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Electronic Concepts(basics) (COM3113)

H-Bridge And using it in Automatic Reversible Fan

team 1

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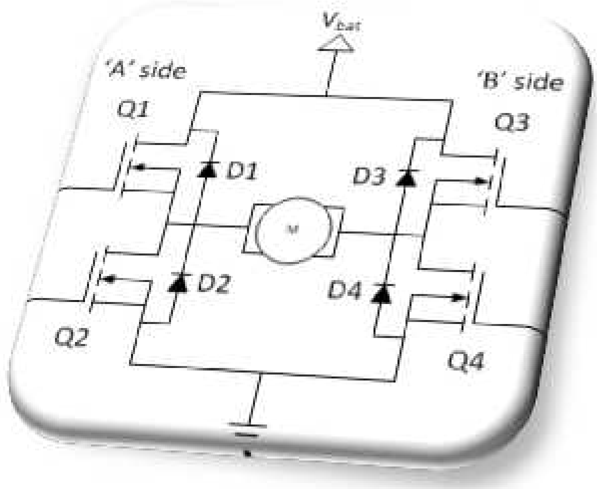
Abstract

This report “H-Bridge and using it in Automatic Reversible Fan” aims to discuss how the project is made, the tools and components we used, the concept behind making this project. The project is about the common H-Bridge and using it to control a motor to work as an automatic fan working in both ways (Automatic Reversible Fan).



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1. Introduction

There are several industrial, automatic, and other processes that require the control of angular position of a motor (or translation position), this aim is achieved by using dc motor which allow us to control the position at a wider range of speeds in both reverse and forward direction.

Position control systems are an important component of many industrial products. Examples are found in disc drives, automotive products, robotics, process control and many others.
To control a motor you have a lot of options, and in this project we applied the simple way to control it, using h-bridge. And execute it to control a fan which rotate in both ways, one if the temperature is high, the other when the system indicates smoke.
An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards or backwards.

Most DC-to-AC converters (power inverters), most AC/AC converters, the DC-to-DC push–pull converter, most motor controllers, and many other kinds of power electronics use H bridges. In particular, a bipolar stepper motor is almost invariably driven by a motor controller containing two H bridges.

1.1 Problem Statement

H-Bridge is a way to control a motor. The target is to execute it and use it in applications.

1.2 The meta behind the project (Objectives)

To apply what we studied in the course, to know the applications of electronic components we used and know how to use them in other projects.

To know the concept of H-Bridge and, use it in many applications

To learn about the structure and behavior of electrical components

To gain practical experience with dealing with electrical circuits

2. Steps of project Execution

We first searched for the appropriate design(circuit) for H-Bridge:

2.1 Choosing the circuit

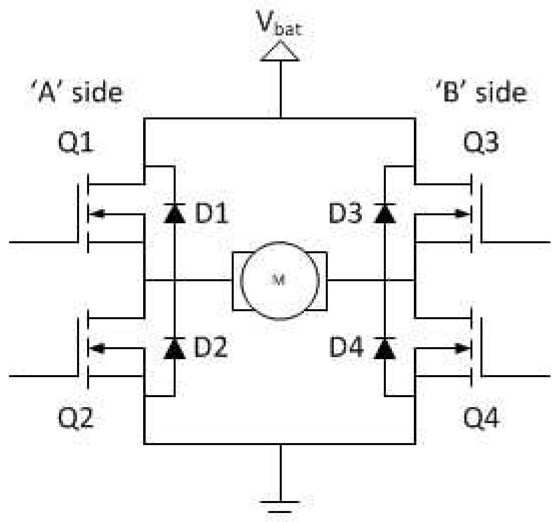


Figure 1 - Circuit

2.2 Using Electronic Design tool (Proteus)

Proteus is an easy to use tool to implement a circuit and make sure it works correctly. We used it to test our circuit.

