Lab 3: Sensors and Actuators

(Fuel Injection Control)

How Gasoline Engine Works:
https://www.youtube.com/watch?v=_QXH5MaoKEE

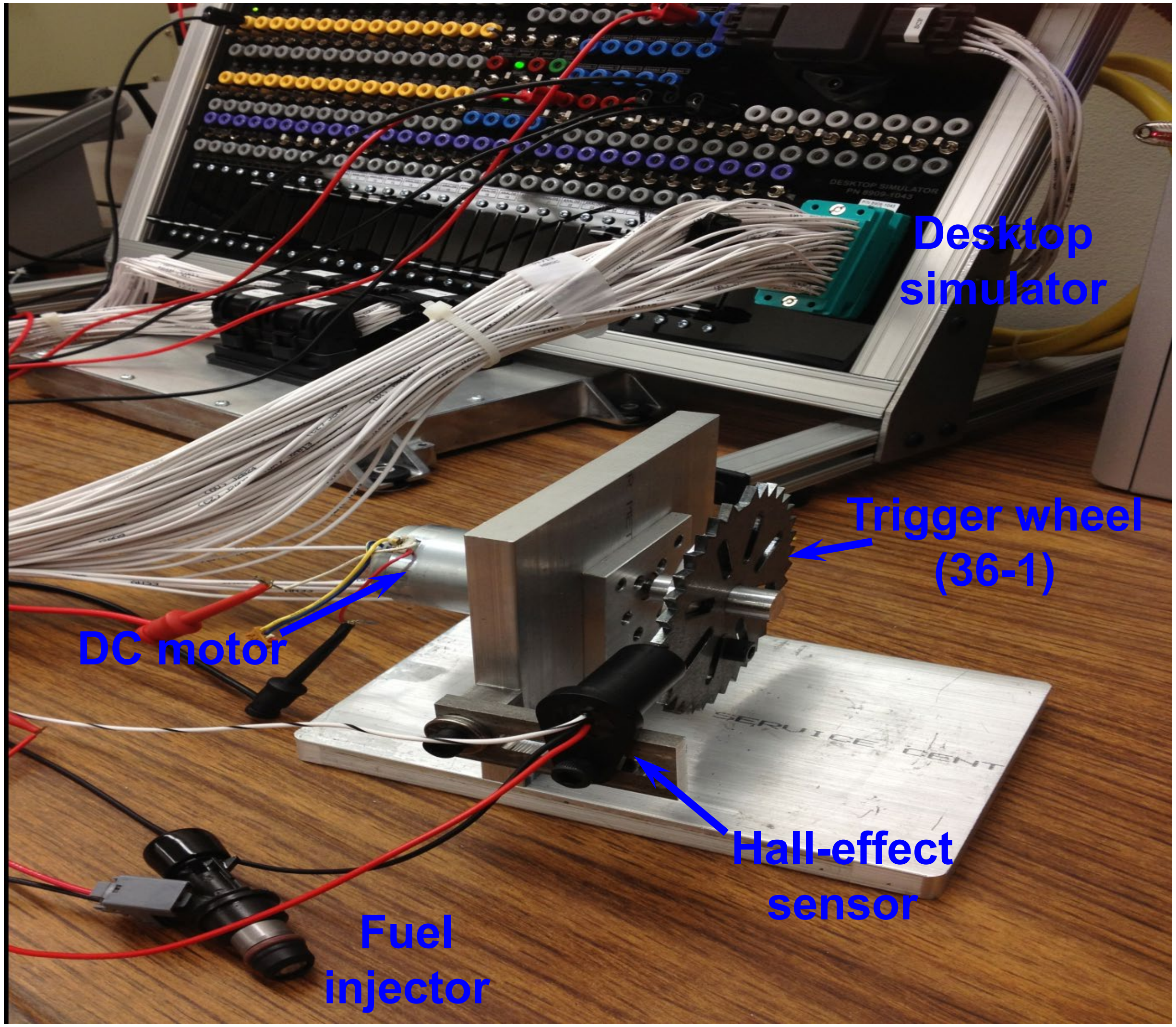
Objectives

- Learn how to read sensor data using analog input and crank sensor input of the MotoTron rapid prototyping system.
- Get familiar with several commonly used sensors and actuators: potentiometer, thermistor, hall-effect sensor, solenoid, and DC motor.
- Use “motohawk_encoder_def,” “motohawk_encoder_average_rpm” and “motohawk_encoder_angle” blocks to calculate engine RPM and crank angle based on crank sensor data.
- Understand the relation among engine RPM, Injection Duration, and Start Of Injection (SOI).

