FPGA Implementation of a PID Controller with DC Motor Application

Members	Advisors
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This project aims to implement a digital PID controller by means of an FPGA. This system will be used to control a DC motor (driven by a PWM signal) which has a high degree of non-linearity and serves to test the performance of the controller. Our preliminary research has primarily focused on simulating the entire system, although recently we have begun work on the VHDL code to program the FPGA. Upon completion of the VHDL, we will begin testing and improving the overall system.

Outline

- Functional Description
- Progress to Date and Projected Timeline
- Matlab and Simulink Work
- VHDL Work
  - PWM System
  - Encoder to 7-Bit Number System
  - PID System
  - Other Systems
- Closing

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Functional Description

This project will implement a digital "Proportional-Integral-Derivative" (or PID) controller in an existing DC motor system. The DC motor system will be controlled by a PWM signal. The system will be implemented in 'closed' loop form, which will correct the non-linearity and unreliability of the change in loads on the DC motor.

The entire system will be programmed in VHDL, and implemented on a FPGA Development Board. This will allow the user to input a desired RPM and be able to monitor the speed of the DC motor. It will also provide an economical solution to DC motor control.

System Inputs and Outputs

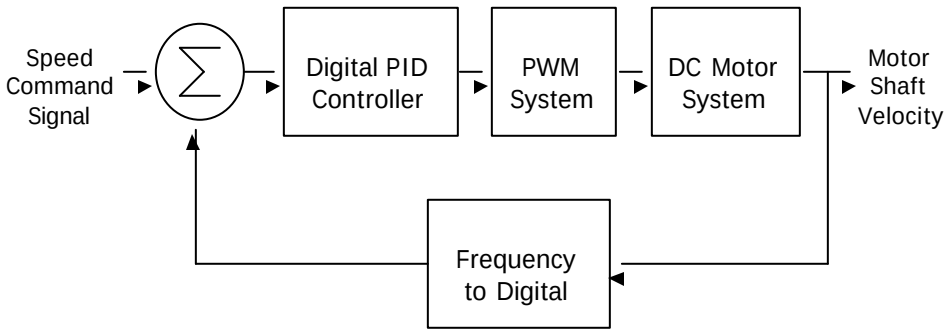
Inputs

- Speed Command Signal

Outputs

- Motor Shaft Velocity
- System Display

System Block Diagram



Modes of Operation

- Full Speed
- Off
- 0 to 860 RPM via user

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Progress To Date

- Matlab Design Program
- Simulink System Model
- FPGA Development Board
- VHDL Programming
- PWM System in VHDL
- Frequency to RPM Converter in VHDL
- Display Code in VHDL

Projected Timeline

Week	Goals
Feb. 25	Finish up VHDL code, debug
March 4	Hardware interface design, initial system test
March 11	System testing
March 18	PID controller redesign, VHDL code improvement
March 25	Complete system testing
April 1	Design, implement, and test additional features
April 8	Design, implement, and test additional features
April 15	Documentation, Tech Expo, presentation preparation
April 22	Documentation, Tech Expo, presentation preparation
April 29	Documentation, Tech Expo, presentation preparation

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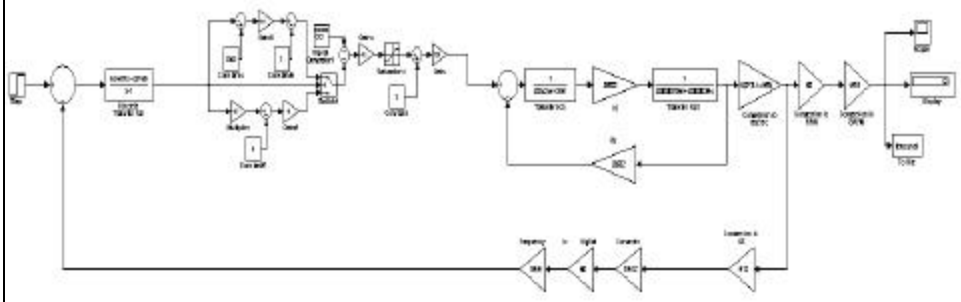
Matlab Design Program