2.2.1 Schematic Design

In schematic design, we implemented our circuit using components and ICs we needed listed in proteus as shown in figure

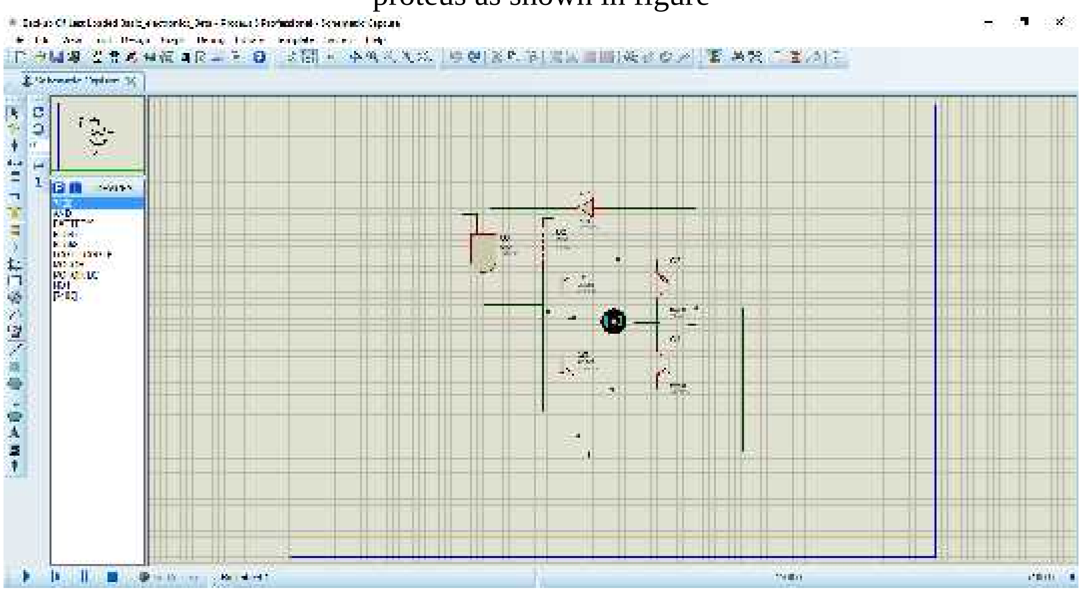


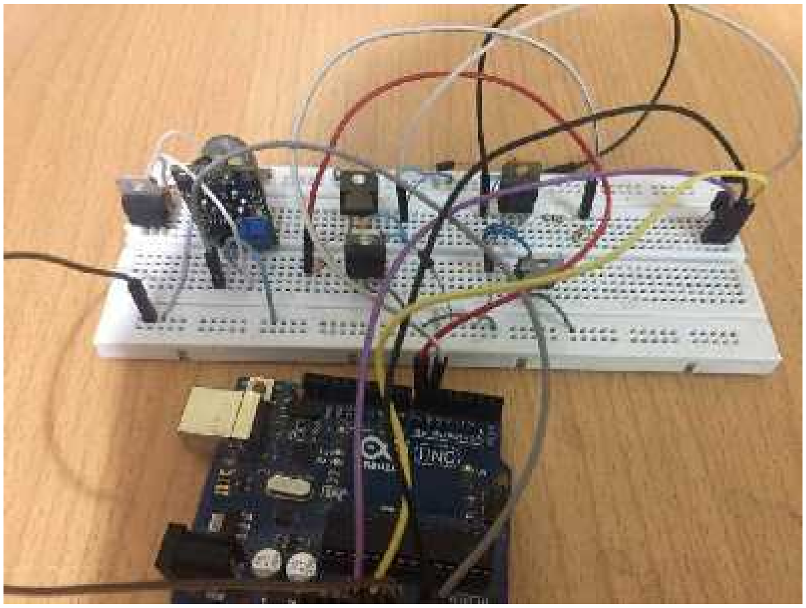
Figure 2 - Schematic Design

2.3 Test Board Experiment

Testboard experiment is an indicator whether the project is working or not as shown in figure.

Advantages:

- Easy to use and execute the project on it.
- Easy to fix and correct the problems.
- Can be implemented using protues schematic design directly.



