Universidade do Vale do Itajaí

Computer Engineering

Basic Electronics

Fifth Assignment for Basic Electronics

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Teacher Advisor: Walter Antonio Gontijo

September

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Fifth Assignment for Basic Electronics presented for the class of the Third of September, 2021.

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1 Objective

The analysis of multiple electrical circuits containing simple rectifiers.

2 Introduction

This paper has the purpose of describing multiple circuits diode rectifiers, along with simple step-up and step-down transformer examples.

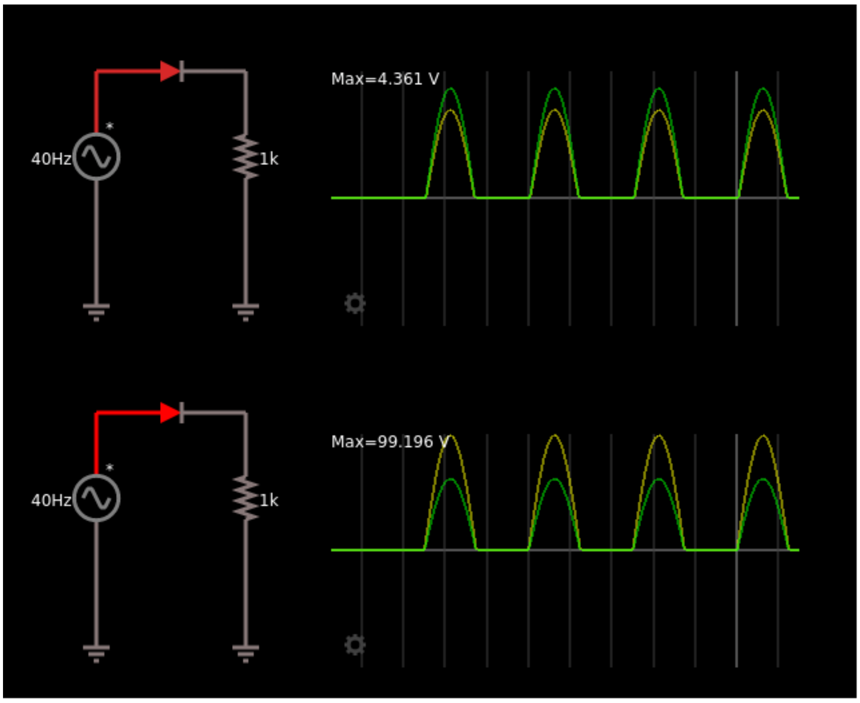
2.1 Rectifiers

Rectifiers are circuits which filter an `AC` signal into a `DC` signal, ideally with no losses. Rectifiers are usually made with one or more diodes.

3 Development

3.1 Single Diode Rectifiers

3.1.1 First Circuit



$V1_{AC_{peak}} = 5V$ —— $V2_{AC_{peak}} = 100V$
Diodes `1N4004` used.

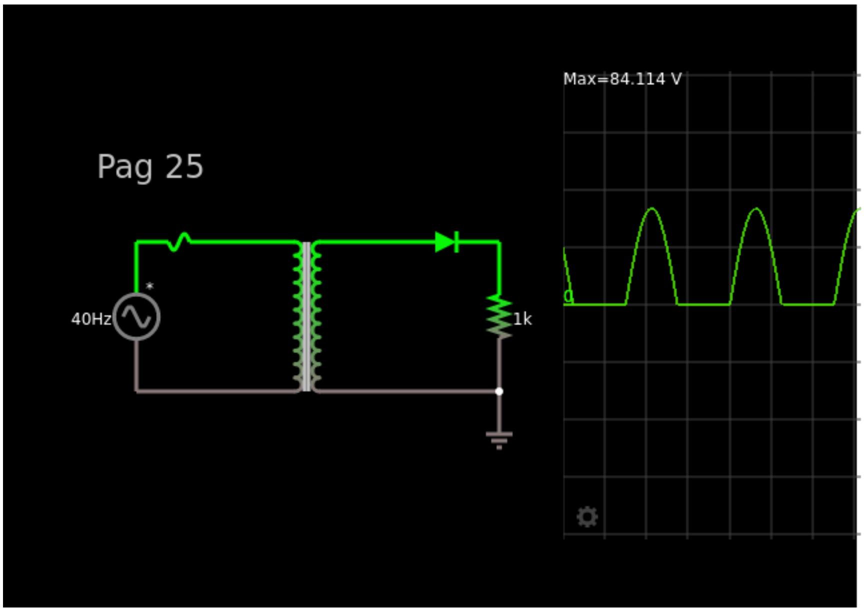
This is a rectifying circuit with on diode, it dismisses the negative cycle of the wave (Reverse voltage and current not withstanding). This type of rectifier, for it's inefficiency should not be used for power applications, it is found mostly in circuits that require a dc signal like radios and television receivers.

