Printer Carriage Motion Control

Purpose

- To introduce the L293D quad channel push-pull driver chip for bi-directional dc motor control
- To introduce reflective photo-switches, opto-interrupter switches, and micro-switches.
- To introduce the concept of using limit switches to prevent over-travel.

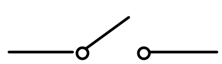
Components

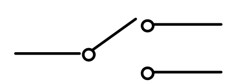
Qty.	Item
1	OOBOT40- II board with OOPic II+ microcontroller and serial port cable
1	Printer carriage assembly
1	Photo-interrupter (Optek OPB960T51) and mechanical limit switch bracket
1	Photo-reflective (OMRON EE-SB54-E) and mechanical limit switch bracket
1	L293D push-pull four channel driver with diodes
1	74LS04 hex inverter
1	tact switch

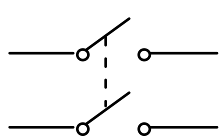
Introduction

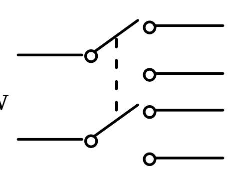
Switches are common devices that permit or interrupt the flow of current. In addition to simply controlling electrical power to a device (such as a motor or light), they can be used in motion control to detect whether or not a movable element has reached a predetermined position.

Mechanical switches come in a variety of designs. They are all referred to by the number of poles and throws they have. The number of poles represents the number of separate circuits that can be completed by the same action of the actuating lever or button. The number of throws represents the number of individual contacts for each pole. The most common types are:

Single-pole/single-throw


Single-pole/double-throw


Double-pole/single-throw


Double-pole/double-throw


Micro-switches typically refer to mechanical switches of small size that have a spring-loaded, momentary contact, operated by a push-button directly or via a pivoted cantilever. Micro-switches find use in many consumer products such as floppy disk drives (to detect the presence of a disk and whether it is write-protected), notebook computers, appliances (to detect if a cover is closed), etc.

Opto-switches (e.g. opto-interrupters, etc.) are often used in mechatronic devices to indicate that a movable element has reached its desired position or end-of-travel. Examples include printers, copiers, and automated manufacturing tooling. They are solid-state, reliable, relatively inexpensive, non-contact devices that are straightforward to interface with logic circuits.

The Project

You are going to use two types of opto-switches, a reflective (Omron EE-SB54-E) and an interrupter-type (Optek OPB960T51) on a printer mechanism and use them to drive the printer carriage between preset limits. You will also use two microswitches to provide a fail-safe limit on the end-of-travel of the carriage in case one of the opto-switches fails.

Here again, we will construct the system in a modular way by building and testing pieces of the system as we go. This is a good general approach in any kind of electronic work, system design, or even computer programming. Avoid the temptation to wire everything up first and hope that it will all work the first time. This approach is doomed to fail, and you'll end up spending gobs of time trying to figure out what is not working.

Module 1 - Reflective Opto-switch

Check that the reflective opto-switch is mounted on its aluminum bracket and attached to the left side of the printer frame. Verify that it functions properly when wired as shown in Figure 1.

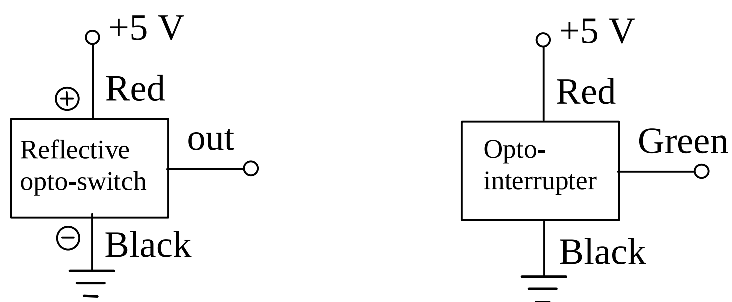


Figure 1. Opto-switch connections for photoreflective and photointerrupter switches

a. Measure the voltage at the output of the reflective opto-switch when the sensor has an opaque object within about 5 mm of its face. What does this voltage represent, logic high or low?
b. Measure the voltage at the output when the sensor is unblocked. What does this voltage represent, logic high or low?
c. What should the voltages be in parts a and b?

If you are satisfied that the reflective opto-switch is working correctly, go on. If not, figure out what is wrong, and fix it.

Module 2 - Photo-interrupter

Check that the photo-interrupter (the one with the big slot in it) is mounted on its aluminum bracket and attached to the right side of the printer frame. Verify that it functions properly when wired as shown in Figure 1.

a. What is the voltage at the green wire output when the photo-interrupter has an opaque object in its gap?
b. What is the voltage at the green wire output when the photo-interrupter is unblocked?

c. What should the voltages be in parts a and b?

If you are satisfied that the photo-interrupter is working correctly, go on. If not, figure out what is wrong and fix it.

