Solve a Challenge: PN Diode

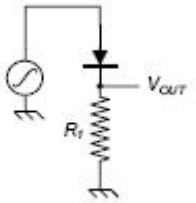
Dragica Vasileska and Gerhard Klimeck

Diodes have many applications. Here are a few of them:

A. Diode Rectifiers

Half-wave rectifier

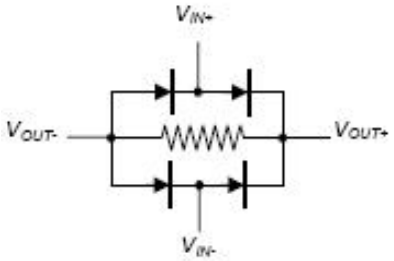
One of the most common uses for diode is to rectify AC voltage to make a DC power supply. Since a single diode can only conduct current one way, when the input wave goes negative, there will be no current. This is called a half-wave rectifier.



A half wave rectifier

Full-wave rectifier

With four diodes, you can make both halves of the waves positive. This is called a full-wave rectifier diode bridge. For both positive and negative swings of the input there is a forward path through the diode bridge. While two of the diodes are forward biased, the other two are reverse biased and effectively eliminated from the circuit. Both conduction paths cause current to flow in the same direction through the load resistor, accomplishing full-wave rectification. Full-wave recitifiers are used in power supplies to convert AC voltages to DC voltages (or at least ones which are positive). A large capacitor in parallel with the output load resistor reduces the ripple from the rectification process.



A full-wave rectifier

B. Frequency multipliers

A full-wave rectifier is also a frequency multiplier. The output of a rectified 60 Hz signal is at 120 Hz, but also has components at 240 Hz, 360 Hz, etc.

C. Frequency Mixers

A full-wave rectifier can also be used as a frequency mixer when two frequencies, $\mathbf{f_1}$ and $\mathbf{f_2}$ are input simultaneously into the full-wave rectifier: the output will include frequencies at $\mathbf{|f_1-f_2|}$ and $\mathbf{f_1+f_2}$, in addition to the harmonics of $\mathbf{2f_1}$ and $\mathbf{2f_2}$.

Design Exercises:

Design Exercise 1: Design a 12 V DC power supply out of an AC line source (120 V AC), a transformer with $N_p/N_s = 10$, some diodes, and a low pass filter (i.e. a large capacitor). Calculate the ripple voltage at the output of your supply when it has a 50 Ohm
load.

Design Exercise 2: Design a frequency doubler with an input of 10 kHz and an output of 20 kHz, which rejects the input frequency and higher harmonics (not the second harmonic!) by at least 40 dB. The output should not include a DC bias.