TI-RSLK MAX

Texas Instruments Robotics System Learning Kit

TEXAS INSTRUMENTS

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, in order to improve signal to noise ratio
LEARN the Nyquist Theorem and the Central Limit Theorem.
DESIGN, BUILD & TEST A SYSTEM
Create a real-time data acquisition system that measures either sound from a microphone, or distance from 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:

- Chapter 15, **Embedded Systems: Introduction to Robotics,** Jonathan W. Valvano, ISBN: 9781074544300, copyright © 2019

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 amplitude that can vary over time, but the value does not instantaneously change. A **digital signal** is one that is discrete in both amplitude and time. 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 greater than or equal to 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 either a microphone or IR distance sensors. We create an analog circuit to interface the transducers to the microcontroller, and then we use the ADC to convert analog voltage into digital samples. You will use periodic interrupts to sample the signal at a fixed rate. We can use sound to receive commands for the robot. For the IR distance sensors, we can use the classification algorithm developed in Lab 4 to solve an autonomous driving challenge.

For the sound option, we generate tones on one robot with a speaker, and receive tones on the other robot with a microphone. On the receiver, we will develop a pitch classification algorithm and use the sound system to send commands from one robot to the other.

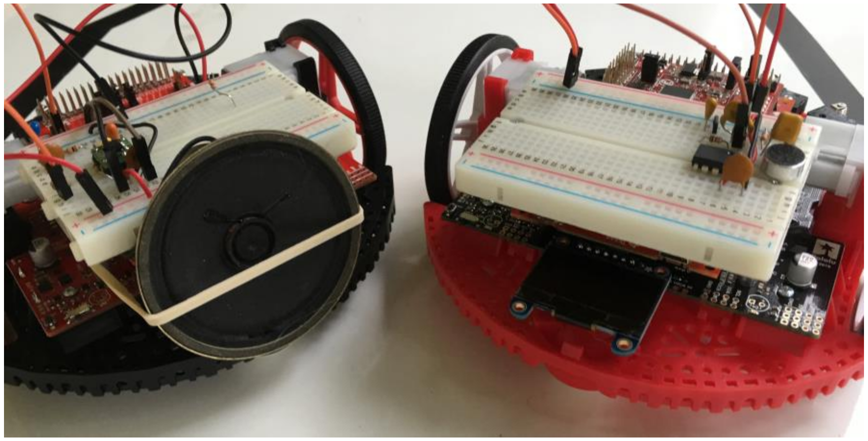

Figure 1. Sound output on one robot and sound input on the other.

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