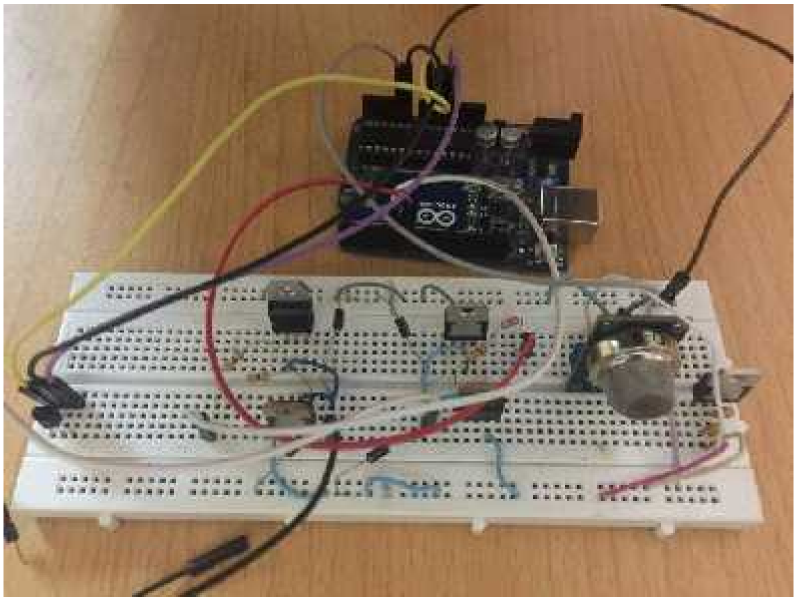


Figure 3 - TestBoard

3. Components

We used simple electronic components:

- Transistors(TIP)
- Diodes
- DC Motor
- Voltage Regulator
- Resistors
- Gas (smoke sensor)
- Heat sensor
- Arduino
- Battery

3.1 Transistors

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals controls the current through another pair of terminals.

Figure 4 – Transistors

NPN & PNP type bipolar transistors can be made to operate as "ON/OFF" type solid state switch by biasing the transistors Base terminal differently to that for a signal amplifier.

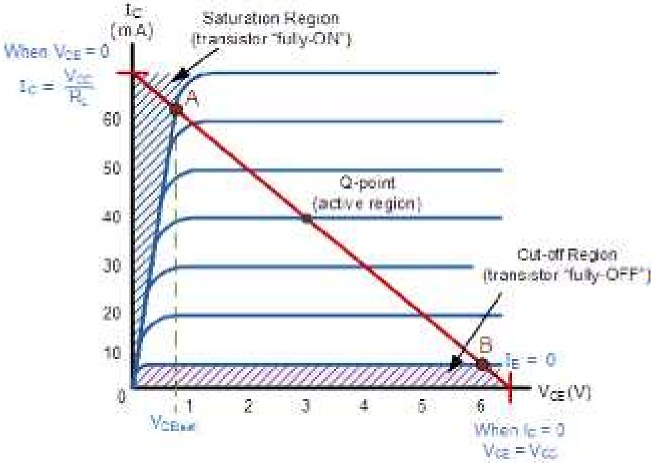


Figure 5 - Transistors Regions

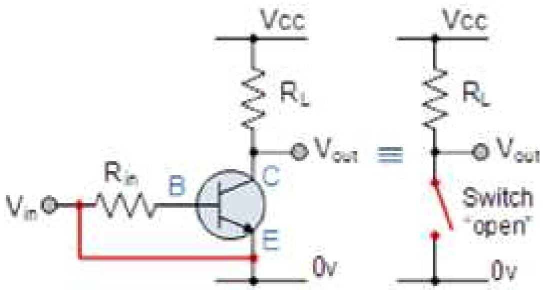


Figure 6 - Open switch transistor

- The input and Base are grounded (0v)
- Base-Emitter voltage V_{BE} < 0.7v
- Base-Emitter junction is reverse biased
- Base-Collector junction is reverse biased
- Transistor is "fully-OFF" (Cut-off region)
- No Collector current flows (I_C = 0)
- $V_{OUT} = V_{CE} = V_{CC}$ = "1"
- Transistor operates as an "open switch"

