Reversing Motor Control

The robot you will be building requires a system for controlling the two gear motors. Each motor must be independently controlled and capable of turning the wheels forward or backward. The circuits must also be capable of handling the relatively larger currents that the motors draw. Your robot is designed to be controlled by control signals from the parallel port of a computer. While it is possible to connect low-current devices like LEDs directly to the outputs of the parallel port of the computer, but the larger current drawn by a motor would burn out the circuits inside the computer. So we must use circuits that will *interface* between the parallel port and the motors. The following circuit diagrams are provided to explain how electronic DC motor controls work. You may recreate them in Crocodile Physics to study how they work.

Figure 1 shows a single switch used to turn an DC electric motor on and off. The polarity of the voltage determines which way the motor will turn. The only way to change the direction of the motor rotation with this circuit is to reverse the connections at the battery or at the motor.

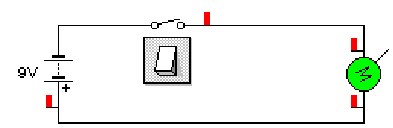

Fig. 1 Simple Motor Control Circuit

A reversing motor control circuit must be capable of reversing the voltage at the motor. This means disconnecting both leads and connecting them to the opposite terminal of the power supply. To accomplish this a *double-pole, double throw switch* is used, as shown in Figure 2.

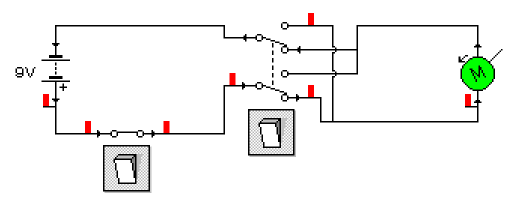

Fig. 2 Reversing Motor Control Circuit

However, this circuit is not suitable for the robot because the switch requires an operator to physically move the contacts. Instead we need to use an electronic circuit that will perform the same functions as the double-pole, double-throw switch, in response to electrical signals (Low voltage represents Logical 0 or Off, High voltage represents Logical 1 or On).

The circuit we will use to control the motors on the robot is a version of the H-Bridge circuit. The basic version of this circuit depends on the use of two types of transistors: NPN and PNP. In Figures 3 and 4, you can see that the voltages on the PNP transistor are opposite to those on the NPN transistor circuit. In both cases, the transistor is controlled by the voltage at the base (B) of the transistor. However, the NPN transistor is oriented so that the Emitter (E) is connected to the negative terminal of the battery, but the PNP transistor has the Emitter connected to the positive terminal. For more information, refer to "Introduction to Electronics" which can be found by following the links to Mr. Snider's homework page from the glenforestlibrary.com web site.

C = Collector B = Base E = Emitter

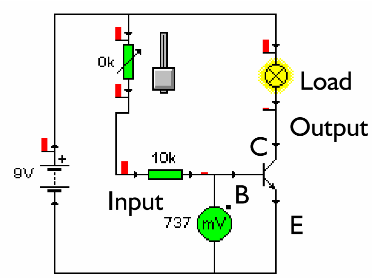

Fig. 3. NPN Transistor Circuit

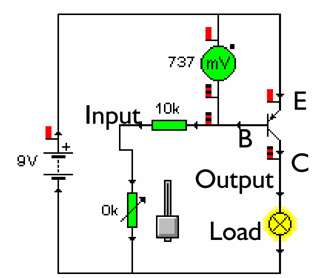

Fig. 4 PNP Transistor Circuit

Figure 5 shows an NPN and a PNP transistor used in tandem to control a motor. Note that both transistors must be on for the motor to run. A single transistor could be used in this case, but this circuit is shown here to help explain the H-Bridge circuit. When the switch is closed it provides the current to the base of the first transistor, turning it on. This has the effect of drawing current from the base of the second transistor, which also turns on. When both transistors are on, current flows through the motor, causing it to turn.

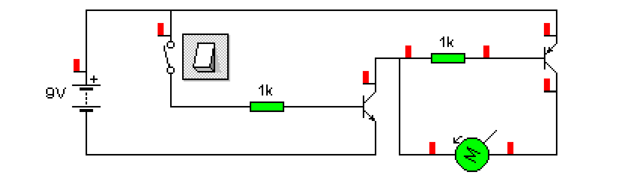

Fig. 5 Transistor Motor Control Circuit

Finally, Figure 6 shows how four transistors can be used to provide a reversing motor controller similar to the double-throw, double-pole switch in Figure 2. When the switch is connected to Input 1, transistors Q1 and Q2 conduct, causing the motor to rotate in a counter-clockwise direction. When the switch is connected to Input 2, transistors Q3 and Q4 conduct, causing the motor to rotate in a clockwise direction.

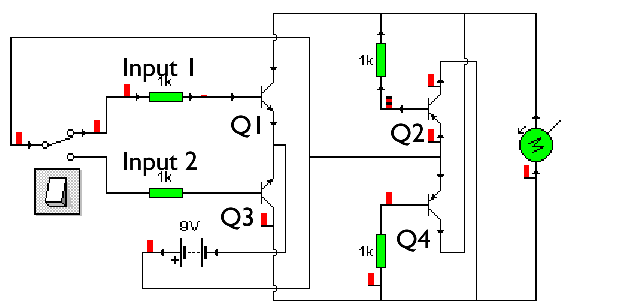

Fig. 6 Reversing Transistor Motor Control Circuit

Note that a single-pole, double-throw switch is used on the inputs. This is to prevent a situation where both input transistors are energized at same time, which would damage or destroy the transistors. These inputs can be controlled from a variety of sources, including the parallel port of the computer. Your program must include safeguards to ensure that only one motor control input is high at any time.

It is also possible to use an integrated circuit like the L293D which contains two H-bridges to control two motors independently. One H-Bridge is shown on the diagram below. The circuit has tri-state outputs, meaning that when it is not enabled there is a very high resistance to current flow in either direction. EN stands for Enable: connect pin 1 to +5V to activate the outputs. When a High voltage (+5V) is present on pin 2, the motor supply voltage is connected to pin 3. The motor supply voltage (VCC1) may be as high as 36 volts, and the circuit can supply 1 to 2 amps, depending on the chip. The input on pin 7 must be low, so that pin 6 is low, providing a path for the current through the motor. The truth table shows the state of the inputs necessary to make the motor turn in either direction.

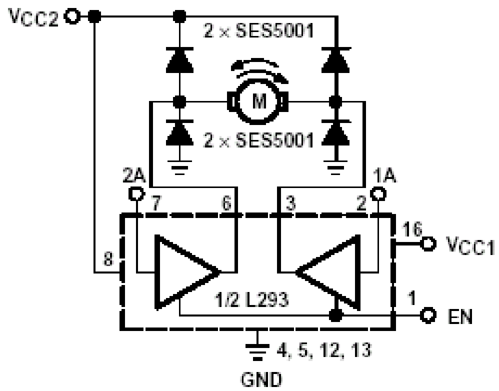

Figure 5. Bidirectional DC Motor Control

EN	1A	2A	FUNCTION
H	L	H	Turn right
H	H	L	Turn left
H	L	L	Fast motor stop
H	H	H	Fast motor stop
L	X	X	Fast motor stop

L = low, H = high, X = don't care