Limit Switches

Move the printer carriage by hand, and make sure that each of the two microswitches will be actuated when the aluminum “flag” on the carriage passes beneath them. The switches will be used to cut the power to the motor if the carriage travels beyond the opto-switches. In general, it is very important that any device you design with moving components have some means to reliably prevent or deal with over-travel. Over-travel protection is important to avoid damage to the device and ensure the safety of others working with the machine or in the near vicinity.

Connection to the OOPic II+

Wire the outputs of the opto-switches to the OOPic, and write a short program that reads the state of each switch and prints the corresponding logic level to the PC monitor. Verify that your program correctly detects the change of state of the switches. Show the TA that your program functions properly before going on. Save your program to a floppy disk. Draw your own schematic, and document which pins you used.

74LS04 Hex Inverter

The 74LS04 is a logic IC containing six independent inverter or NOT gates. Figure 2 shows how the chip is layed out. The output of an inverter or NOT gate simply “reverses” the logic level that is presented at its input. So if a logic high is presented at the input, the output of the inverter will be at logic low.

Connect one unused OOPic pin to one of the inverters, write a short program that toggles the voltage to the input of the inverter, and verify that the inverter functions properly.

NOTE: The hex inverter’s function can also be done entirely by software. The oButton’s ‘Invert’ command will also reverse the logic level presented at the input.

L293D Push-Pull Driver

The L293D is an IC designed for driving inductive loads, such as motors and solenoids from logic level signals. The chip has 4 push-pull channels, and each pair has an enabling input, and integral clamping (flyback) diodes. (See Figure 3). Each channel can source or sink up to 600 mA continuous current. A push-pull channel consists of two transistors, a PNP and an NPN, in which the collectors and bases of the two devices are connected. In this arrangement, when a logic level signal is applied to the common base, one of the transistors will be saturated and the other cut-off. This arrangement allows the channel to either source (push) or sink (pull) current from the common collector junction, hence the name “push-pull”. If two channels are used, a dc motor can be driven bi-directionally from a power supply of single polarity.

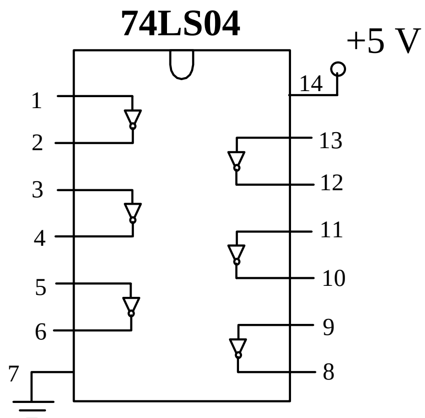


Figure 2. 74LS04 connections. The 74LS04 is a logic IC containing six inverters, also called NOT gates. The schematic symbol for a NOT gate is a triangle with an open circle at the end.

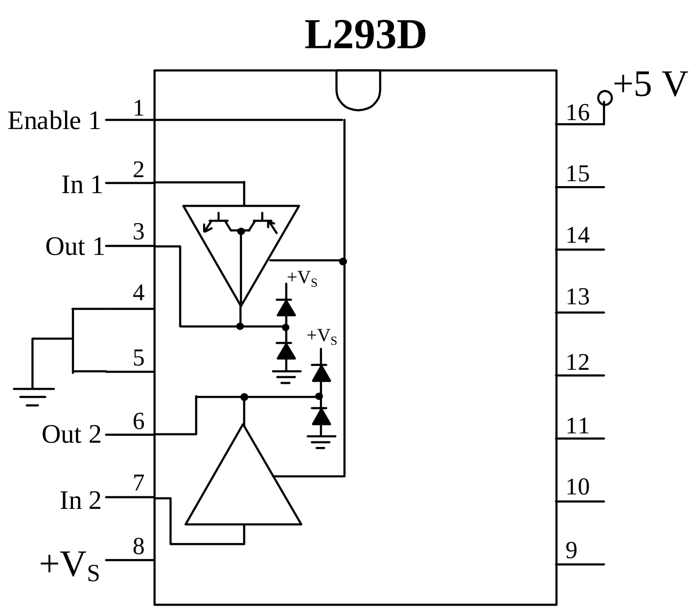


Figure 3. L293D connections. The L293D is a 4-channel push-pull driver chip with integral clamping diodes. Only two of the four channels are shown. The chip needs +5 V to operate and $+V_S$, where V_S must be between 5 and 36 V (We will use V_S=+6 V). The channels are enabled by applying +5 V to the Enable 1 pin. If a logic high is applied to pin 2 (In 1), pin 3 (Out 1) will go high (to about 1.4 V lower than V_s). If a logic low is applied to pin 2, pin 3 will go low (to about 1.2 V above ground). Pins 6 and 7 operate in like fashion.

Pin 1 of the L293D is the enable input for the channels 1 and 2. When pin1 is taken to logic high, the pair of channels is “enabled”, meaning that they are made operational. Thus if a logic high is applied to pin 2 (Input 1), pin 3 (Output 1) will go high (to about 1.4 V lower than V_s). If a logic low is applied to pin 2, pin 3 will go low (to about 1.2 V above ground) When pin1 is taken to logic low, the two channels are “diasabled”, which means that the outputs effectively disconnected from the circuit.

