

Performance Engineering of Real Time and Embedded Systems

Research Project

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Abstract

The main objective of the project is to control the position of ping pong ball in the tube, using the PWM fan and an ultrasonic sensor. PID control algorithm which gets the feedback from ultrasonic sensor and sets input for the PWM module, is used to move the ping pong ball to the desired position in the tube. Implementation is done on a PSoC 5LP board which provides the required PWM module.

Design Methodology

The first objective was to get the PWM fan to work. This was done using a PWM PSOC block. The PWM had a period of 50uS and an input range between 0 and 1200. A digital output pin was used to output the PWM from the board. The fan was powered through an external 12V power supply.

In order to read the output of the ultrasonic sensor there had to be some output from the board. This could have been done in a multitude of ways but it was decided that a USBUART serial connection from the board to a pc would be the best approach as it would allow both printing output, and board input. Board input was significant because it allowed PID values to be modified on the fly without the need to restart the board every time. This greatly decreases development time when finding the right PID values. This also allows for a ping pong ball setpoint to be entered at any moment.

A timer module is used to measure the time interval of the echo signal from ultrasonic sensor. From the round trip time of echo signal and speed of sound, distance of ping pong ball from the ultrasonic sensor is measured. This measured distance is used as a feedback data to the PID controller, which calculates the error value and gives correct input to the PWM fan, to move the ping pong ball to the setpoint.

Results

Initially the fan was not behaving as it should have. Eventually the grounds between the fan and the board were tied together and all the issues were resolved. The fan was being controlled by a simple software function that changed the duty cycle.

The USBUART IO proved to be the most difficult part of the project. A special driver was needed in order for the pc to see the board as a serial connection. This driver was unable to load on the lab computers. For this reason a separate laptop was used for the serial connection. This worked well for device output but device input was not working. A wait until transmit complete statement was added before the board tried to read input which solved the issues.

Special input functions were created to modify the PID controller values on the fly as well as the ping pong ball setpoint.

The ultrasonic sensor also proved to be more difficult than first expected. Initially the measured distance was twice what it was supposed to be because the round trip time was not accounted for when measuring. This was easily fixed by simply dividing by two. From here the sensor read very accurate values. The difficulty occurred between the tube and the ultrasonic sensor. When measuring outside of the tube the ultrasonic sensor performed very well, but once it was placed inside the tube it continuously reported values of less than 10cm when it should have been around 100cm. After much experimenting, a dampening device was added inside the tube so only a solid reflection would be picked up. This device mitigated this issue.

Once everything was in place the system was run with PID values and setpoint values modifiable on the fly. Through many quick iterations, proper PID values were selected. The PID values were then hard coded into the program and only the setpoint could be changed. The system was then tested with various setpoints and performed well. The only questionable performance was if the ball was being held toward the very top of the tube and the setpoint was set to the bottom of the tube. This situation required a longer wait time for the ball to reach the desired setpoint.

Conclusion

A PID control algorithm is successfully implemented on PSoC 5LP board to control the position of ping pong ball in the tube by taking the feedback input from ultrasonic sensor and controlling the input to PWM fan. Setpoint of ping pong ball is varied during the experiment and it is observed that settling time is minimal for almost all setpoints. This is achieved with optimal derivative term which improves the settling time and stability of the system.