Objectives (Cont.)

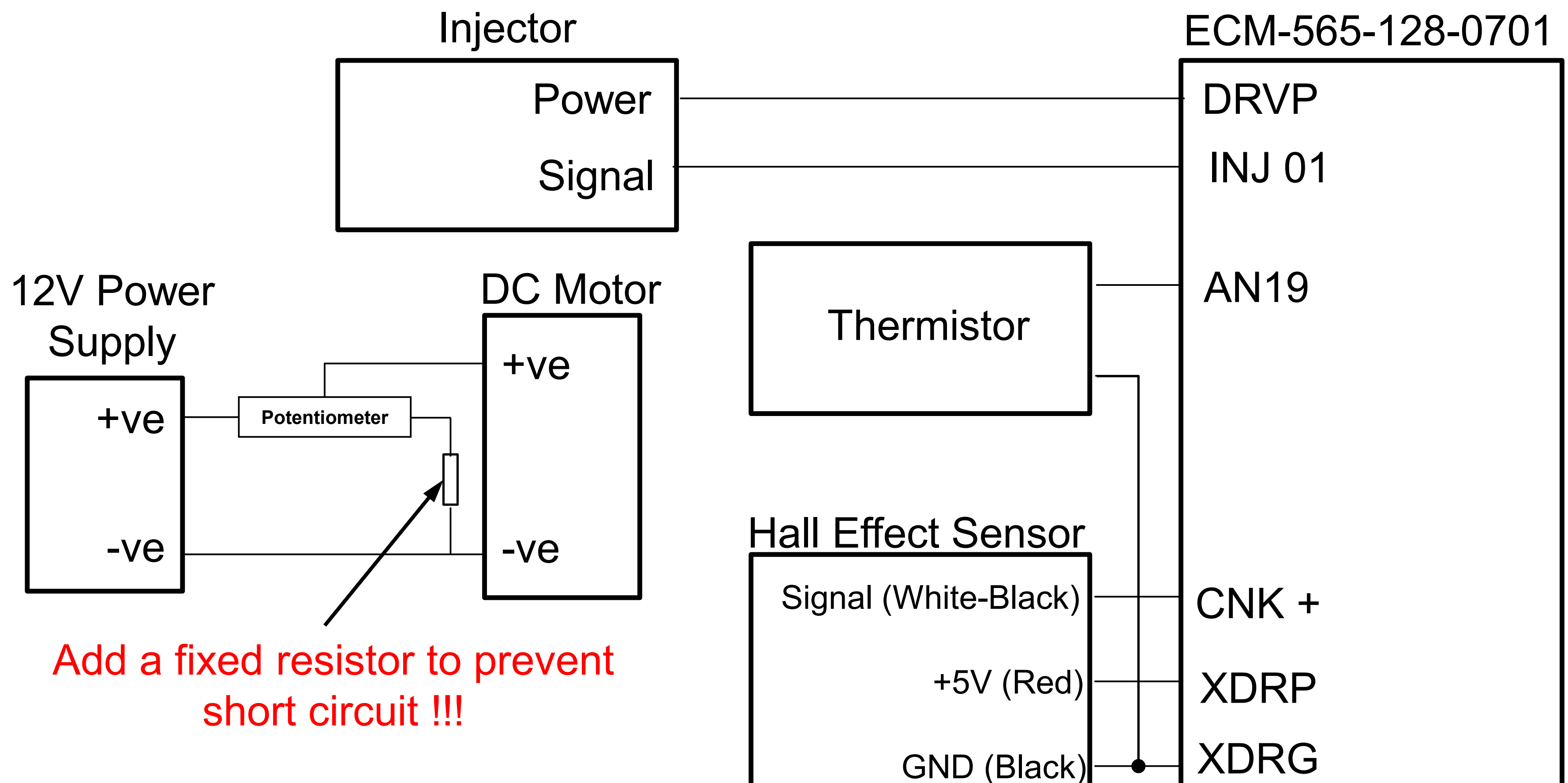
- Learn how to actuate a fuel injector using “Dual PSP” block and simulated engine data.
- Design temperature compensation and protection models to improve the fuel injection control.

