



# Module 13

Introduction: Timers



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## Educational Objectives:

**UNDERSTAND** Timers and their uses in embedded systems

**INTERFACE** The DC motors using hardware PWM

**CREATE** Multi-threaded software using multiple periodic interrupts

**DESIGN** Robot commands that move forward, turn left, turn right, and move backward

**Prerequisites** (Modules 9, 10, 12)

- Pulse width modulation (Module 9)
- Periodic interrupts using SysTick (Module 10)
- Mechanical and electrical interfaces of motors (Module 12)

**Recommended reading materials for students:**

- Volume 1 Sections 8.7, and 9.7

**Embedded Systems: Introduction to the MSP432 Microcontroller**, ISBN: 978-1512185676, Jonathan Valvano, copyright (c) 2017

or

- Volume 2 Sections 6.2, 6.3, and 6.5

**Embedded Systems: Real-Time Interfacing to the MSP432 Microcontroller**, ISBN: 978-1514676585, Jonathan Valvano, copyright (c) 2017

This module, together with the last (Module 12), will develop the robot so it moves. Back in Module 9 you created software using pulse width modulation that dimmed an LED. You will now replace software-generated PWM with hardware-generated PWM. More specifically, you will configure the timer hardware on the MSP432 microcontroller. This will allow the system to adjust the power delivered to the DC motors on the robot with very little software overhead. Software will initialize the times, setting the PWM period and initial duty cycle. The hardware timers will automatically create the PWM outputs. Software needs to execute only when the system wishes to change the applied power or change the direction.

Back in Module 10, you created two threads: main program and SysTick ISR. In this module, you will use the hardware timers to create an additional periodic thread. Having multiple threads allows you to increase the complexity of the system in a modular way.

MSP432 microcontrollers have timers that are separate and distinct from SysTick. Input capture mode is used to make time measurements on input signals (Module 16), measuring the period from the tachometer (Lab 16). The MSP432 microcontroller has four **General Purpose Timer Modules** called Timer\_A. Each timer has one 16-bit timer and seven associated capture/compare registers.

In this lab, you will use Timer A0 to create two PWM outputs for the motor interface, and you will use the Timer A1 to create an additional periodic interrupt that can be used by robot explorer. You will use Timers A2 and A3 later in Module 16 to interface the two tachometers.

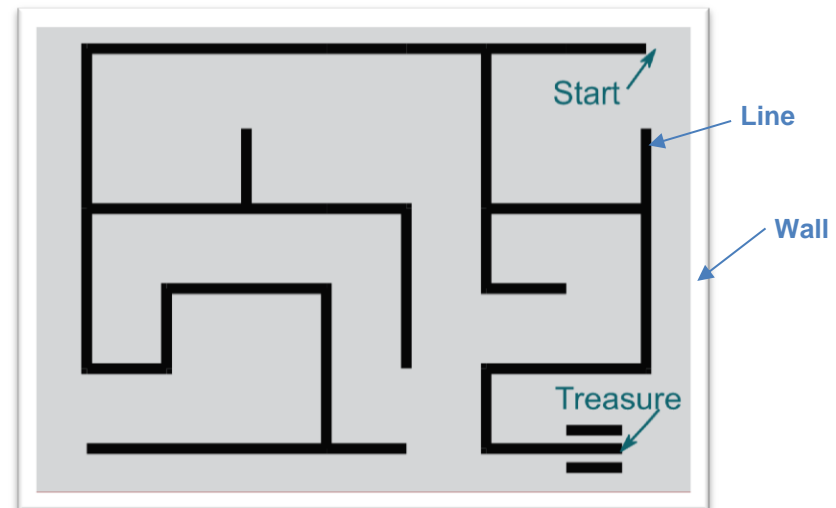


Figure 1. (From Lab 6) After this lab you could create a robot explorer that finds its way out of a maze, using just the line sensors and bump sensors. Similarly, you could create a robot explorer that follows a line.

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