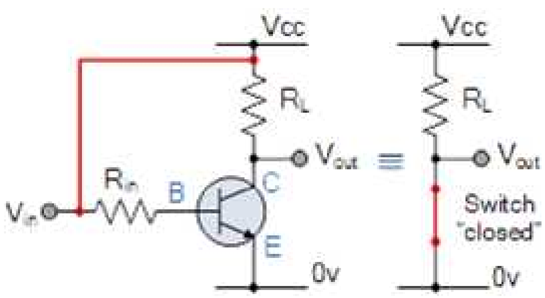


Figure 7 - Closed switch transistor

- The input and Base are connected to V_{CC}
- Base-Emitter voltage V_{BE} > 0.7v
- Base-Emitter junction is forward biased
- Base-Collector junction is forward biased
- Transistor is "fully-ON" (saturation region)
- Max Collector current flows ($I_C = Vcc/R_L$)
- V_{CE} = 0 (ideal saturation)
- $V_{OUT} = V_{CE}$ = "0"
- Transistor operates as a "closed switch"

3.3.1 Why using TIP (TIP 122 npn & TIP 127 pnp)

TIP produces high current up to 6 ampere

The Darlington Bipolar Power Transistor is designed for general purpose amplifier and low frequency switching applications. The TIP140, TIP141, TIP142, (NPN); TIP145, TIP146, TIP147, (PNP) are complementary devices.

Features

- High DC Current Gain
- Min hFE = 1000 @ IC
- = 5 A, VCE = 4 V
- Collector-Emitter Sustaining Voltage @ 30 mA
- VCEO(sus) = 60 Vdc (Min) TIP140, TIP145
- VCEO(sus) = 80 Vdc (Min) TIP141, TIP146
- VCEO(sus) = 100 Vdc (Min) TIP142, TIP147
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor
- Pb-Free Packages are Available

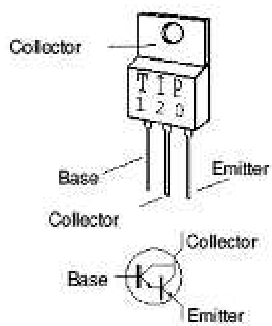


Figure 8 - TIP

3.2 Diodes

A diode is a specialized electronic component with two electrodes called the anode and the cathode. Most diodes are made with semiconductor materials such as silicon, germanium, or selenium. Some diodes are comprised of metal electrodes in a chamber evacuated or filled with a pure elemental gas at low pressure. Diodes can be used as rectifiers, signal limiters, voltage regulators, switches, signal modulators, signal mixers, signal demodulators, and oscillators.

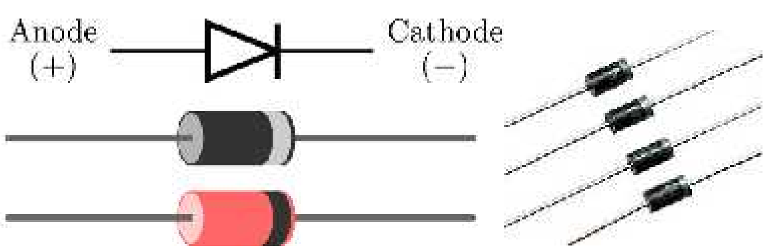


Figure 9 - Diodes

The fundamental property of a diode is its tendency to conduct electric current in only one direction. When the cathode is negatively charged relative to the anode at a voltage greater than a certain minimum called forward breakover, then current flows through the diode. If the cathode is positive with respect to the anode, is at the same voltage as the anode, or is negative by an amount less than the forward breakover voltage, then the diode does not conduct current. This is a simplistic view, but is true for diodes operating as rectifiers, switches, and limiters. The forward breakover voltage is approximately six tenths of a volt (0.6 V) for silicon devices, 0.3 V for germanium devices, and 1 V for selenium devices.

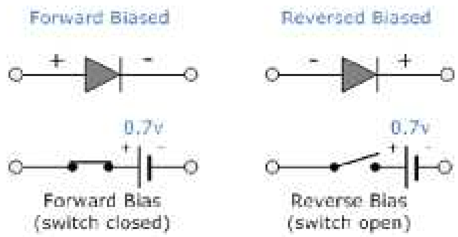


Figure 10 - Diodes biasing

The Signal Diode

The semiconductor Signal Diode is a small non-linear semiconductor device generally used in electronic circuits, where small currents or high frequencies are involved such as in radio, television and digital logic circuits.