Connect the microcontroller to the 74LS04 and the L293 as shown in Figure 4. Set V_S=+6 V. Include a tact switch on pin z of the OOPic. Write a short program that looks for the tact switch to close, then enables IN 1 of the L293, and toggles IN 1 and IN 2 (by toggling the bit written to pin y) continuously. Verify that the voltage measured between OUT 1 and OUT 2 on the L293D reverses polarity when the bit written to pin y toggles.

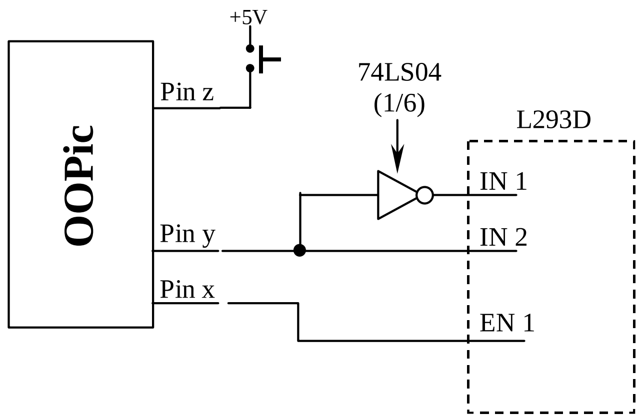


Figure 4. Connections to the OOPic, the 74LS04, and the L293D. Note that the connections for V_S and +5 are not shown on the L293D, but need to be connected.

<u>Printer Carriage Motion Control</u>

Assuming you have gotten all the pieces to work so far, you are now ready to interface the printer carriage motor, and get things moving! Connect the motor in series with the two limit switches between OUT 1 and OUT 2 of the L293. Connect the output of the opto-switches to the OOPic if they are not still connected. The general layout of your system should look like Figure 5.

Write a program that will drive the carriage back and forth between the opto-switches after the tact switch has been pressed. Your program should stop the carriage when the tact switch has been pressed again. Before you jump in and start coding, think about the logic of how you are going accomplish the task! Write a flow chart and develop the logic of your code before you try to move the carriage. You will recognize a part of the diagram as being similar to that from previous labs, especially the two tact switches. (But rather than using the oButton object, consider using the oFlipFlop object.) Use your experience from previous labs to fashion your program, and take a modular approach, rather than trying to write the program from start to finish in one go.

IT IS EXTREMELY IMPORTANT THAT THE LIMIT SWITCHES FUNCTION PROPERLY. IF YOU DRIVE THE CARRIAGE BEYOND THE OPTO-SWITCHES, MAKE SURE THAT THE LIMIT SWITCHES CUT POWER TO THE MOTOR. The motor, belt, and/or carriage assembly may be damaged if the carriage crashes at the end of the stroke. We don’t want you to have to buy us new printer if your break this one!

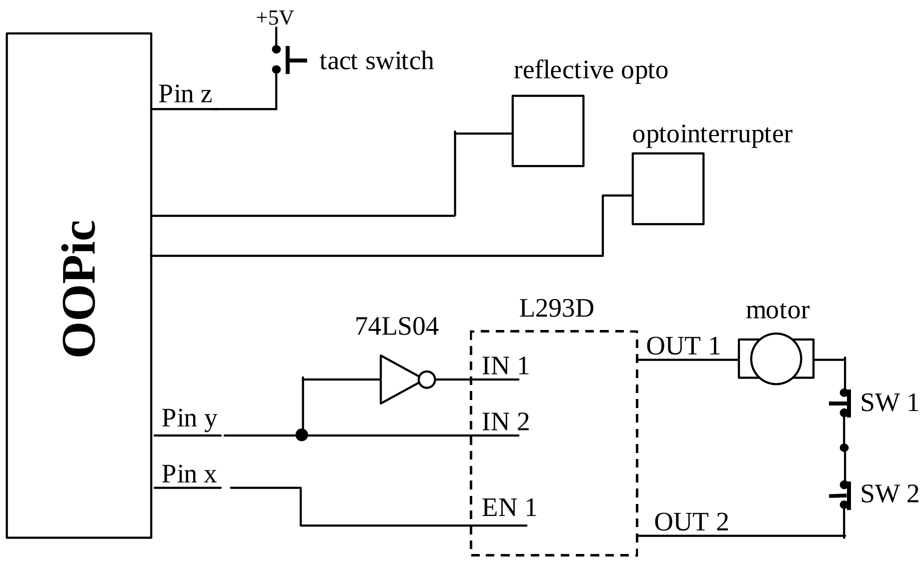


Figure 5. Printer Carriage Motion Controller. The carriage is driven between limits set by the two opto-switches continuously after the program detects that the tact switch has closed. The carriage stops when the tact switch is pressed again.

For more information on the L293D, look at the data sheets on the STMicroelectronics web site:

http://www.st.com

For more information on the 74LS04, look at the data sheets on the Texas Instruments web site:

http://www.ti.com