Lab Setup



36 minus 1 reluctor wheel

Fuel Injection Control Using MotoTron Rapid Prototyping System



Use a DC motor to emulate engine RPM

Engine RPM, Injection Duration, and Start Of Injection

- Two tables are provided in the next slide for fuel injection control. The first table relates engine RPM and Injection Duration, and the second table relates engine RPM and Start Of Injection (SOI).
- Start Of Injection is specified in terms of crank degrees before top dead center (BTDC).
- Given engine RPM, you can find start of injection angle and injection duration (or stop of injection angle) using provided tables.

Two Tables Relate Injection Duration and SOI with Engine RPM

RPM	Inj. Duration (msec)
0	2
650	2
1000	2
1250	1.95
1500	1.95
1750	1.8
2000	1.8
2250	1.7
2500	1.7
2750	1.5
3000	1.5
3250	1.25
3500	1.25
3750	1
4250	1
5000	1

RPM	SOI (btdc)
0	-80
650	-80
1000	-80
1250	-77
1500	-76
1650	-69
1750	-67
2000	-56
2500	-54
3000	-51
3500	-42
4000	-31
4500	-22
5000	-9

Injection Control Based on Engine RPM

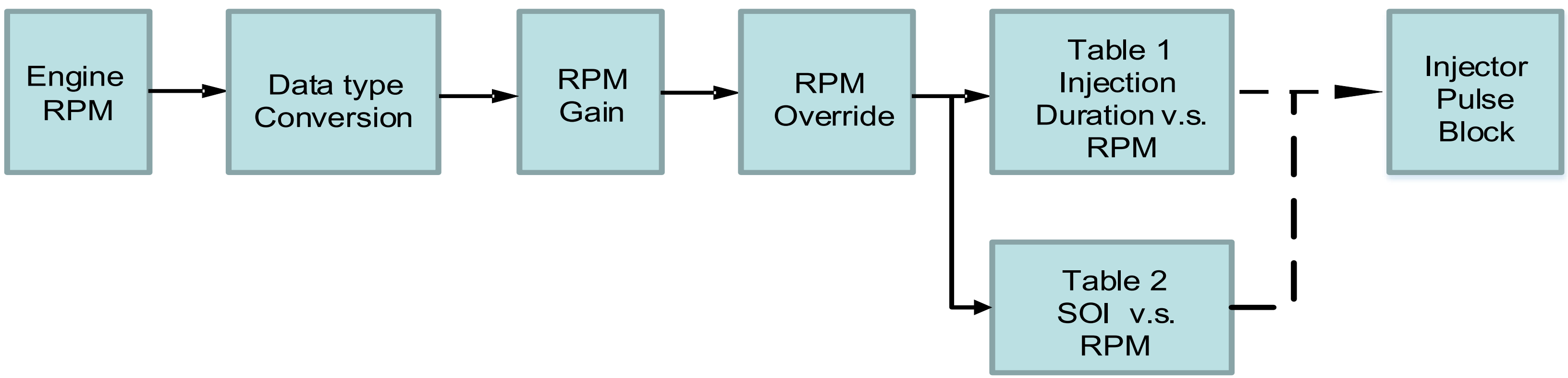
- Use “motohawk_encoder_def,” “motohawk_encoder_average_rpm” and “motohawk_encoder_angle” blocks to find engine RPM and crank angle. This model is provided to you.
- Use a RPM Override block for manually inputting engine RPM.
- Display crank angle, engine RPM, injection duration, and SOI in your model.
- Use “Dual PSP’ block to control a fuel injector.
- Use a calibration block to enable and disable injection.