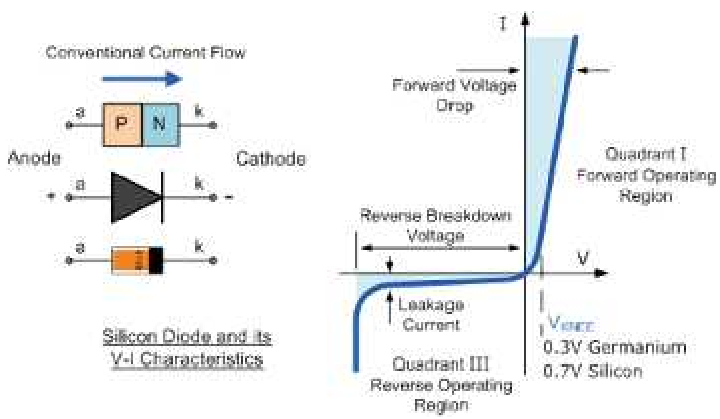


Figure 11 - Diode V-I Characteristics

We used it to protect the circuit from the reverse current of the motor potential (Schottky diodes)

The Schottky diode (named after German physicist Walter H. Schottky), also known as hot carrier diode, is a semiconductor diode formed by the junction of a semiconductor with a metal. It has a low forward voltage drop and a very fast switching action. The cat's-whisker detectors used in the early days

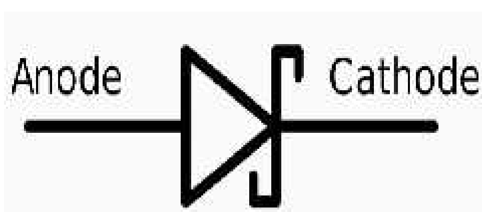


Figure 12 - Schottky diode

of wireless and metal rectifiers used in early power applications can be considered primitive Schottky diodes.

When sufficient forward voltage is applied, a current flows in the forward direction. A silicon diode has a typical forward voltage of 600–700 mV, while the Schottky's forward voltage is 150 – 450 mV. This lower forward voltage requirement allows higher switching speeds and better system efficiency.

3.3 Arduino

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

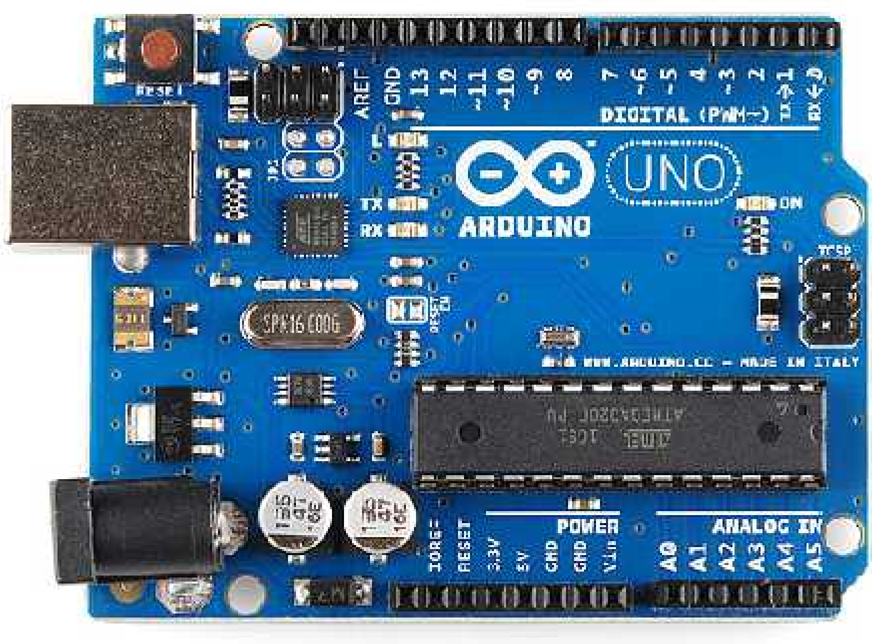


Figure 13 - Arduino

The Uno is one of the more popular boards in the Arduino family and a great choice for beginners.