- Shows uncompensated system plots
- Shows compensated system plots
- Determine Digital PID Controller coefficients

Simulink System Model



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PWM System

- Receives a number from the PID controller between 0-128 (7-bits)
- Uses internal counters along with the clock input to determine the PWM signal, by number comparison
- Includes out of range checks

PWM System

INPUTS

- 7-BIT Unsigned Number
- Clock
- Negative Trigger

OUTPUTS

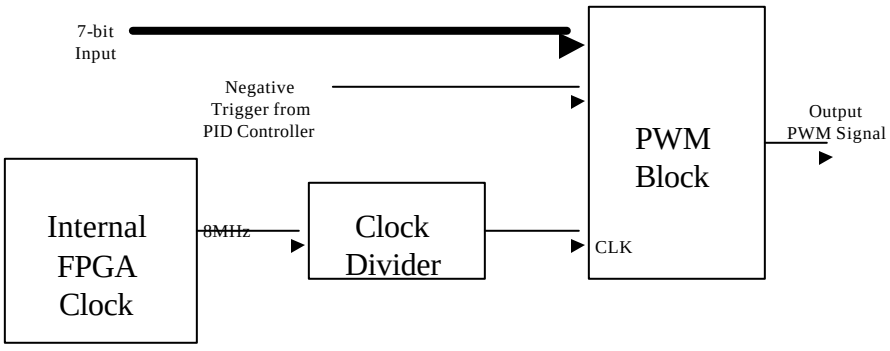
- Pulse Width Modulated Signal

PWM System

Problems

- Usage of an External Clock
  - Solution
    - Designed a VHDL block to divide an internal clock signal

PWM System Schematic



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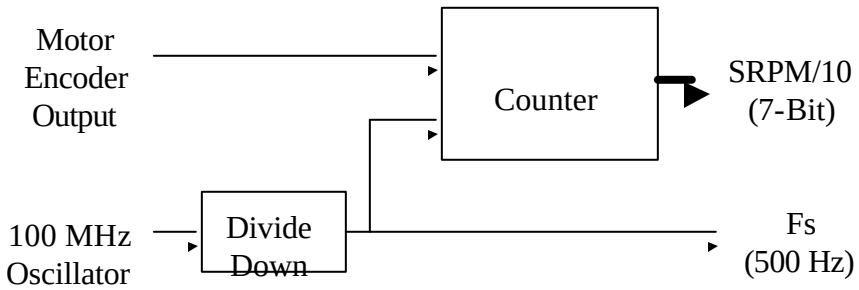
Encoder to 7-Bit Number System

- This system converts the rotary encoder output of the motor (512 pulses per revolution) to a 7 bit number (0 to 86) where that number is one-tenth the speed of the motor shaft in RPM.
- Because the system sampling frequency is 500 Hz, this system is not fully accurate.

Encoder to 7-Bit Number System

- This system works by counting the number of pulses that occur within T=2ms (fs=500Hz).
- Once we have a fully functional complete system, we will come back to this subsystem and try to find a way to improve it (possibly by measuring time between pulses).

Encoder to 7-Bit Number System



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PID System

- No work has begun work on the PID system at this time.

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Other Systems

- A few other systems will need to be written for the system:
  - Display System (Paul is currently working on)
  - Command Input System
  - Error Signal System

Display System

- This system will allow for the display of either the current command input signal or the current motor speed (both in RPM).
- The user can switch between either display by means of an onboard toggle.
- This system utilizes three of the four onboard seven-segment displays.

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Closing

- Overall, we are about right on schedule.
- No major problems have come up yet, however, there has been some difficulty in getting a computer to use.
- We hope to have a working system within a week.