Injection Control Based on Engine RPM

- Simulink “Data Type Conversion” block can be used to convert data from one type to another, for example, integer to double. Use this block whenever the data conversion is necessary.
- Verify data types: From the Format menu select Port/Signal Displays and check Port Data Types. The data type appears adjacent to each wire. This is a convenient way to verify that your data types are consistent in your model.

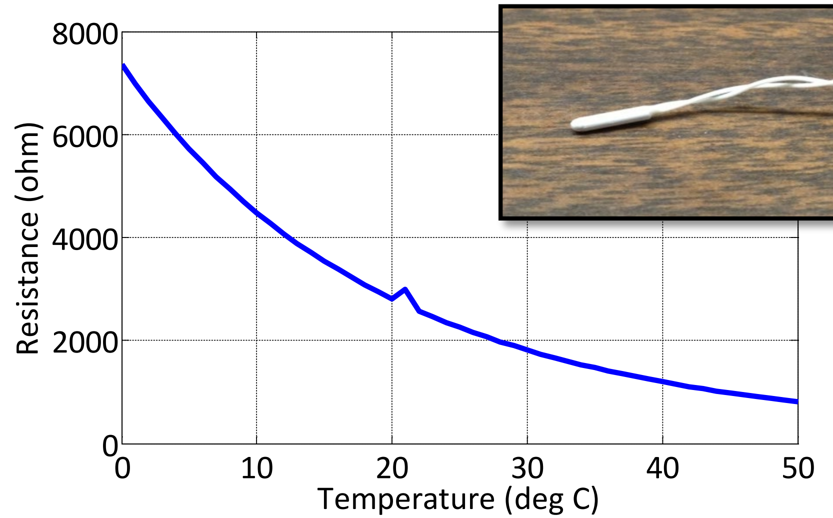
Injection Control Based on Engine RPM

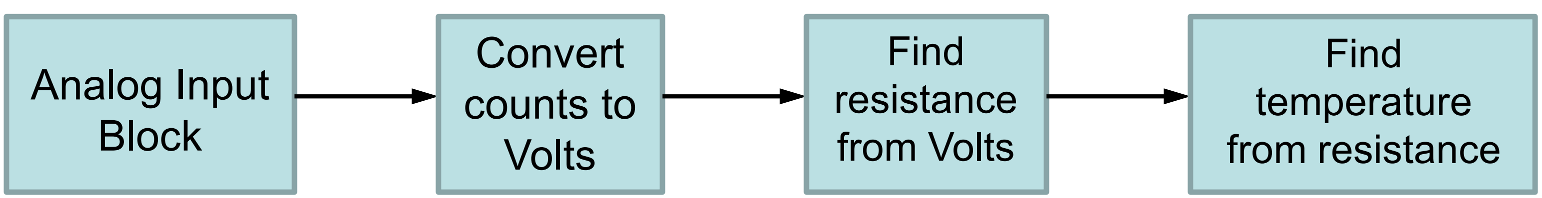
- The block diagram below shows the possible components in your model from "motohawk_encoder_average_rpm" block to "Dual PSP" block. Calibrate the value in your 'RPM gain' block such that the display shows 5000 rpm when the maximum voltage is applied to the DC motor.



Measure Temperature Using A Thermistor

- NTC thermistor
- Refer to the given data sheet to generate a lookup table containing the relationship of thermistor’s resistance and temperature.





Temperature Compensation and Protection

- Design a temperature detection model to read in temperature values using a thermistor.
- Thermistors are commonly used to measure temperatures in an engine such as Exhaust Gas Temp., Oil Sump Temp., and Inlet Air Temp. etc.
- Due to the limitation of the lab facility, you may choose relative low temperature ranges for your model implementation.
- Perform a literature search to find temperature compensation and protection methods based on the exhaust gas temperature for the fuel injection control
- Design temperature compensation and protection model based on the literature.

