The application of multiple parallel diodes to control large currents

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Abstract. This paper discusses a few issues concerning diodes and their application in electric circuits. Considering voltage and current restrictions, experimental and theoretical efforts are made to safely apply semiconducting diodes in circuits working with large current regimes. Combinations of diodes and protecting resistors connected in series and parallel have demonstrated to be of great help with the task of controlling electric currents. To this aim, several activities have enabled participants to observe and measure, or to calculate and display valuable data. Therefore, important class conclusions are stated.

Keywords: diode, resistor, series, parallel, current

Introduction

Semiconductor diodes are among the most common components of electrical and electronic circuits. Their use is multiplying, for directing variable currents, generating multiple signals, redirecting two – way signals, or more [1]. The study of diodes' behavior in physics laboratories focuses mainly on simple schemes, with one to two components. The possible combinations are: 1) diode and resistor, 2) diode and capacitor, 3) diode and coil, 4) diode and transistor. Like many cirquit compoments, diodes also show restrictions on voltage and current with respective working regimes [2]. For this reason, the goal is to increase the efficiency of diodes and implement them in cirquits of one – direction electric current. It is known that for high voltages, over 6V, diodes' reliability falls greatly and the unilaterality of currents cannot be realized. Our concrete work is based on schemes with combinations of some diodes and resistors, to cope with alternating voltage and proper current regimes. At laboratory schemes, diodes and resistors are visible and easily used by participants. After all, these schemes are used to build stamped diodes, diodes – chips, or diodes – processors.

Theory

The first schema used, presented in figure 1, serves to demonstrate violation of diodes unilaterality under low or high voltage.
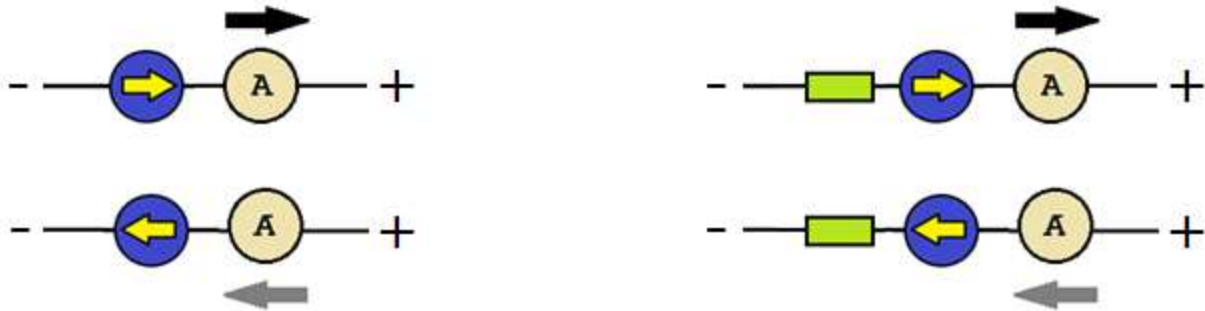
Figure 1

At a working regime of alternating voltage up to 6V, diode's unilaterality in the circuit is realized at the ratio of If = K Ir; K > 1. That is called asymmetric conductance.

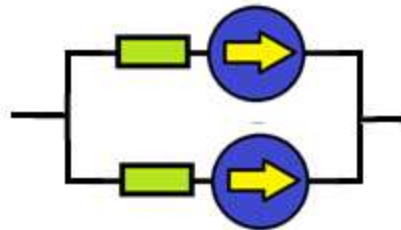(Forward Current = K Reverse Current; K > 1)

Figure 2

At 6V, the straight forward current reaches its maximum value, but diode's lifetime decreases significantly. To maintain a long working lifetime, shunt resistor applies to weak and low – priced diode, figure 1. As current drops at lower values, double diodes should be applied in parallel, figure 2.

Normally, a diode under alternating voltage U = 6 V conducts a straight forward pulsing current If = 600 mA. For safety reasons, the diode is secured by one protecting resistor R = 100 Ohm, figures 1. Therefore, the pulsing current is about If = 60 mA, and safe to both diode and resistor!

To increase the county current to the required values, protected diodes are combined in parallel. Figure 2 introduces an initial scheme with two parallel protected diodes. It is obvious that in this case, currents in the circuit are twice as large, since the Ohmic resistance is twice as small.

