ME 310 : Microprocessors and Automatic Control Lab

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Experiment 3: Running PMDC motor using PWM interface and amplifier

Objectives:

1. Understand what is Pulse Width Modulated (PWM) signal and why it is useful to drive motor
2. Know fundamentals of H-bridge motor driver or amplifier and why it is necessary! **It is NOT decision making element. ☺**
3. Be able to program PWM interface of XEP 100 and use it to drive a PMDC motor.
4. Based on the preliminary experiments on the motor get a 'feel' of friction in motor (in terms of PWM duty cycle needed to start motor) and dynamic, inertia of motor.

DC motors are at heart of several automatic control/ mechatronic applications and form basic actuator elements (example robots). It is important to know how to drive them using microprocessor and control them finally.

Background knowledge required:

1. Thorough understanding of slides posted if any
2. Reading through Ch 19 of XEP 100 datasheet to figure out how this interface works: Read functional description
3. Basic fundamentals about electronics (working of transistors)
4. Fundamentals of dynamics

PWM (Pulse width modulation)

As the name suggests it is a periodic signal (Pulse) for which on and off times can be changed or modulated. So clock you generated is PWM signal with 50% duty cycle. PWM signal is characterized by its frequency and duty cycle. Duty cycle refers to % of "on" time. Such signals can be easily generated by microcontroller with PWM interface programming. (Q: why we need dedicated PWM interface when we can generate similar signals on Digital I/O say PORTA?)
These can further be amplified and used to drive motor. (Scratch your head Why??)

Motor for its running needs current which typically is in few Amps. Microcontroller cannot directly provide these high currents. Hence we will need something to amplify these currents and voltages. Suppose we use digital to analog conversion interface and use transistor amplifiers we have to live with the dead zone for transistor (base bias voltage beyond which transistors start functioning). Hence its good to operate transistor always at higher input voltage. But we also need a facility to vary input to motor from zero to its full power. This is where PWM comes into picture. If we set Pulse frequency to be 10kHz, motor with its mechanical inertia cannot respond to these individual pulses, instead what it will see is the average power delivered to the motor corresponding to the

duty cycle of the PWM. Additional circuit is there in H-Bridge amplifier to change the direction of motor.
Read datasheet Chapter 19 on PWM: to start with the functional description 19.4.

Things to do?

1. Read datasheet Chapter 19 on PWM: to start with the functional description 19.4, specifically look at registers PWME, PWMCLK, PWMPOL, PWMPRCLK, PWMDTYx, PWMPERx and their functionality. Based on the task given below find their values. PWMPERx should be 0xFF and should not be changed. Think why??
   Identify registers responsible to set the PWM Frequency See section 19.4.2.5 : PWMx Frequency = Clock (A, B, SA, or SB) / PWMPERx

   Generate PWM signal with frequency of Y kHz (Y is last digit of your roll no. OR 1 if last digit is zero) and duty cycle of 5% 20% 50% and 100% on a PWM channel corresponding to the last digit of your roll number (consider digits 8 and 9 to be 4 and 3 respectively). *How do you verify that you have generated correct waveform??*
2. Using data in 1. Generate PWM and see the waveform output on the Easyscope oscilloscope. Show these to TA. Now put PWMDTYx = 300 and observe the signal on Easyscope. Can you justify what you observe?
3. With help of TA, connect the motor to the amplifier and PWM and digital output signals from Port A to the input of amplifier. Observe running of motor using PWM signal in both directions for various duty cycles.
4. Hold motor shaft of the running motor and see its effect on current drawn? Will more current be drawn from microprocessor?
5. Change PWM frequency to 50 Hz and observe motor behavior. You may reduce it further and see. Can you explain the behavior?
6. Theory: Look into the slides and understand model of motor which considers its electrical circuit and mechanical free body diagram. With electrical circuit we have related Voltage to current (neglect the inductance of motor L di/dt term) and with free body diagram one can relate "generated torque" to inertia, damping and other load torques including friction torque. Think what are the terms causing coupling of mechanical to electrical domain?
   a. Study this model under different situations: I) Driving torque is just equal to friction torque II) driving torque is much more than friction torque> what will happen in transient and steady state domain. III) you are holding motor shaft even if it wants to turn (load torque). What will be balance of torques in this situation.
   b. Can situations of a. be seen in the actual experiments
7. ***(Challenge problem)*** Use Theory given (motor model in slides) to think about various kinds of experiments you can perform to estimate back emf constant of motor. Think how do you measure speed of motor??
8. ***(challenge problem)*** Program microprocessor to generate triangular waveform output with frequency of approximately 0.1 Hz. for duty cycle 0% to say 30%. Implement this output on motor and observe the motor

behavior. This can be used to estimate static friction and Coulomb friction. Think what else do you need to estimate friction values??

Material required:

1. Easyscope oscilloscope
2. Handout for expt 4 and Datasheet of XEP 100 microprocessor
3. Motor and its amplifier

Food for thought:

1. Can you think of a way we can get PWM by programming the port A? what you will have to do? Why we are using dedicated channels then to get PWM??
2. What all registers will change if a different PWM channel is to be giving the same output?
3. What parameters/ registers PWM frequency is dependent on?