The Hong Kong Polytechnic University

Department of Electronic and Information Engineering

EIE3123 Dynamic Electronic Systems / EIE3105 Integrated Project

Joint Laboratory Exercise (Lab 6): The Dynamic Control of a Robot Car

(Deadline: Please check the course information)

Objective:

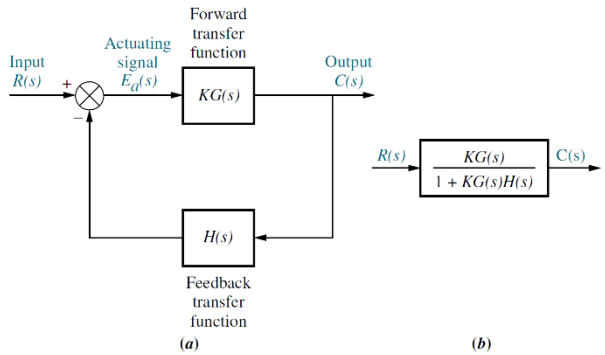
To design and implement a dynamic control system for the wheels of a robot car so that the car can move forward on a straight line.

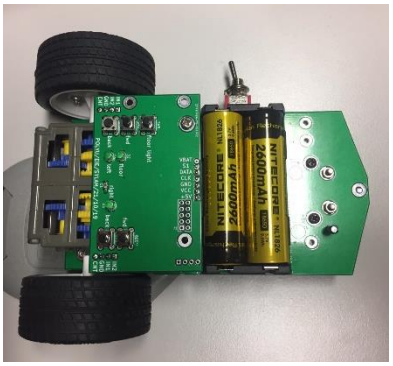
Equipment:

uVision (software)
STM32F103RBT6 or compatible microcontroller (hardware)
Robot Car (hardware)

Theory:

In EIE3123, you learn how to develop a dynamic close-loop control system. In EIE3105, you learn how to program a microcontroller. Now you need to design a dynamic close-loop control system and implement the system into an ARM microcontroller so that the microcontroller can control a robot car to move along a straight line.





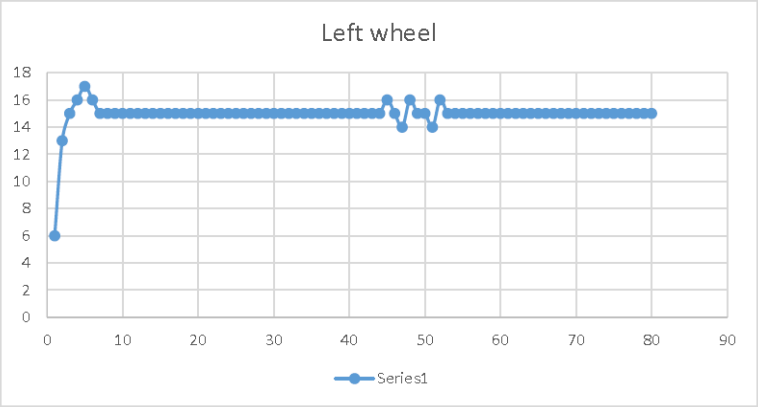
To control the movement of a robot car, we need to monitor and control the movement of its two wheels. The rotation speed of a wheel is controlled by its input PWM and monitored by a counter. When the percentage of the duty cycle increases (decreases), the rotation speed of the wheel increases (decreases). The frequency of the PWM should be between 100 Hz and 2 kHz. The PWM with a higher frequency (up to 200 kHz) may also work but it is not verified yet. The default setting of the PWM for the two wheels is 400 Hz. The counter is to measure the rotational speed of a wheel. It counts once when the gear of the wheel rotates over a tooth (there are 12 teeth in a gear). The rotation speed of a wheel can be measured by measuring the number of counts in a specified period and the default period is 2.5 ms.

