyright (c) 2017

or

- Volume 2 Section 8.4, and Chapter 10
  Embedded Systems: Real-Time Interfacing to the MSP432 Microcontroller, ISBN: 978-1514676585, Jonathan Valvano, copyright (c) 2017

An **analog signal** is one that is continuous in both amplitude and time. An **analog signal** is one that is continuous in both amplitude and time. Neglecting quantum physics, most signals in the world exist as continuous functions of time in an analog fashion (e.g., voltage, current, position, angle, speed, force, pressure, temperature, and flow etc.) In other words, the signal has an amplitude that can vary over time, but the value does not instantaneously change. To represent a signal in the digital domain we must approximate it in two ways: **amplitude quantizing** and **time quantizing**. From an amplitude perspective, we will first place limits on the signal restricting it to exist between a minimum and maximum value (e.g., 0 to +3.3V), and second, we will divide this amplitude range into a finite set of discrete values. The **range** of the system is the maximum minus the minimum value. The range has units, such as volts or cm. The **precision** of the system defines the number of values from which the amplitude of the digital signal is selected. Usually precision is given in binary bits. For example, an 8-bit system can uniquely identify 256 different values. The **resolution** is the smallest change in value that is significant. The resolution is given in the same units as the range.

range = resolution*2^n, where n is the precision in bits

The second approximation occurs in the time domain. Time quantizing is caused by the finite sampling interval. In practice we will use a periodic timer to trigger an **analog to digital converter** (ADC) to digitize information, converting from the analog to the digital domain. The **Nyquist Theorem** states that if the signal is sampled with a frequency of f_s, then the digital samples only contain frequency components from 0 to ½ f_s. Conversely, if the analog signal does contain frequency components larger than ½ f_s, then there will be an **aliasing** error during the sampling process. Aliasing is when the digital signal appears to have a different frequency than the original analog signal.

In this lab, we will attach three IR distance sensors to the robot and interface the transducers to the microcontroller using ADC inputs. You will use periodic interrupts to sample the distance to the wall from three positions on the robot. Using the classification algorithm developed in Lab 4, there will be an option to solve a systems-level robotic challenge.

Figure 1. IR distance sensors, positioned at the front of

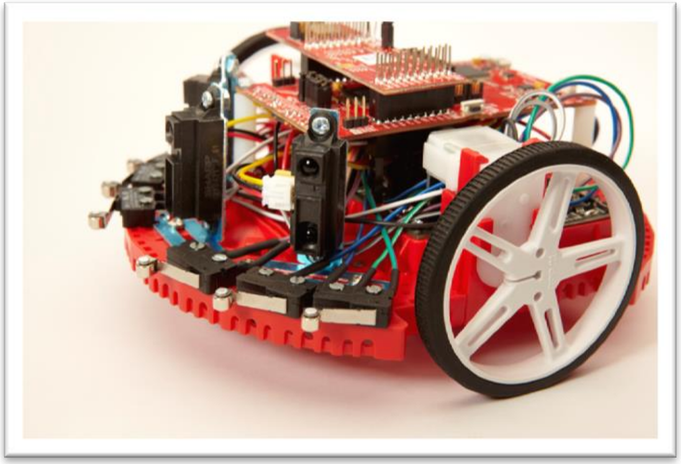

Figure 1. IR distance sensors, positioned at the front of the robot.