# ENG1004 - Electronics & Sensors

# Tutorial 1 – Diode Circuits

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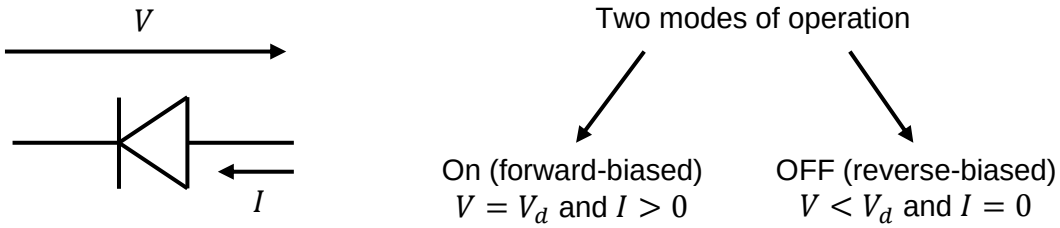
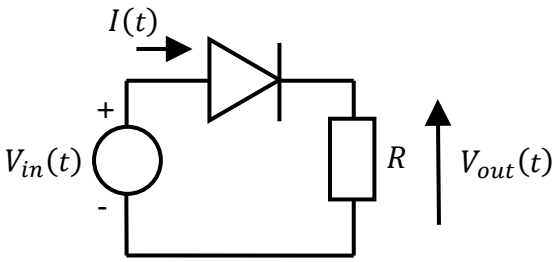



**Question 1: Half-Wave Rectifier**

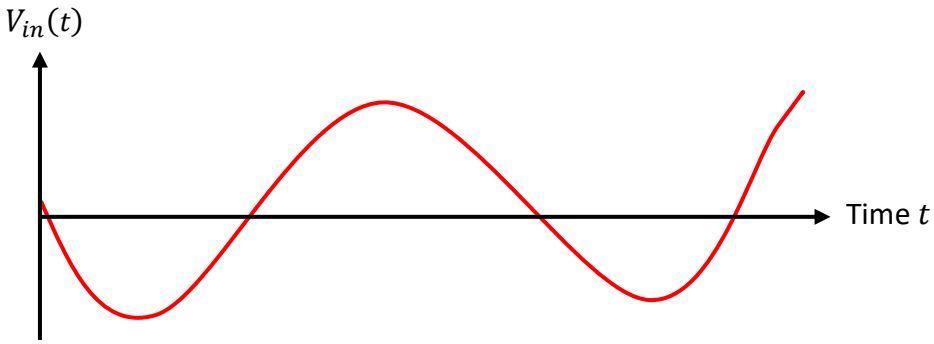
The primary function of a rectifier circuit is to change an AC input voltage into a voltage that is only positive or only negative. In essence, a rectifier eliminates the unwanted polarity of the input waveform.

Consider the circuit below called *half-wave rectifier*.



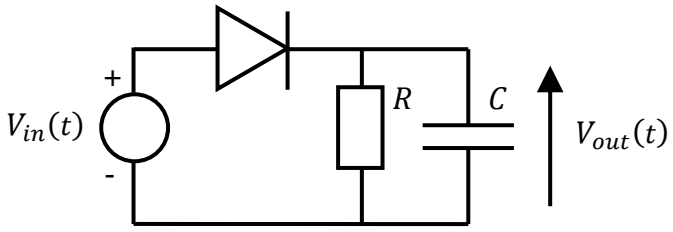

Study the operation of this circuit by using the laws of circuit theory (here, Kirchhoff's voltage law and Ohm's law) and the two-state model for a diode.

As an illustration of your analysis, sketch the output signal $V_{out}(t)$ obtained with the input signal $V_{in}(t)$ depicted below.




**Question 2: Half-Wave Rectifier with Capacitor**

We can modify the half-wave rectifier studied in Question 1 by placing a capacitor in parallel with the resistor. We thus obtain a half-wave rectifier circuit with parallel capacitor, as shown below.

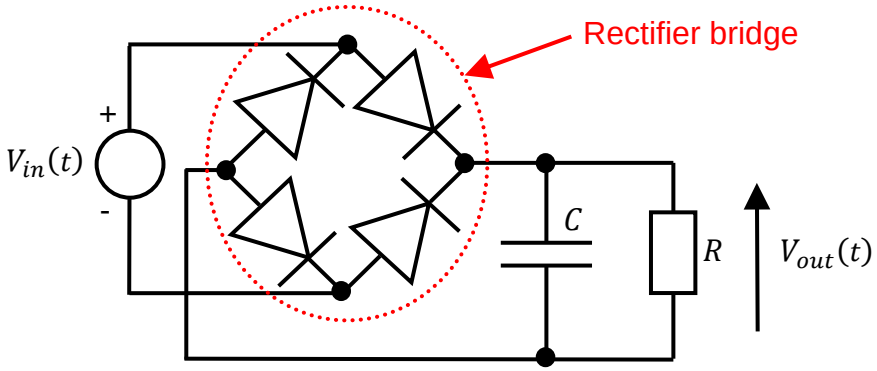



Study the operation of this circuit assuming that the input signal $V_{in}(t)$ is a sinusoidal signal.

