High-Side & Low-Side Switching

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Low-side transistor configuration

When the transistor is connected to **ground**, that means the load is between **+V** and the **transistor.** Since the transistor is switching the path to ground or is sitting on the low side of the load, it is called a low-side switch.

Typically, these use an **NPN BJT** or an **N-Channel MOSFET**.

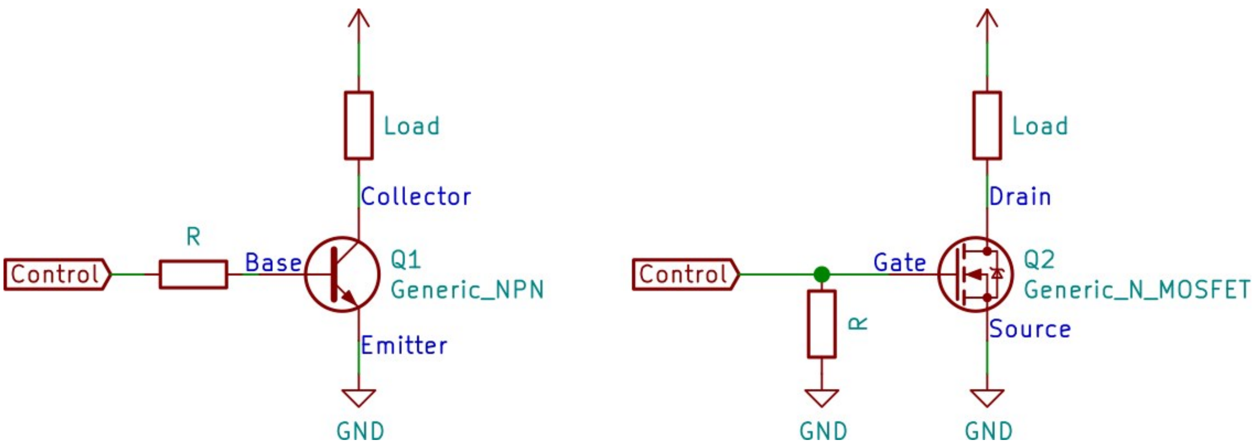

Figure 1 Low-side Transistors

For an **NPN BJT**, the emitter connects to ground, and the collector attaches to the negative side of the load. As a switch, the **BJT** operates in **saturation** mode. Saturation means there is enough base current to turn on the transistor fully.

For an **N-Channel MOSFET**, the source connects to ground, and the drain connects to the negative side of the load. While you can use a **JFET** for this circuit, an enhancement mode **MOSFET** works better

High-side transistor configuration

The opposite of the low-side switch is the high-side switch. This transistor connects between **+V** and the **load**. Because of how transistors work, these can be a little more difficult to use in an **Arduino or Raspberry Pi circuit**.

Typically, these use a **PNP BJT** or **P-Channel MOSFET**.

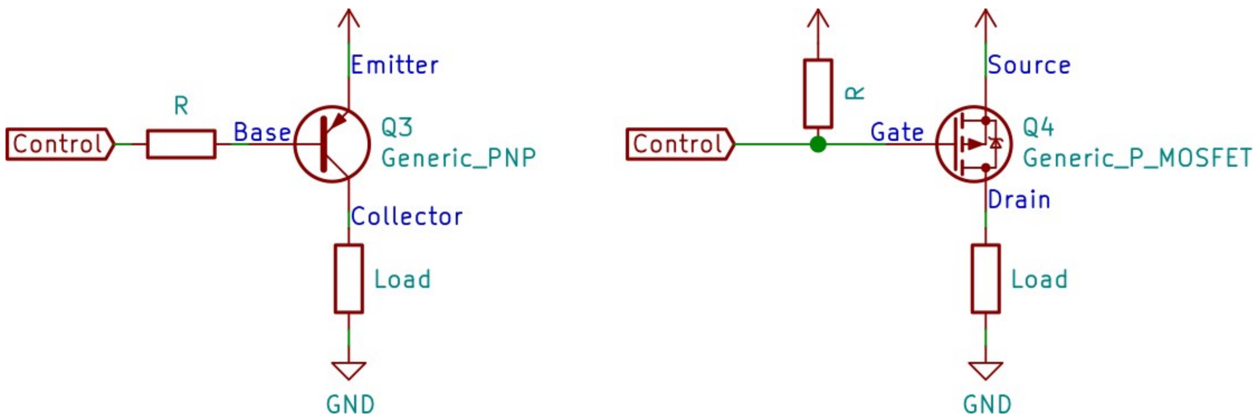

Figure 2 High-side Transistors

For a **PNP BJT**, the emitter connects to the voltage source, while the collector connects to the load's positive side. Looking at the schematic drawing for an **NPN** and **PNP**, the **PNP** might look like it is upside down. Like the **NPN**, the **PNP BJT** must operate in the saturation region to turn on the transistor fully.

When to use one over the other

Avoid dangerous situations

High-side switching is the preferred switching technique in situations where short circuits to **ground** are **likelier** to occur than short circuits to the **positive power line**. Think for instance of cars or machines where most of the structure or body is connected to ground. In such cases it is safer to disconnect the load from the battery than from ground. Also, in humid environments, this usually results in less connector corrosion as the load carries no voltage in the off state.

Power switching is better with N-type devices

Because **N-type** transistors in general can carry more current than **P-types**, they are preferable for **switching heavy loads**. Low-side switching with N-type devices **is easier** than high-side switching and can often be done by microcontroller ports without the need for special drivers. Using an

N-type transistor for high-side switching is possible but requires a control voltage higher than the load voltage connected to the source/emitter. Some sort of charge pump is needed to pull the gate/base above the source/emitter voltage

A fuse can make all the difference

Thus, low-side switching tends **to be cheaper** than high-side switching. However, when the load and its controller are not located right next to each other, two fuses **are necessary** to protect them both in such a setup; high-side switching would only need one. Saving a fuse may seem futile, but when you take into account the wiring and work required to make the fuses accessible in a fuse box, having to add a fuse may very well annihilate the cost advantage of low-side switching.

Good ground is good

Low-side switching has one ground connection for both the load and its controller, **thus avoiding ground potential differences** (ground shifts) between the two when currents are high. Low-side switching therefore is more **robust** to ground noise than high-side switching.