

Objectives

- To control the speed of a DC motor to a selectable set-point
- To control a single servo motor
- To control a pair of servo motors

Section 1: Closed-loop speed control of a DC motor

DC motors and DC servo motors are used in many robotics applications. A DC motor can be driven from a microcontroller using a Pulse Width Modulated (PWM) signal. The inherent low-pass characteristic of the DC motor leads to the averaging of the PWM signal over time; this is in effect equivalent to driving the motor with a DC voltage. Where available, a programmable DC voltage supply can be used instead.

This first section of laboratory LMP8 will address the design of a closed-loop speed control system for a DC motor. Figure LMP8-1 shows the set-up to be used for this experiment: A small DC motor can be driven using an analogue control signal on pin 7 of the connector. A second DC motor is mechanically coupled to the driving motor; used as a passive component, this motor acts as generator or tachometer. The generated output voltage is proportional to the velocity of the shaft of the driving motor. By monitoring this voltage, a simple closed-loop speed control system can be implemented.

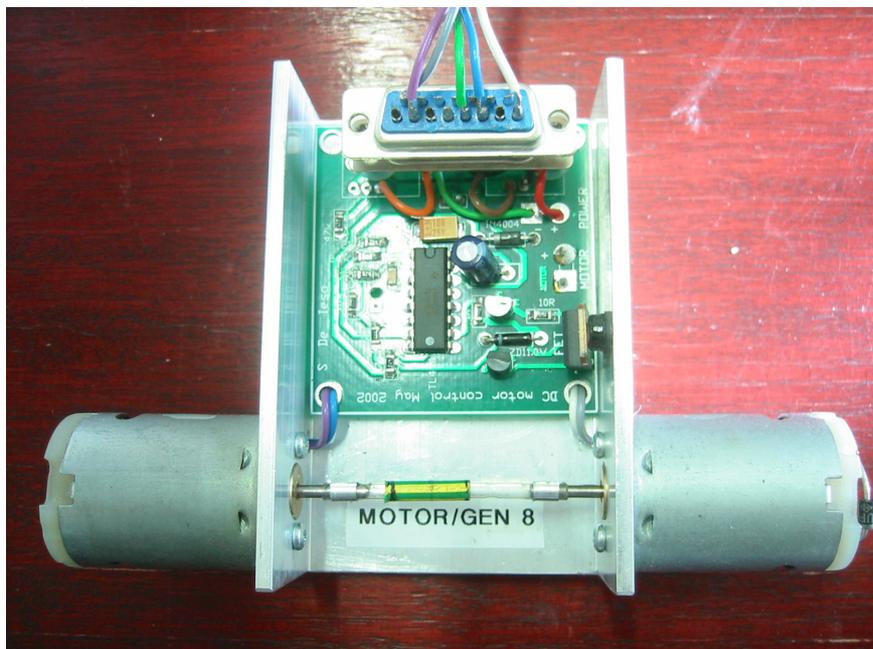


Figure LMP8-1 DC motor and DC voltage generator (tachometer)

Your program should use one of the on-board D/A converters (e.g. DAC0) to generate an analogue control signal u_c (0 ... 2 V). The feedback signal from the tachometer u_{fb} (0 ... 6 V) is to be read by the microcontroller using channel 3 of the A/D converter unit (ADC). The set-point signal u_{sp} should be taken from one of the on-board potentiometers; this voltage also needs to be acquired, e.g. using channel 4 of the ADC. A *proportional control* law is to be implemented, i. e. control signal $u_c = K \cdot (u_{sp} - u_{fb})$, where K is the proportional control gain.

In a first iteration, the whole control cycle – from data acquisition (u_{fb} , u_{sp}), via the calculation of control signal u_c through to the output of this signal on DAC0 – should be implemented within an endless loop. The controller then runs as quickly as possible with the next control cycle directly following the previous one.

However, digital control systems commonly execute at a *fixed sample rate*. This can be achieved by running the control cycle from within a timer Interrupt Service Routine (ISR), where the timer has been configured to elapse at the end of the desired sample interval. This means that all control signals are only updated at these fixed pre-programmed sample instances. Extend the design of your digital control system to execute at a sample rate of 100 Hz.

Section 2: Driving DC servo motors

DC servo motors (short: servo motors) are DC motors with an in-built *position control system* (Figure LMP8-2). Depending on the type of servo motor, the output shaft can reach angles of up to 60°, 90°, 180° or approaching 360°. The set-point signal is a Pulse-Width Modulated (PWM) pulse train with a fixed period of commonly 20 ms. Typical duty cycles range from 3 % to 12 % (0.6 ms to 2.4 ms).



Figure LMP8-2 A small (DC) servo motor

Write a short program that reads an analogue set-point signal from one of the two on-board potentiometers and uses this signal to control the angular position of the output shaft of a servo-motor. The minimum set-point signal of 0 V should correspond to the minimum angular position of the motor (0°, pulse width: 0.6 ms); the maximum set-point signal of 5 V should correspond to an angular position of 90° (pulse width: 1.6 ms). The period of the PWM signal is required to be 20 ms. Test your program using the oscilloscope; the pulse width of the 50 Hz PWM signal should vary with the angular position of the set-point potentiometer within the above limits (0.6 ms ... 1.6 ms).

Extend your program to allow for the independent control of two servo-motors. A second set-point signal is to be read from the second on-board potentiometer, defining the duty cycle of the PWM signal of the second servo motor. Both motors should be able to reach any angle between 0° (0.6 ms) and 90° (1.6 ms). Use the two channels of the oscilloscope to verify that your program achieves independent control of both servo motors.