Module 14

Introduction: Real-time Systems

Introduction: Real-time Systems

Educational Objectives:

UNDERSTAND how to use priority interrupts for creating real-time systems
EXPLORE different techniques to interface switches
LEARN how to generate port interrupts on the GPIO input pins
DESIGN, BUILD & TEST A SYSTEM
Create a real-time system for collision detection

Prerequisites (Modules 8, 9, 10, and 13)
- Switch interfacing (Module 8)
- Time delays (Module 9)
- SysTick periodic interrupts (Module 10)
- Timer_A periodic interrupts (Module 13)

Recommended reading materials for students:
- Volume 1 Sections 9.1, 9.2, 9.3, 9.4, and 9.5
  Embedded Systems: Introduction to the MSP432 Microcontroller ISBN: 978-1512185676, Jonathan Valvano, copyright (c) 2017

or

- Volume 2 Sections 4.5, 5.1, 5.2, 5.3, 5.4, and 5.5
  Embedded Systems: Real-Time Interfacing to the MSP432 Microcontroller, ISBN: 978-1514676585, Jonathan Valvano, copyright (c) 2017

Previously we defined a **real-time system** as one with bounded latency. In other words, the **latency**, which is the time between when a service is requested and the time when service is initiated, is always less than small and acceptable limit. Depending on the situation, we could alternately define real time as having a bounded **response time.** For example, for collision detection on the robot, we define response time as the time between a collision (bump sensor hardware edge signifying a service is requested) and the time when the motors are stopped (service is complete). To make it real time, we will configure the bump sensors to request an interrupt on touch.

The basic approach to a system requiring multiple software tasks is to deploy multithreading. One software **thread** is the traditional main program, which runs most of the time. This thread will implement high-level strategy. Interrupts will be used to create additional threads. The SysTick periodic interrupt will measure data from the line sensor. In Module 13, we studied how to execute periodic tasks using Timer_A. In this module, we will learn how use edge-triggered interrupts generated by I/O pins.

Any of the pins on Ports 1 – 6 can request an interrupt. We can configure the interrupt request on a rise or a fall of the input signal. If the bump switches are interfaced with negative logic, then a falling edge signifies a collision has occurred. Interrupts communicate with other threads via global variables. When deploying multiple interrupts we use priority to sort out the order of service if multiple events coincide. This collision detection is a very high priority task and hence we will configure it as a high priority event.

In this lab, the collision will cause the motors to stop and also set a global error flag. The main program will recognize this event, and then do something appropriate, like back up the robot turn 90 degrees and continue forward again. In the lab, there will be an option to solve a very simple systems-level robotic challenge.

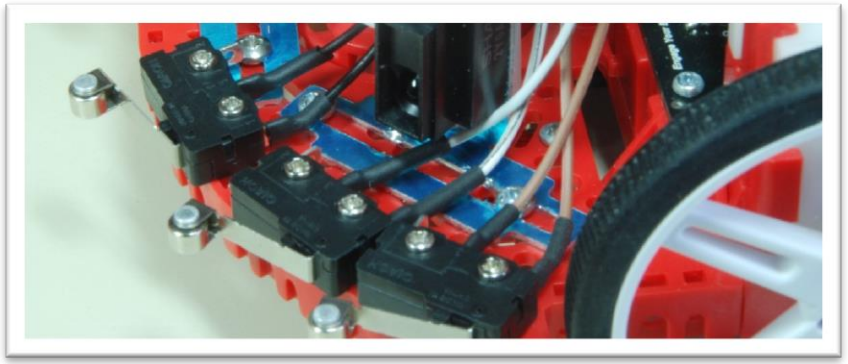

Figure 1. Bump sensors, positioned at the front of the robot.

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265