We used the Arduino to control which input overcomes and rotates the motor on way, When the temperature is high the motor is controlled to rotate in a way, when there is smoke indicated it is controlled to rotate in the other way.

We control it to rotate to remove smoke (priority 1)

The code is as follow:

```
#define tempPin  A0     //arduino pin used for temperature sensor
#define smokePin A1     //arduino pin used for temperature sensor

#define fan      7      // the pin  to active fan direction
#define Suction  6      // the pin  to active Suction direction

float temp;  //variable to read temperature
float smoke; //variable to read smoke

void setup() {

pinMode(fan, OUTPUT);
pinMode(Suction, OUTPUT);

pinMode(tempPin, INPUT);
pinMode(smokePin, INPUT);

Serial.begin(9600);

}

void loop() {

temp = analogRead(tempPin);
temp = (temp *5.0*100.0)/1024.0; //calculate the temperature in Celsius

smoke= analogRead(smokePin);

Serial.print("The temperature is :");
Serial.println(temp);

Serial.print("The smoke is :");
Serial.println(smoke);
Serial.println(); // just print new line


if(smoke > 400 ) { // if smoke is more than 400

  digitalWrite(fan, LOW);        // Disable fan direction
  digitalWrite(Suction, HIGH);   // active Suction direction

}else if(temp > 37) { //If temperature is higher than the 37 Celsius

  digitalWrite(fan, HIGH);       // active fan direction
  digitalWrite(Suction, LOW); // Disable Suction direction

}else{
  digitalWrite(fan, LOW);       // Disable fan direction
  digitalWrite(Suction, LOW); // Disable Suction direction

}

delay(1000); // delay in between reads for stability

}
```

Figure 14 - Arduino code

3.4 DC Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical power into mechanical power.

Figure 15 - DC motor

3.5 Voltage Regulator L7805cv

A voltage regulator is designed to automatically maintain a constant voltage level. it generates a fixed output voltage of a preset magnitude that remains constant regardless of changes to its input voltage or load conditions. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

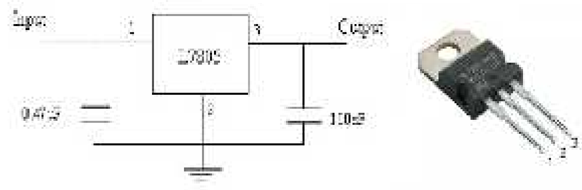


Figure 16 - Voltage Regulator

3.6 Heat sensor (lm35)

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range.

Features:

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

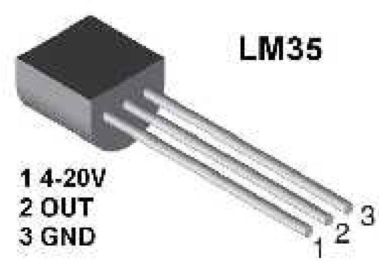


Figure 17 - Heat Sensor LM35

3.7 Gas sensor (MQ-9)

Sensitive material of MQ-9 gas sensor is SnO which with lower conductivity in clean air. It make detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensor’s conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it detects Methane, Propane etc.

combustible gas and cleans the other gases adsorbed under low temperature. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-9 gas sensor has high sensitivity to Carbon Monoxide, Methane and LPG. The sensor could be used to detect different gases contains CO and combustible gases, it is with low cost and suitable for different application.

Character

* Good sensitivity to CO/Combustible gas
* High sensitivity to Methane, Propane and CO
* Long life and low cost
* Simple drive circuit

Application

* Domestic gas leakage detector
* Industrial gas detector
* Portable gas detector

Figure 18 - Gas Sensor MQ-9

4. How it Works

H-Bridge is a method used to control the activation and output rotational direction of a motor. The H-Bridge uses the four transistors to control the directional flow of current through the motor. Two of the transistors are used to close circuits from a power source to the motor while the other two transistors are used to close the circuit to ground.
We used 2 npn and 2 pnp transistors as follow:

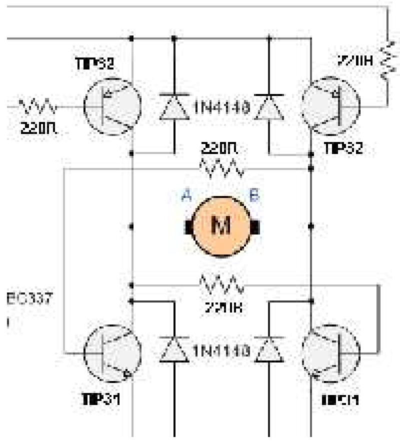
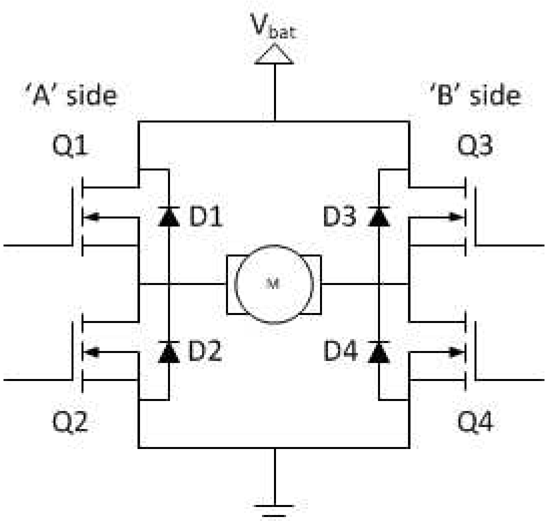


Figure 19 - Circuit using TIP

In general an H-bridge is a rather simple circuit, containing four switching element, with the load at the center, in an H-like configuration:



The switching elements (Q1..Q4) are usually bi-polar or FET transistors, in some high-voltage applications IGBTs. Integrated solutions also exist but whether the switching elements are integrated with their control circuits or not is not relevant for the most part for this discussion. The diodes (D1..D4) are called catch diodes and are usually of a Schottky type.

The top-end of the bridge is connected to a power supply (battery for example) and the bottom-end is grounded.

In general all four switching elements can be turned on and off independently, though there are some obvious restrictions.

Though the load can in theory be anything you want, by far the most pervasive application if H-bridges is with a brushed DC or bipolar stepper motor (steppers need two H-bridges per motor) load. In the following I will concentrate on applications as a brushed DC motor driver.

4.1 Static Operation

The basic operating mode of an H-bridge is fairly simple: if Q1 and Q4 are turned on, the left lead of the motor will be connected to the power supply, while the right lead is connected to ground. Current starts flowing through the motor which energizes the motor in (let's say) the forward direction and the motor shaft starts spinning.

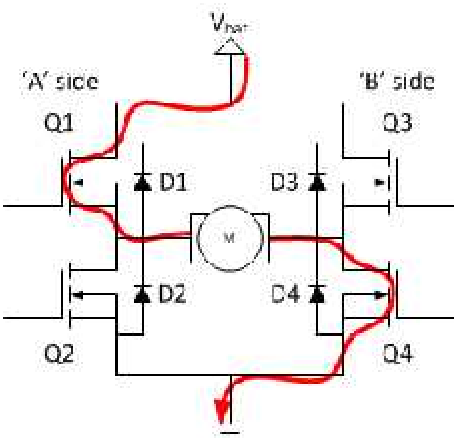


Figure 20 - Current folows when Q1 and Q4 turned on

If Q2 and Q3 are turned on, the reverse will happen, the motor gets energized in the reverse direction, and the shaft will start spinning backwards.

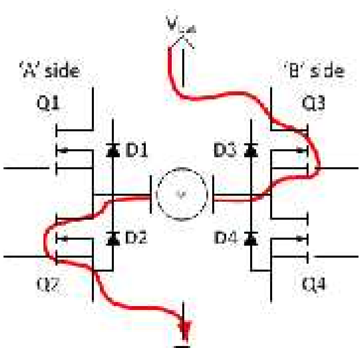


Figure 21 - Current folows when Q2 and Q3 turned on

In a bridge, you should never ever close both Q1 and Q2 (or Q3 and Q4) at the same time. If you did that, you just have created a really low-resistance path between power and GND, effectively short-circuiting your power supply. This condition is called ‘shoot-through’ and is an almost guaranteed way to quickly destroy your bridge, or something else in your circuit.