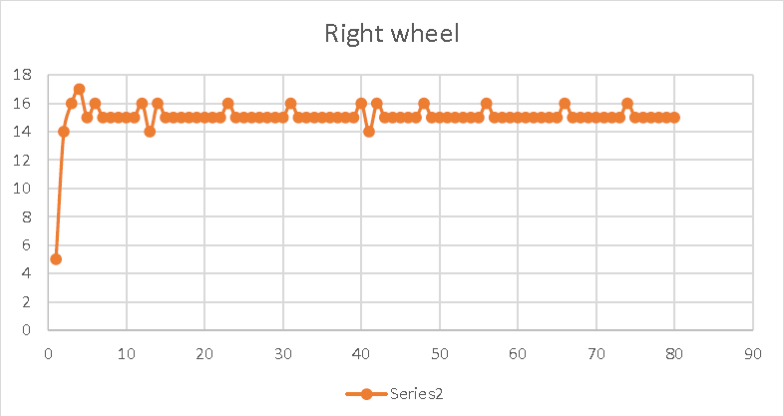
The configuration of a robot car is shown below:

Function	**Device**	**Pin**
Left wheel (Forward)	TIM3 CH2	PA7
Left wheel (Backward)	TIM3 CH1	PA6
Right wheel (Forward)	TIM3 CH3	PB1
Right wheel (Backward)	TIM3 CH4	PB0
Counter (Left wheel)	TIM4 CH2	PB7
Counter (Right wheel)	TIM2 CH2	PA1

The first four pins are used as outputs and the last two pins are used as inputs (feedbacks). Since we focus on the dynamic control in moving forward, we use PA7 and PB1 as the outputs. A sample program is given in Blackboard for you to know how to set the PWMs of two wheels and get the counter values.

To test the performance of your control system, you should move your car on the ground along a straight line and measure the counters of two wheels. You should take ONE demonstration video to record how you carry out experiments THREE times successively. Then you should use the measurement in the last experiment to plot two graphs for two wheels respectively. Note that the ground should be big enough so that ***your car should spend less than five seconds to travel at least two meters***. The control system is perfect if the total counting values of two wheels are the same and also the rotation speed of two wheels at the end are the same. For your reference, we did an experiment and the following two graphs are the readings of the counters of two wheels over four seconds (the unit of the x-axis is 50 ms and the y-axis is the counter value of a wheel).



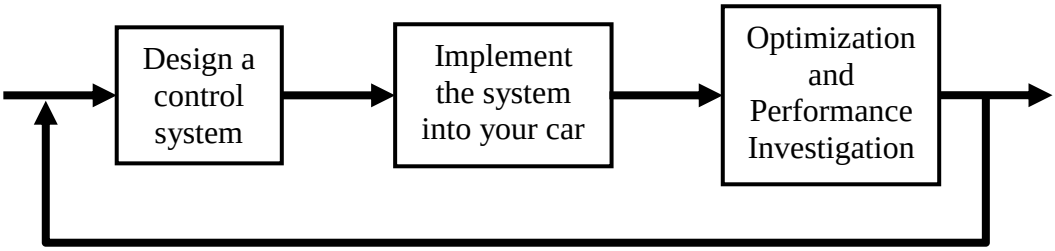


Procedure:

Step 1: Design a dynamic control system so that a robot car can move forward along a straight line.

Step 2: Implement the dynamic control system on your robot car. A simple program to control the robot car is given.

Step 3: Carry out some experiments to optimize the performance of your control system by adjusting some parameters of your control system. If the optimal performance is not satisfactory, go back to Step 1 to re-design the system until the performance of your control system is satisfied.



Submission:

Take a demonstration video for your car to move along a straight line not less than two meters THREE times consecutively. Note that each run should be less than five seconds. Measure the reading of the counters of two wheels in your last run and plot them out to show the performance of your control system.

Zip the video with your program code and a short report (not more than five pages) into a single file. Submit it to Blackboard (both EIE3123 and EIE3105) on or before the deadline. Your report should include:

1. The design of the control system (equation(s) and graph(s)),
2. The simulation result of the control system,
3. The implementation of the control system,
4. The optimization and the performance investigation of the control system (you need to justify the performance is good or not),
5. The measurement of the readings of the counters of two wheels in your last run (like the two diagrams in page 2)
6. The difficulties in the implementation and
7. How you overcome the difficulties.

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