Nonlinear Resistance Circuit Subsection Linearity Decomposition Fitting Analysis

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Abstract: The analysis of circuits is frequently required in the electricity of physics. When analyzing circuits, the general idea is to study the issues related to nonlinear resistance circuits based on commonly used physical and electrical theory. Generally, circuits can be divided into linear resistance circuits and nonlinear resistance circuits. However, for some nonlinear resistance circuit, a small part of them are decomposed through subsection linearity while most of them are adopted the form of hieroglyph combination for subsection decomposition fitting analysis. For the following contents, the author will adopt curve layout method to analyze nonlinear resistance element and relation characteristics of voltage and current; to state the characteristics and nature of common electronic elements in our life, and concepts of concave resistance and convex resistance; to analyze the characteristics of nonlinear resistance circuits through electrical circuit analysis method based on the electrical theorem of physics; finally, to analyze referring to actual cases, study the veracity, verify the feasibility and scientificity of the adopted analytical approach, apply image graphics of the resistance circuits in the convenient way to solve complicated design problems among actual electrical problems.

Keywords: Nonlinear; Resistance; Circuit; Subsection linearity; Decomposition analysis

Subject Project: Numerical Simulation Study of Dynamic Evolution Process of Nonlinear Resistance Wall Model

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In the analysis of linear resistance circuits, based on Ohm's law I=U/R, in the case of unchanged resistance and certain capacitance, the change of voltage incurs that of current: the increase and decrease of voltage are corresponding to the increase and decrease of current respectively. However, nonlinear resistance circuit doesn't obey Ohm's law. For the nonlinear resistance circuit, some characteristics of some resistance are defined. Moreover, due to the nonlinear nature of electronic elements, instead of regular change, the resistance value will change following the change of current or voltage by uncertain time and amount. Thus, common linear resistance is in line with R=U/I, which means the change of resistance in the circuit is regular, and the effect in the planar effect picture is a straight line passing the original point. However, nonlinear resistance is unfit for nonlinear resistance. The resistance value of nonlinear resistance circuits will change irregularly according to the change of voltage or current, resulting in a curve showed in the planar effect picture. And the curve satisfies certain functional equation (namely, nonlinear functional relationship) under certain conditions. The whole circuit of nonlinear resistance circuit has special attributes, thus, the study of the characteristics of current and voltage of nonlinear resistance elements is much valuable.

1. Relational Characteristic of Nonlinear Resistance Elements and Current and Voltage

1.1 Relational Characteristic and Nature of Electronic Elements Commonly Used In Circuit and Voltage and Current

For the commonly used voltage-current characteristics and nature of electronic elements in the circuit, taking the electronic element with interfaces on both ends as an example, the voltage and current can be connected through both sides of the electronic element and then generate directional regular relationship (ignoring internal structure and function of electronic element), which can be divided into two types: straight line-image functional relationship and curve line-image functional relationship. The electronic element with straight line-image is the linear electronic element and the electronic element with curve line-image is the nonlinear electronic element. This shows that all electronic elements having interfaces on both ends and access to circuits have a certain relationship with current and voltage on both ends, and the relationship can be shown in the functional relation decomposition diagram (see Figure 1).

But, in electrophysics, the characteristics of nonlinear electronic elements can't be descirbed by the classic Ohm's law, because the relationship between it and voltage and current is shown as a curve.

The electronic elements with interfaces on both ends are seen frequently in our life, for example, voltage source, illuminated diode, filament lamp, voltage current source, etc. However, among nonlinear electronic elements, there are also special electronic elements, such as filament lamp. As a kind of nonlinear electronic element, filament lamp has unique characteristics. The functional relation between filament lamp and voltage and current is a function curve, which is symmetry at the original point, and the changing direction of the curve is bidirectional. We can also find in our life that when shining or working, the filament in the filament lamp is under high-temperature status. At the same time, the filament in the element has a very big resistance value, and the increased resistance will cause the increase of radiation of the filament and the following increase of the temperature of the filament. Furthermore, following the increasing working time of filament lamp, the temperature and resistance value of the filament will increase through interaction.