Basic Requirement of Lab and Report

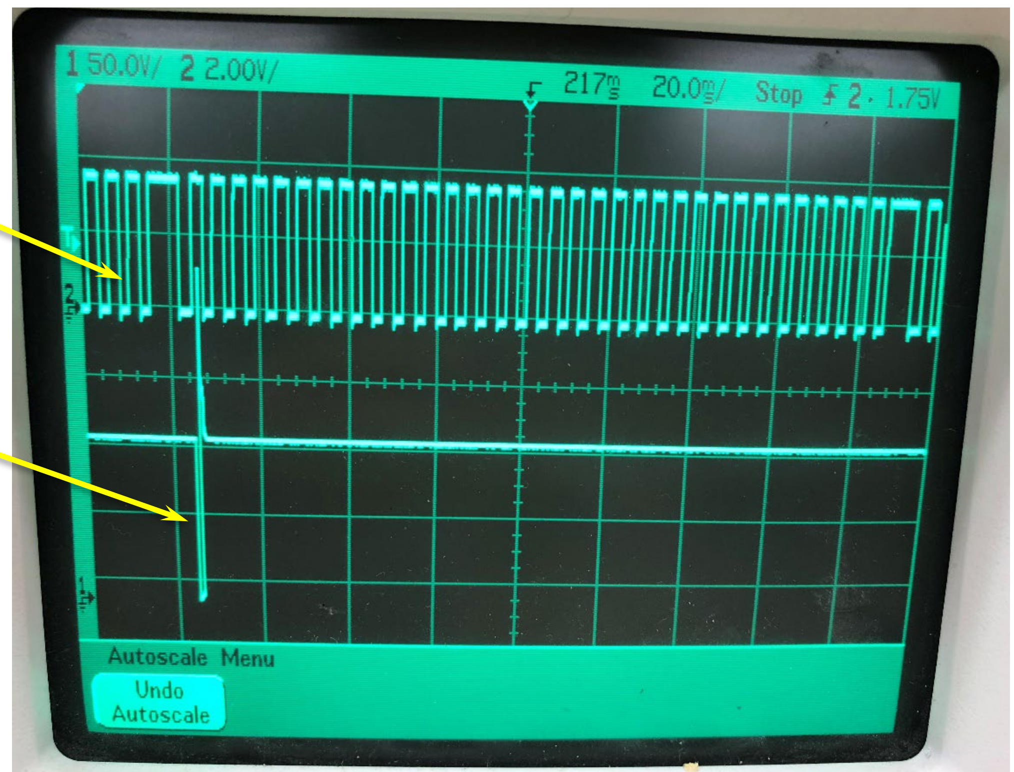
- Use a block diagram to describe your model for the fuel injection control.
- Discuss the A/D converter of the Mototron ECM. Observe the resolution, analog input, and digital output of the converter. Provide examples of these values (obtained from the lab) in your report.
- Find the relation of thermistor analog input voltage and temperature based on provided temperature characteristic curve. Include the results in your report.
- Discuss your model for the voltage to resistance conversion. At room temperature, compare the temperature display in your model with the reading of a thermostat.

Basic Requirement of Lab and Report

- Observe crank angle and injector actuation signals on oscilloscope screen. Include the crank and injector actuation signals of your project in the report. Discuss if the displayed signals meet you control design.

Crank signal

Injector Actuation Signal



Basic Requirement of Lab and Report

- Use an override block in your model to change engine RPM. Observe the changes of the actuation signals of the injector. Discuss if the changes of actuation signal follow your design.
- Capture calibration panels at 3 different RPM readings (other than those given in the table provided) showing corresponding injection duration and SOI and include them in your report.
- Design temperature compensation and protection models for the fuel injection control. Discuss your design in the report. Cite the reference paper or book in your report.

Basic Requirement of Lab and Report

- Observe the change of the fuel injection at different exhaust gas temperatures. Show the results of your temperature compensation and protection models.
- You are encouraged to use various functions available in Matlab and Simulink in your project, for example, Embedded Matlab Function.
- Submit your model file along with your lab report.