Though it should not be used for powering applications, it is still a `DC` source, it's average voltage is found through the following equation.

$$V_{avg} = \frac{V_{peak}}{\pi}$$

Returning an average of $V_{DC} = 1.39V$ and $V_{DC} = 31.57V$ respectively.

3.1.2 Second Circuit



$V1_{AC_{peak}} = 170V$ —— $Ratio = 1 : 0.5$
Diode `1N4004` used.
Oscilloscope division is $50V$ per division.

Normally power rectifiers are not connected directly to the power supply, but instead the voltage is lowered or amplified for the specific use. In this case the voltage is being lowered by half by the transformer and the main power supply is fused as to prevent exciting fires in a short circuit.

The peak output power by the transformers nodes are calculated as such.

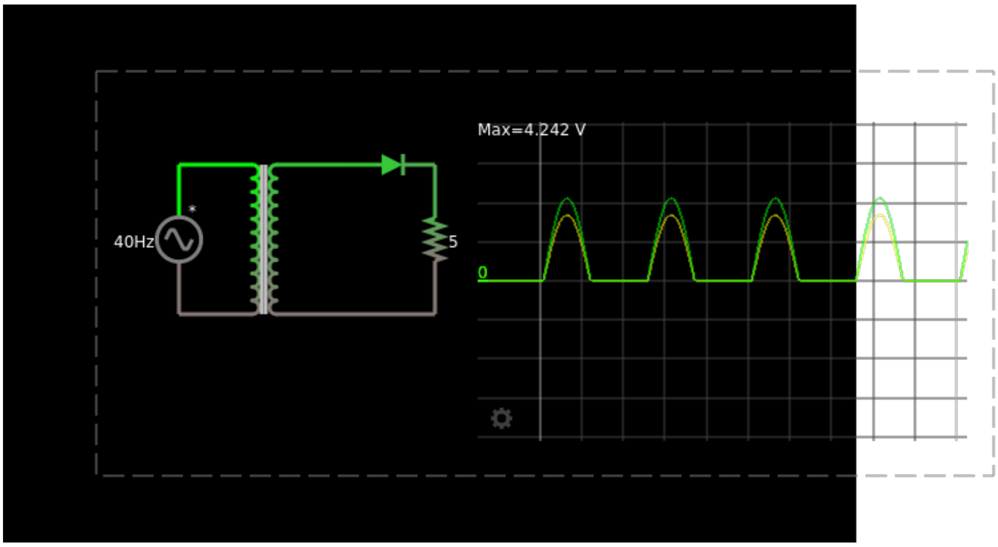
$$n = \frac{Ratio_2}{Ratio_1}, V_{peak_{out}} = V_{peak_{in}} \times n$$

In this circuit the values come to.

$$n = \frac{0.5}{1} = 0.5$$
$$V_{peak_{out}} = 170 \times 0.5 = 85V$$

The value of the peak voltage found in the simulation is slightly lower due to the forward voltage of the diode and its series resistance.

3.1.3 Third Circuit



$V1_{AC_{peak}} = 311V$ —— $Ratio = 60:1$
Diode `1N4004` used.
Oscilloscope division is $2V$ per division.

The peak voltage in the primary of the transformer is $311V$, the ratio is as follows.

$$n = \frac{1}{60} = 0.01666$$

$$V_{AC_{peak}} = 311 \times 0.01666 = 5.1626V$$

The diode has the inverse peak voltage of $5.1626V$. The average voltage past the rectifying diode is as follows.

$$V_{DC_{avg}} = \frac{5.1626}{\pi} = 1.643V$$

Using the simulated voltage from the diode the peak current on the resistor should be.

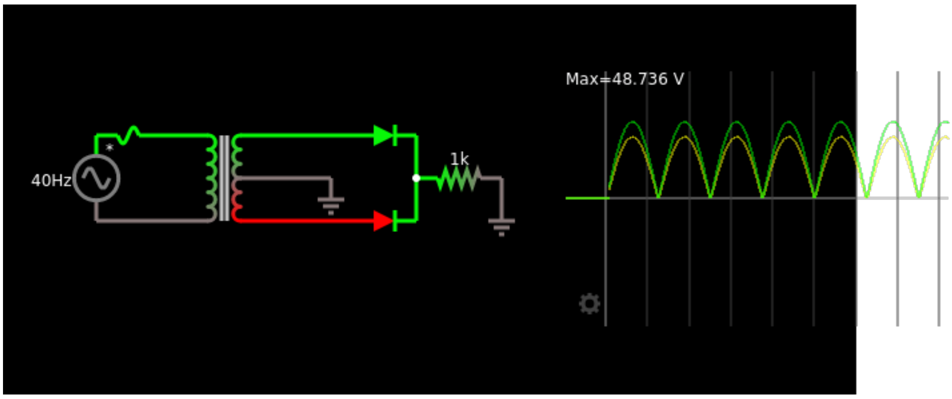
$$I_{peak} = \frac{4.242V}{5\Omega} = 0.8484A$$