As the semi-conductor and nonlinear electronic element, the common light-emitting diode also has its particularity, which means that the diodes with different texture have different voltage value, for example, the voltage value on both ends of the diode of metallic materials is generally 0.2-0.3 V while that of nonmetallic materials is 0.5-0.7 V. Moreover, semi-conductor diode also has another feature, which means that as the nonlinear electronic element, its functional image is asymmetrical at the original point, but the changing direction of its curve is bidirectional, namely forward and reverse. For the reverse section, the change of current is very small, and the increasing range of current and its change are also very small, and even negligible. But it shows a rapid increase tendency, and the voltage value varies greatly from 0 volt to dozens of volts; for the forward section, it is greatly different from the reverse section, which means that the change of voltage is slight and the current on both ends of the diode will change a lot in a short time due to positive-going pressure drop, and the change is shown as rapid increase of current value and sharp rise of the current change curve (see Figure 2).

This shows that the curve of the functional relation feature and nature of semi-conductor diode and voltage and current is asymmetrical at the original point, but it is a vector with forward and reverse directions.

Voltage-regulator diode is also a kind of special bidirectional nonlinear electronic element, with positive characteristics similar to the semi-conductor diode, which means that the change of voltage of the forward section is slight and the current on both ends of the diode will change a lot in a short time due to positive-going pressure drop, and the change is shown as rapid increase of current value and sharp rise of the current change curve. But the reverse characteristic is special. When the reverse voltage starts to increase, reverse current is almost zero. But when the reverse change is large and the voltage on the both ends of the voltage-regulator diode increases to a fixed value, the current on the both ends will suddenly increase, but the voltage will not change. Through the analysis of individual electronic elements including filament lamp, semi-conductor diode and voltage-regulator diode, we can find that nonlinear electronic elements have many different attribute characteristics, and they can be connected according to the resistance circuit diagram. There are many connection methods for nonlinear resistance circuit, including series connection and parallel connection. And different connection methods will lead to different functional relation between electronic element and voltage and current, and different curve characteristics, arising nonlinear curve with different amplitude, endpoint value and curve direction. Thus, based on the special natures of