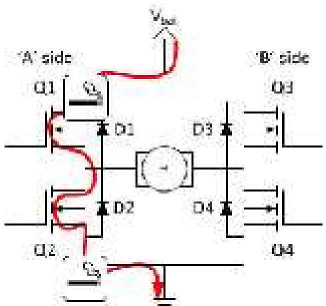


Figure 22 - Q1&Q2 or Q3&Q4 are turned on

4.1.1 Catch diodes

If you look through the mappings above, you’ll see that both in the on-time and in the off-time one switching element is on on each side of the bridge. We did that in order to provide a continuous path for the motor current to flow. But if that’s true, what’s the purpose of these diodes? Can we leave them out? The answer is resounding no, and the reason is the following: it is impossible in any real circuit to turn on or off the high- and low-side switches at exactly the same time. They are either a bit early or a bit late. In one case, both the high- and low-side switch would be on for a short while, in the other both would be off momentarily.

If both are on, you created a shoot-through condition that is very very bad. We want to avoid short-circuiting the supply – even momentarily – by any means. So all practical bridge designs are biased in the other way, making sure that the two switches are never on at the same time, but as a consequence they will be both off for a short while during switching.

Now, when both switches are off on one side, the motor current has nowhere to flow. That’s bad in a different way: the motor voltage will jump as high as it needs to create a path for the current to flow. That voltage jump will probably kill one of the switches and the current path is created through the damaged switch. That’s not a nice way for the bridge to go, so some protection is necessary. The role of the catch-diodes is to provide a path for the current during these short switching periods without the motor voltage needing to rise too high. In some implementations, the intrinsic diodes of the MOSFET switches are used as catch diodes, in others, for example when BJTs are used as switching elements, the diodes must be provided externally.

The other thing to discuss is why not to use the diodes to conduct the off-time current? The main question that determines the answer is heat dissipation. Which one runs cooler: the diode or the switch?

In most bridge setups, the current changes relatively little during the on- and off-time compared to the average current flowing though the motor, so for the following discussion I will pretend the current is constant.

The difference between a diode and the switch (independent of switch technology) is that while your switching elements (when they're closed) have a relatively constant and low resistance, a conducting diode has a relatively constant voltage drop on it. This means that the power dissipated on the switch is proportional to the square of the current:

$P_{switch} = V_{switch} * I = R_{switch} * I^2$
while the power on the diode scales linearly:

$P_{diode} = V_f * I$ (where V_f is the forward voltage drop of the diode)
From this you see that as long as the current is lower than V_f/R_{switch}, you're better off using the switches to conduct the off-time current. For most diodes V_f is in the range of 0.2 to 1V, while R_{switch} is normally way lower than 1Ω, usually lower than 100mΩ. It's also much easier to lower R_{switch} than V_f if you get into trouble with heat dissipation, not to mention that V_f usually goes somewhat higher with the current. You can find MOSFETs with an on-resistance of lower than 10mΩ without too much trouble. Even integrated H-bridges contain FETs with an on-resistance of less than 25mΩ these days. If we take that bridge for example, it's internal diode has a 0.8V forward voltage drop and a 23mΩ on-resistance (these are typical values). With those numbers you'll see that the cross-over point is at 35A, which is over the rated 30A current limit for that part. This is typical except for extremely high-current applications: you operate the bridge under the cross-over point, where it's more beneficial to use the switches to conduct the off-time current.

4.2 Control System

Using Arduino, the voltage output from heat sensor and gas sensor are controlled and then gives voltage to the motor using h-bridge to rotate in the desired way.

5. Benefits of The Project

6. References

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7. Index

H-Bridge: An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards or backwards.

Semiconductor: A semiconductor is a substance, usually a solid chemical element or compound, that can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current.

Diodes: a diode is a two-terminal electronic component that conducts primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance to the flow of current in one direction, and high (ideally infinite) resistance in the other.

Schottky diode: a solid-state diode having a metal-semiconductor junction, used in fast switching applications.

Transistors: A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit.

Battery: (Voltage sources) device consisting of one or more electrochemical cells with external connections provided to power electrical devices