Mechatronics Lab Experiment 3 DC Solenoid Control Using a Transistor and PIC Microcontroller

By:

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Summary:

In this experiment we learnt how to control DC solenoid using Transistor and Diode with Arduino programming and current is applied to coil of solenoid for generation of magnetic field which pulls plunger towards solenoid. For interrupt programming we used Timer.1 library. Current given to solenoid from microcontroller is basically two ways. First, we took digital pin output to operate solenoid in on/off mode and in second method, we use PWM output to control solenoid in proportional mode. We also used Diode for protection of our circuit and to prevent overloading.

List of Components:

1. On/Off (pull) type DC solenoid
2. Transistor: IRF510(MOSFET)
3. Diode
4. Arduino UNO Board
5. Resistor 100 K ohms
6. Breadboard
7. Connecting wires
8. USB Cable

Description of the Experiment:

Purpose and Objective:

Purpose of the experiment is to learn the use of integrated development environment (IDE) software of the Arduino microcontroller. We also basic learnt how to use hardware components like transistor and diode. We also implement code to see effect of magnetic field produced using Timer.1 library and delay function. Objective was to control the DC solenoid using passive components such as transistor and diode.

Theory:

A solenoid is a linear displacement actuator whose length is substantially greater than its diameter, often wrapped around a metallic core, which produces a uniform magnetic field in a volume of when an electric current is passed through it. A solenoid is a type of electromagnet when the purpose is to generate a controlled magnetic field. If the purpose of the solenoid is instead to impede changes in the electric current, a solenoid can be more specifically classified as an inductor rather than an electromagnet. It contains a coil, a
plunger, and a core to guide the electromagnetic field between the coil (stator) and the plunger (rotor). When coil is given current, a responsive force is generated in the direction to reduce the effect of the magnetic field. The current direction does not effect the force direction. The generated force is proportional to the square of the current and inversely proportional to the square of the air gap between the plunger and the stopper.

1) Some solenoids are designed to be operated in ON/OFF mode and some are designed to be operated in proportional mode according to the design. Based on the current in the coil, the ON/OFF operation allows the plunger to fully open or fully close.
2) The position of the solenoid can be programmed as a function of current for the proportional mode. The solenoid opeation is controlled in ON/OFF mode in this present experiment. The proportional mode can be operation with real time complex programming.

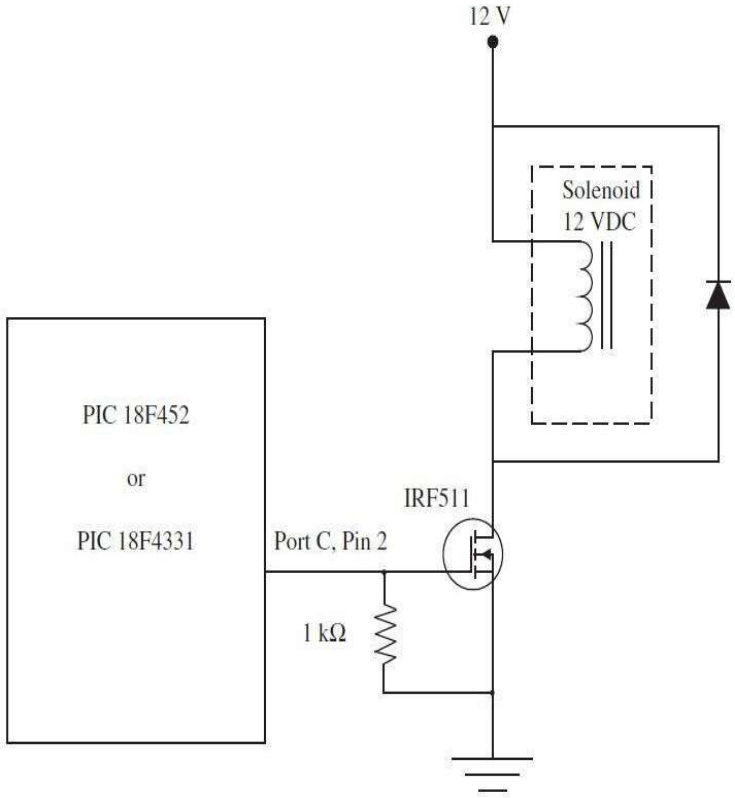
To control the solenoid in ON/OFF mode, output signal from the microcontroller to the transistor, which switches the load current to the solenoid, can be a digital output signal. If we wanted to control it in proportional mode, then a PWM output pin of the PIC should be used to drive the transistor.