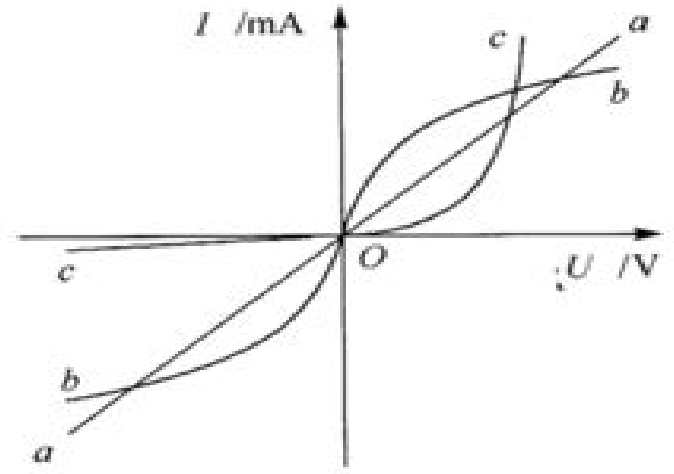

Figure 1. The voltage-current characteristics of nonlinear resistance element

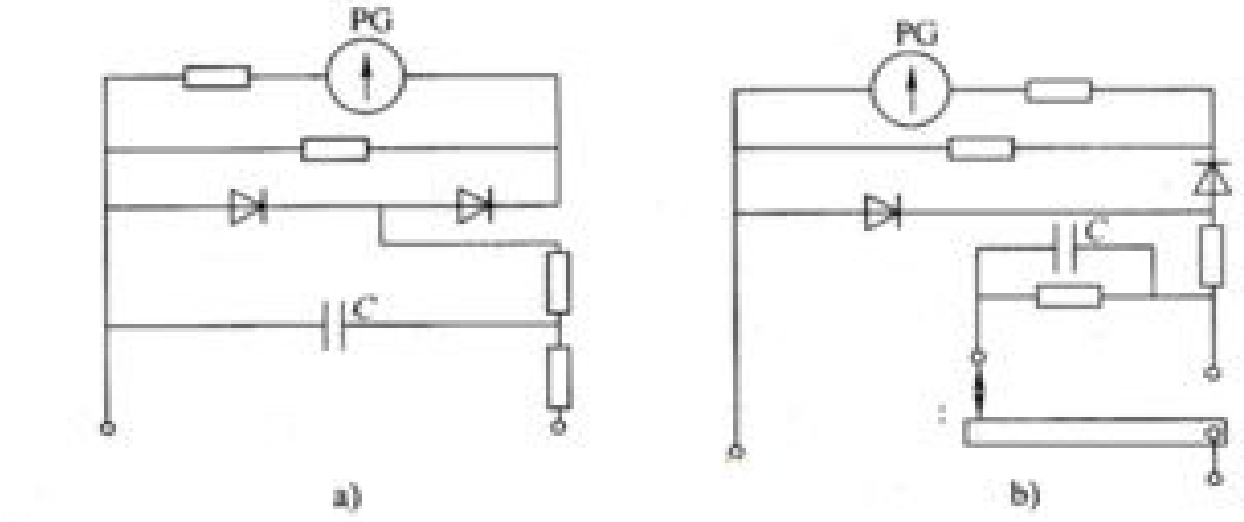

Figure 2. Diode nonlinear circuit diagram

nonlinear electronic elements, we need to use sectional linear methods to analyze nonlinear resistance circuits.

1.2 Concave Resistance

Concave resistance means that connecting two or more electronic elements in series, the total voltage value of the both ends interfaces is equal to the circuit voltage in the circuit voltage functional relation diagram.

Based on the concept of concave resistance, we know the voltage is an important factor influencing the concave resistance. In the circuit diagram, power supply voltage and circuit voltage exist simultaneously. In different circuits or power supply circuit diagrams, the concave resistance will be different. Thus, the concave resistance is closely related to the power supply voltage and circuit voltage, and there is a quantitative parameter relationship between them.

1.3 Convex Resistance

Different form concave resistance, convex resistance means that connecting 2 or more electronic elements in

parallel, the total current of the both ends current of every electronic element is equal to the total current in the circuit.

2. Nonlinear Resistance Decomposition and Coordination of Subsection Linearity

2.1 Show the Voltage-Current Characteristic Curve of Nonlinear Resistance by the Subsection Linearity Method

In general nonlinear resistance circuit of subsection linearity, different unidirectional monotonic functions can be fitted to different functional relations and functional relation curve graphs based on their voltage-current characteristics. Based on the concepts and attribute characteristics of concave resistance and convex resistance, according to the series connection or parallel connection decomposition method, to conduct subsection linearity analysis and coordination, and finally obtain the required nonlinear resistance or resistance circuit diagram.

2.2 Series Connection Decomposition and Coordination Method

In the voltage and current relation diagram, the series connection decomposition and coordination method shows that in a certain circuit current condition, the total voltage on the both ends of each electronic element is equal to the total voltage in the circuit, namely, the power supply voltage, which can be expressed as a functional relation: $U = U_1+U_2+U_3+...U_n$. Subsection linearity method means that decomposing the whole voltage and current functional relation curve of the nonlinear resistance circuit into small different sections, which shall be connected in series.

2.3 Parallel Connection Decomposition and Coordination Method

In the voltage and current relation diagram, parallel connection decomposition and coordination method shows that in the case of certain voltage, the total current of the both ends current of every electronic element is equal to the total current in the circuit, namely, $I = I_1+I_2+I_3+...I_n$. This subsection linearity method means that decomposing the whole voltage and current functional relation curve graph of the nonlinear resistance circuit into several small sections, which shall be connected in parallel.

In our life, many nonlinear resistance circuits adopt the method of combining series connection and parallel connection in the physical application, thus, the curve of the functional relation between them and their voltages and currents will be analyzed and fitted relying on series connection and parallel connection coordination method. Generally, in a complex circuit diagram, the series connection decomposition and coordination method shall be used in the beginning, decomposing the circuit diagram into several small sub-diagrams and fitting them according to circuit characteristics. Similarly, then to decompose the complex circuit diagram by parallel connection decomposition and coordination method, analyze attribute of each electronic element, and finally connect them.

3. Circuit Case-Decomposition and Fitting

3.1 Test Preparation

First, to prepare the voltage current source, diode, voltage-regulator tube, schedule and linear resistor; then, to conduct circuit series connection decomposition of the series connection circuit diagram b; through the analysis of the circuit diagram, we can know the voltage and current functional relation is the series connection of 2 convex resistances, in other words, in two circuit diagrams, diode and resistance are in parallel connection, meanwhile, power supply and diode are in parallel connection. Finally, two circuit diagrams are in series connection, as shown in Figure 3 and Figure 4.