Show that this circuit can be employed as a basic power supply circuit that accepts an AC voltage as its input and provides a DC voltage as its output.

**Question 3: Power-Supply Circuit using a Full-Wave Bridge Rectifier**

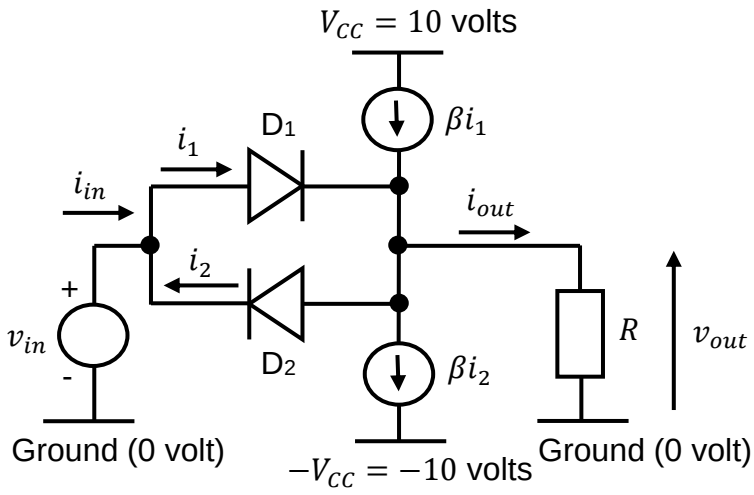
The power supply circuit considered in Question 2 can be improved by replacing the single diode with a rectifier bridge composed of four diodes, as shown below.




Study the operation of the circuit assuming that the input signal $V_{in}(t)$ is a sinusoidal signal.

**Question 4: Push-Pull Circuit**

Consider the circuit shown below. It is referred to as a push-pull circuit.




This circuit is designed using two diodes D1 and D2, each of them having a threshold voltage $V_d$, a resistance $R$, and two dependent current sources $\beta i_1$ and $\beta i_2$, where $\beta$ is a constant parameter equal to 100, and $i_1$ and $i_2$ are the currents flowing through diodes D1 and D2, respectively.

The circuit is also connected to two voltage supplies (power sources) $V_{CC} = 10$ volts and $-V_{CC} = -10$ volts.

Write the five general equations for this circuit.

Show that, by using only two of these equations, we can easily express the output current $i_{out}$ as a function of the input current $i_{in}$.

Use this result to show that the push-pull circuit is a current amplifier, i.e., an electronic circuit in which the output current $i_{out}$ is an amplified replica of the input current $i_{in}$.

Determine the expression and compute the value of the current gain, $A_i$, defined as the ratio between $i_{out}$ and $i_{in}$: $A_i = \frac{i_{out}}{i_{in}}$.

Plot the DC current transfer characteristic that shows the variation of $i_{out}$ as a function of $i_{in}$.

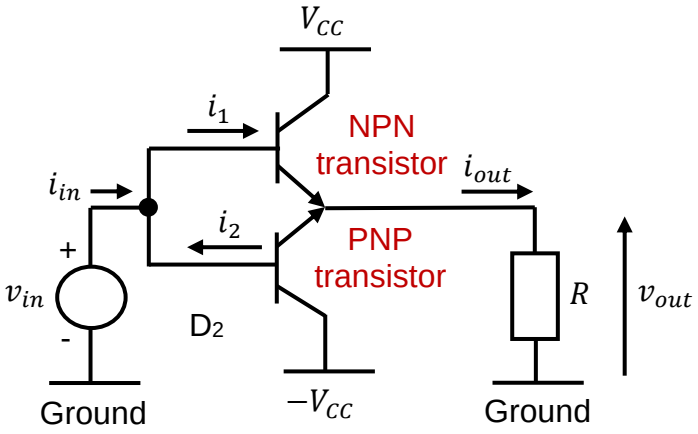
Using the five general equations as well as the two-state model for both diodes, determine the DC voltage transfer characteristic that displays the variation of the output voltage $v_{out}$ as a function of the input voltage $v_{in}$.

Show that the push-pull circuit is NOT a voltage amplifier. In other words, show that $v_{out}$ is NOT an amplified replica of $v_{in}$.

An “ideal” linear current amplifier is such that $v_{out} = v_{in}$ and $i_{out} = A_i i_{in}$, with $A_i \gg 1$. Is it the case with the push-pull circuit?

Final note: It is worth mentioning that the circuit considered throughout Question 4 is actually implemented, in practice, by using two bipolar junction transistors (BJTs), as shown below. The BJT is a semiconductor device that will be studied in the third chapter of your lecture notes.

The diode D1 and its associated dependent current source $\beta i_1$ form the equivalent model for an NPN BJT, whereas the diode D2 and its associated dependent current source $\beta i_2$ constitute an equivalent model for a PNP BJT.




Note that a BJT can be modelled using a diode and a dependent current source only if this BJT does not saturate. This condition is satisfied in this circuit.

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