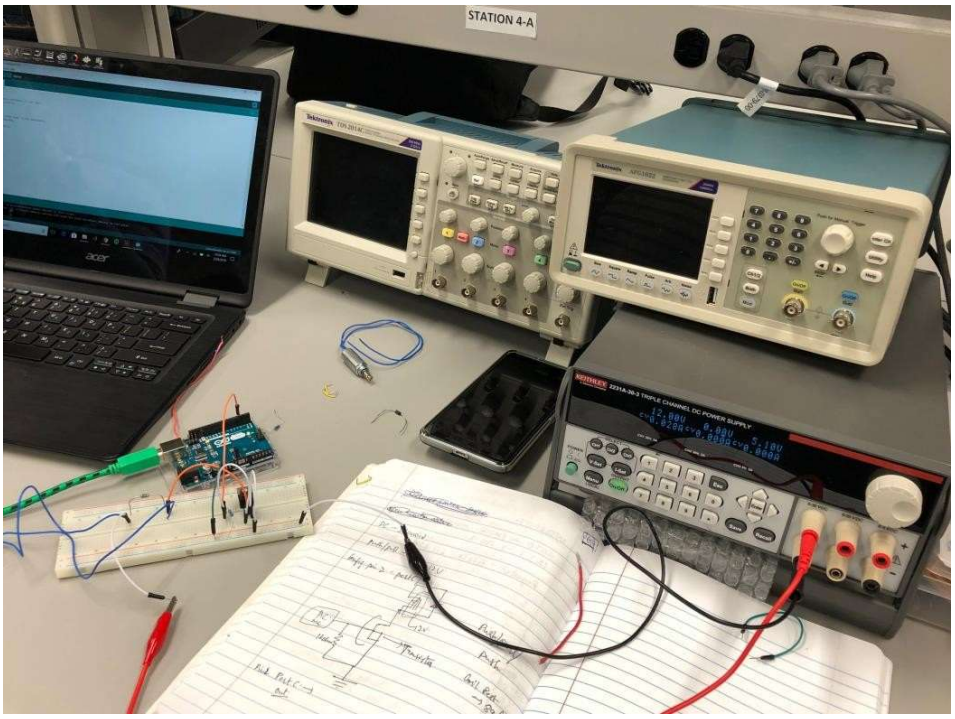
The circuit is designed to switch the voltage across the solenoid during the ON/OFF periods of the cycle. In every cycle, when the voltage is high (12V) the coil is energized by the
current flowing through it. A magnetic field, and the resulting actuation force, is produced due to the tendency of ferromagnetic plunger and coil generated magnetic flux to seek the minimum reluctance point. This magnetic field pulls the plunger in towards the stopper.
When the voltage is low (0V) for the remainder of the cycle (OFF period) the base current of the transistor falls below a minimum value and it stops transmitting current to the solenoid. As a result the magnetic field collapses and the plunger is released. A protection diode is connected in parallel to the solenoid.

Procedure:

1. Setup the breadboard circuit using the figure given in the manual using specified components. Circuit is assembled on the breadboard as shown in the circuit diagram. Take care not to connect the 9-V supply until the entire circuit has been assembled.
2. Potentiometer, Transistor are used of for changing of voltage and proper current supply for solenoid. Connect the potentiometer output to transistor source and output is applied to solenoid.
3. Open the Arduino and prepare sketch which configures the pin as a digital output controlled by an ON/OFF under the control of the software.
4. Download and run the program on the Arduino microcontroller. Now verify the response of the solenoid and its motion.
5. Now Prepare another sketch which configures the pin as a PWM output and repeat the above procedure.

Circuit Diagram:

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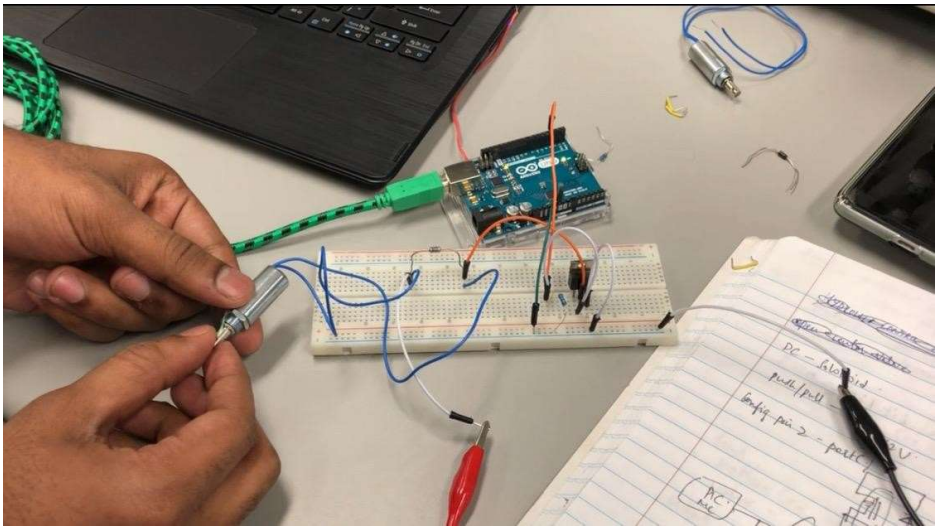

Code:

Digital OUTPUT

Result:

For the given supply voltage of 9 volts, the output is controlled by ON/OFF by the software. The force response is felt when the voltage is supplied.

Conclusion:

In this experiment the objective was to energize and generate force by reducing electromagnetic reluctance in solenoid using microcontroller and arduino IDE programming to operate solenoid in on/off and proportional mode using transistor and diode.

References:

1. Lab Manual
2. Google