3.2 The Experimental Process Analysis

Voltage-current characteristic curve designed according to experiment principle, as shown in Figure 5 and Figure 6.

Through the analysis of the experimental circuit diagram in the experiment, the obtained voltage-current characteristic curve is the curve graph of the functional relation between resistance and current and voltage. Within the measurement allowed error range, it is found that subsection linearity decomposition method can be used for nonlinear resistance circuit, and the result of the experiment is basically the same as theory.

4. Conclusion

According to the above analysis and experimental investigation, we know that the types of nonlinear resistance circuits are various and abundant, and are very convenient to be used. Actually, many nonlinear problems in electricity also exist in our life, which requires the decomposition and fitting. This is also a benefit of nonlinear event, compared with linear event, namely, one method for various complex difficulties. Currently, nonlinear resistance circuits can be applied in many aspects of life, thus the study of the resolutions has time value and significance.

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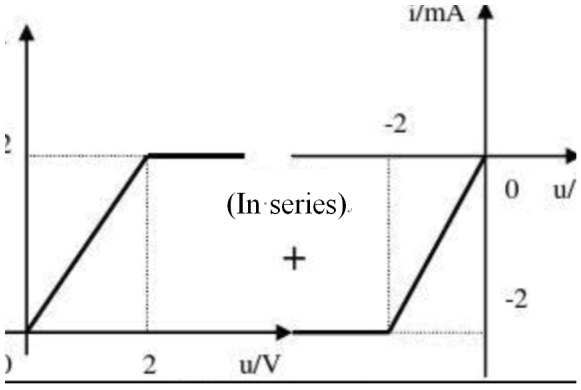

Figure 3. 2 Convex resistance series connection functional relation diagram of b

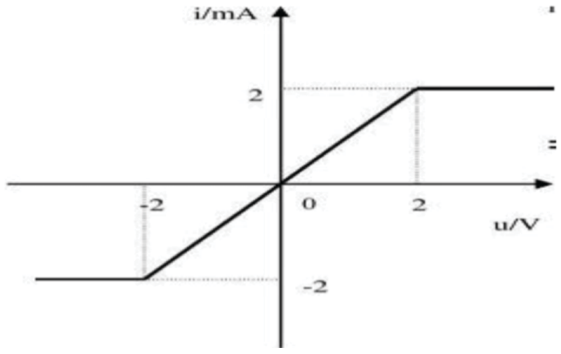

Figure 4. Circuit functional relation diagram of original b

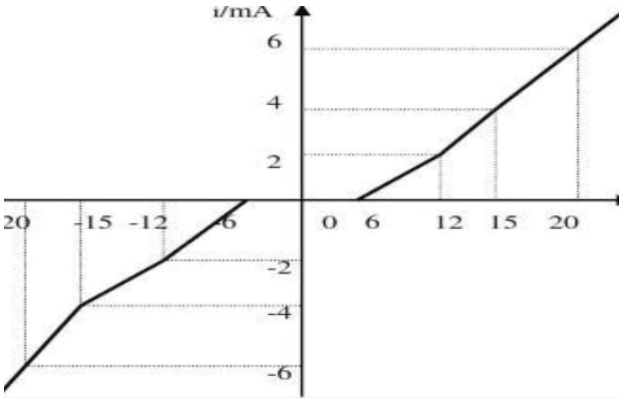

Figure 5. b Circuit voltage-current characteristics analysis diagram

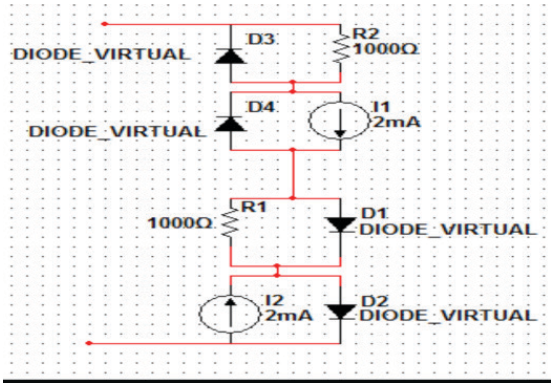

Figure 6. Circuit b connection diagram

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