And an average current of.

$$I_{avg} = \frac{1.643V}{5\Omega} = 0.3286A$$

3.2 Full Wave Rectifiers

3.2.1 First Circuit



$V1_{AC_{peak}} = 100V$ —— $Ratio = 1:1$
Diodes `1N4004` used.

This is an example of a full wave rectifier circuit with a tapped transformer. Because of the center tap reference the peak voltage is now the normal peak voltage divided by two minus the diode series resistance and forward voltage.

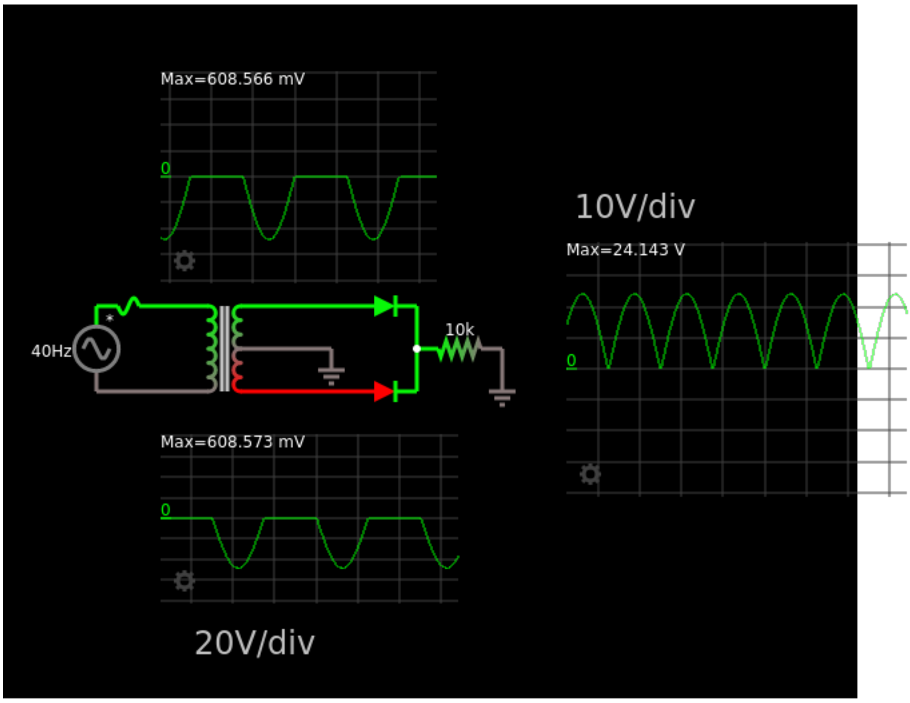
All previous calculations for averages get multiplied by two, as now both the positive and negative cycles of the wave are used.

If, for example, one of these diodes breaks due to a short or too high reverse peak voltage, the circuit will only rectify the part of the wave the working diode is meant to handle, in essence, it will turn into a single diode rectifier with half the peak voltage.

If one of the diodes is inverted the current will flow through both causing a short.

If both are inverted the diodes will not allow any current through, only the minimal reverse current if non ideal.

3.2.2 Second Circuit



$V1_{AC_{peak}} = 100V$ —— $Ratio = 2:1$
Diodes `1N4004` used.

The peak voltage is as follows.

$$n = \frac{1}{2} = 0.5$$
$$V_{AC_{peak}} = 100 \times 0.5 = 50V$$
$$V_{AC_{peak_{nodes}}} = \frac{50}{2} = 25V$$

Since the transformer is tapped, the final peak voltage is divided by the number of outputs, in this case only two.

The reverse voltage the diodes must handle will be the peak minus the forward voltage and linear series resistance, though the following equation will use a simplified model.

$$V_{inv} = 50V - 0.7V = 49.3V$$

The simulator calculated a similar result, but with the series resistance accounted for.

The `DC`, or the average of the output is as follows.

$$V_{DC_{avg}} = \frac{2 \times 24.3}{\pi} = 15.46V$$

4 Conclusion

In this paper was discussed, demonstrated and simulated rectifying circuits, their characteristics and limitations.

It was also introduced a new component, the tapped transformer, though these components are not used as often, and these rectifiers are not as common as full wave four diode rectifiers.