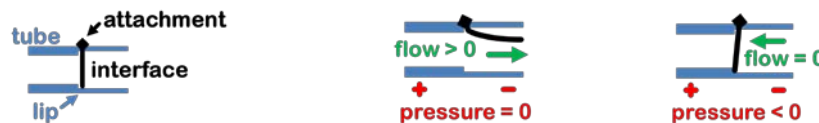


The Diode Mechanical Analog: Operation, Applications, and Non-Ideal Behavior

A good way to understand the operation of a diode and how a diode can be applied in electronic circuits is to relate the diode to its mechanical analog, the valve. As with the diode, the valve permits flow in one (positive) direction and restricts flow in the other (negative) direction. The image below on the left shows a simple 2D representation of a valve. A rigid tube has a discrete step down in diameter to provide a lip for a flexible (rubber) interface spanning the entire cross-section of the wider tube to rest. This interface is attached at single point, shown here as a diamond at the top.



Operation: When flow is oriented in the positive direction (left to right) the flexible interface will bend, opening the valve, allowing air/fluid flow with zero pressure difference between the left- and right-hand sides (center image above: $\text{flow} > 0$, $\text{pressure} = 0$). This mode is analogous to the forward biased diode ($i_D > 0$, $v_D = 0$). When pressure is oriented in the negative direction (right to left) the interface is pressed tightly against the lip and no flow is permitted from right to left (right image above: $\text{flow} = 0$, $\text{pressure} < 0$). This mode is analogous to the reverse biased diode ($v_D < 0$, $i_D = 0$).

Applications: Understanding that diodes behave similarly to mechanical valves, we can use diodes in many similar applications as valves are used; except that rather than fluid flow and pressures, diodes are used to control current flow and voltages. A few examples are provided here:

A pump (bicycle floor pump) – Mechanical valves are used in pumps to convert up-and-down motion (pressures) into a single direction of air flow. Diodes are used in a similar way to convert AC voltages into DC voltages. Diodes are a major component of cell phone chargers that produce 5V-DC from a 120 V_{rms} AC outlet.

Pressure Regulator (in a gas grill) – Mechanical valves are used in gas grills to regulate the fluctuating pressure of a propane tank to provide a constant “steady pressure” as the amount of propane in the tank decreases. This allows consistent grill temperatures for cooking. Diodes are used in a similar way to provide consistent “steady” voltages for several applications such as charging and low-noise amplifier power supplies.

Protection – Mechanical check valves are used in plumbing to only permit flow in a single direction as a form of protection to prevent backflow. Diodes are used in a similar manner to charge batteries by preventing discharge through the diode in the reverse direction.

Non-ideal Behavior: There are a number of non-ideal behaviors of valves that can be translated into actual (not ideal) diodes described here and expanded on in the Junction Diode Notes.

The valve requires a small amount of pressure to be applied before it opens and at these small pressures there is still some restriction to flow.

A small amount of air may flow in the negative direction due to leaks in the interface.

If a very large negative pressure is applied, the flexible interface will bend to a point where it will open allowing back flow.