With the increase in the parallel number of diodes specifically protected, and also shunted, the branch currents decrease, while district current remains the same, figure 3.
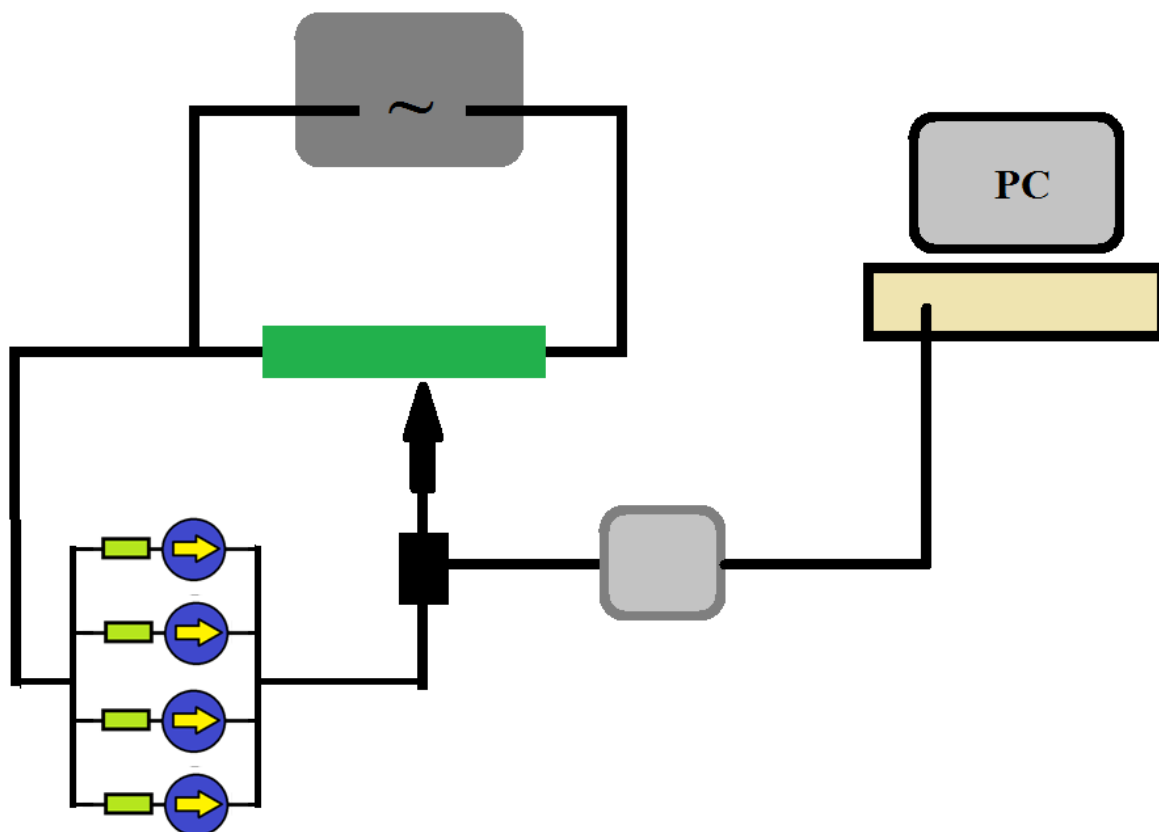
Figure 3

With the increase in the parallel number of protected diodes, the current spreads through branch diodes and values are calculated according to several physicals, as Ohm's laws and Kirchhoff's laws [3].

Actually, these values belong to the past, for nowdays, diodes come of larger currents. Therefore, of shorter lifetimes.

Method and materials

Alternating electric source, diodes and resistors are used to build and study the circuit. Vernier's Logger Pro, current sensor, voltage sensor, interface and computer program are used to observe and measure physical qualities and quantities [4].

Diodes unilaterality is tested by the computer – interface - sensor system and diodes' data are shown in table 1, voltage, currents and asymmetric conductance.

Table 1: Diodes' Volt – Ampere Data

U (V)	If (mA)	Ir (mA)
2	750	0
4	1700	0
6	2500	0

Protector shunt resitors are of R = 100 Ohm.

Diodes are first connected in series with each resistor, as illustrated in figure 1, or 2. Later they are placed in circuit, added one by one in parallel, creating a component of multiple diodes protected in parallel, figure 3.

Three main circuits are used of different voltages: 2V, 4V and 6V.

Current values display continously on the screen, table and graph, figure 4.

Figure 4

These values are used in Excel to build the sum up table 2 and graphs If = f(N) [5].

Table 2: Diodes' Volt – Ampere Data versus the Number of Parallel Diodes

N Protected Diodes	If (mA) (U = 2V)	If (mA) (U = 4V)	If (mA) (U = 6V)
1	20	47	70
2	35	80	143
3	53	120	182
4	60	140	250

From table 2, it can be easily deduced that a good deal of parallel protected diodes are needed to reach the top current of If = 2500 mA.

Implementing generative experimentality, students were invited to figure out the result data in the case of diodes paired with good resistors of R = 10 Ohm, table 3 [6].

Table 3. Calculated Diodes' Volt – Ampere Data versus Parallel Diodes

N Protected Diodes	If (mA) (U = 2V)	If (mA) (U = 4V)	If (mA) (U = 6V)
1	200	470	700
2	350	800	1430
3	530	1200	1820
4	600	1400	2500

Attending students were asked to point out the number of protected diodes connected in parallel in order to conduct the total current of If = 2500 mA. Observing circuits at current risk, they also realized that parallel diode – resistor branches work the better.

Conclusions

Diodes are important components of electric and electronic circuits. Along with other components, they influence the behaviour of these circuits. Diodes are fragile consumers and their malfunctioning may put at risk not only their own conducting branch, but also the entire circuit. Therefore, careful attention should be payed to their applications. The strategy of using resistor protected diodes connected in parallel is an efficient approach to build a good working circuit.

In extremis, power supply diodes used to control large currents need to apply at least a double scheme of parallel diodes in order to ever lasting [7]. There are some good examples from the internet concerning circuits and diodes connected in series and parallel. Although, we carefully insisted on working with the design of figure 2 or figure 3. Thence, a few steps can be listed to build a component of multiple diodes.

1. Measure diodes data, voltages, currents and unilateralities.
2. Get the extremety data, maximum voltage, top current and unilaterality.

3. Get a good protecting resistor and connect it to a single diode in series (Current drops).
4. Connect protected diodes in parallel and add several until reaching the top current of a single unprotected diode (Current increases).
5. Try adding other protected diodes and check out atop the total current. Careful!
6. *Keep the circuit running and check out resistor – protected diodes temperature.*

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