Impact Analysis of Electrical Current Characteristics in Relay Function for Electrical & Electronic Protection

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This paper is to study effect of electrical current on relay reaction, which has coil and switch inside the relay. An analysis on the electrical current will be conducted to determine current limitation for relay activation purpose. The result of analysis showing that current characteristic of relay and applied load will present their affect to the relay function performance. Finding from this result will bring the idea to develop a suitable design circuit for electrical and electronic protection.

Katakunci/keyword : coil, applied load

Introduction

Electrical current in a conductor is proportional to the voltage applied to it provided the temperature remains the same. At the same resistance, doubling the potential difference doubles the current in the circuit. Graph below showing the relationship between current and voltage.

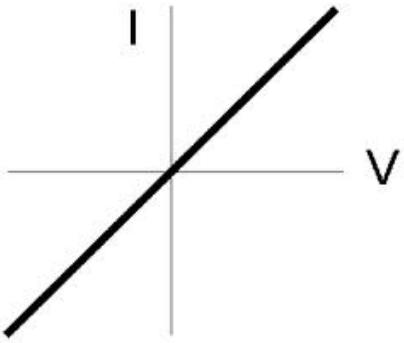

Figure (a): Relationship Current, I and Voltage, V

Since a relay is an electromagnetic device, the electrical current flowing through the coil in the relay as shown in Figure (b) affects relay operation mechanical action of a switch that open and closes the electric circuit in the relay.

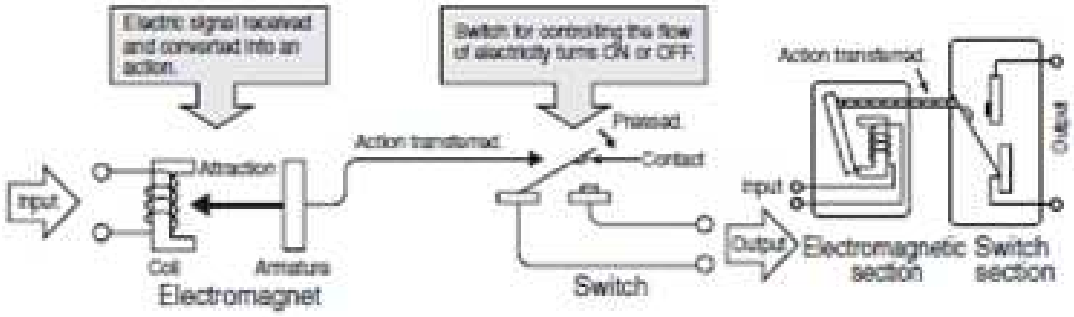

Figure (b): Structure Action of Relay[1]

Problem Statement

This study is carrying out due to limitation of a relay itself to regulate amount of current flowing through a relay coil and activate the relay.

Methodology

The following design diagram from Figure (a1) to (a4) is used to measure current. For Figure (a1) of Basic Circuit diagram, current is measured to identify it's characteristics on pure fix resistance value. While the rest three Figure of (a2), (a3) and (a4), the current are measured to identify its characteristics based on relay's natural properties and the external pure resistance factor that may influence its natural properties.

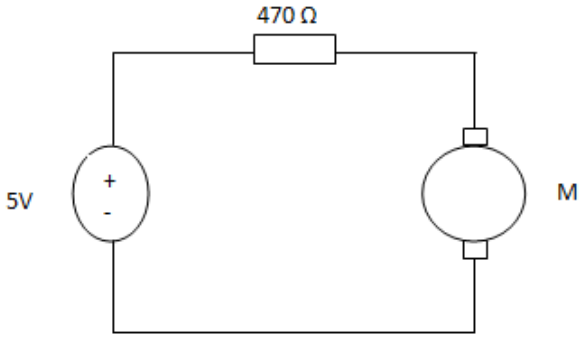

Figure (a1): Basic Circuit

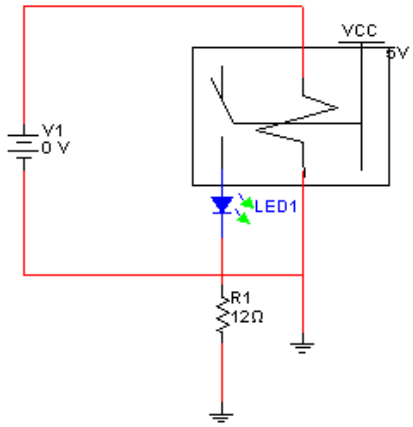

Figure (a2): Relay Only

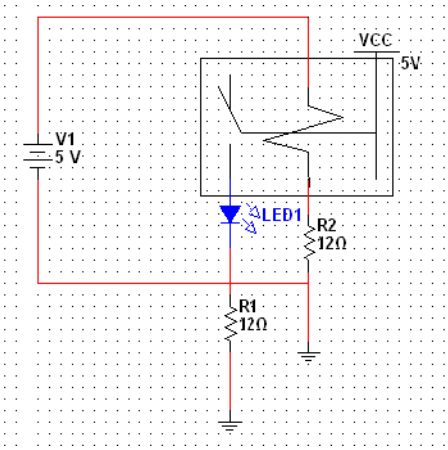

Figure (a3): Relay with Series Load

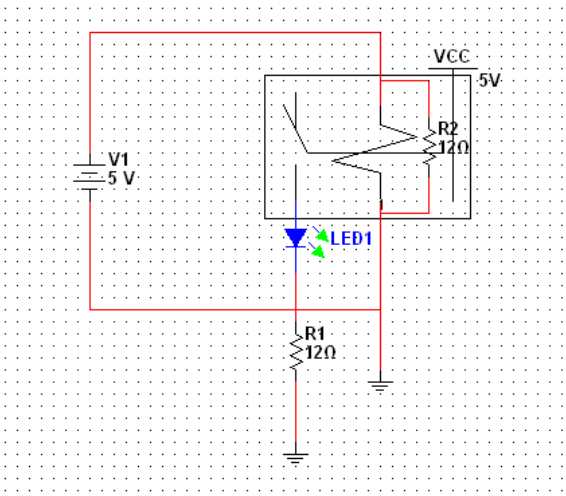

Figure (a4): Relay with Parallel Load

Result & Discussion

Results showing parameters output of current and voltage depend on variable parameter input of voltage and resistance. The results present according to two types data application. They are Basic Circuit Application presenting in Table 1(a) and Relay-Basic Circuit Comparison presenting in Table 1(a). This data from Basic Circuit Application is used to show basic relationship among prospective current, I and voltage input, V. While data from Relay-Basic Circuit Comparison is to compare different circuit application among relay parallel to series to basic circuit. All these data are generated based on experiments conducted onto respective diagram of Figure (a1), (a2), (a3) and (a4).

a. Basic Circuit Application

Table 1(a): Output Parameter with Variable Voltage Input of Basic Circuit

Vs	I (A)
1 V	0.002
2 V	0.004
3 V	0.006
4 V	0.008
5 V	0.01

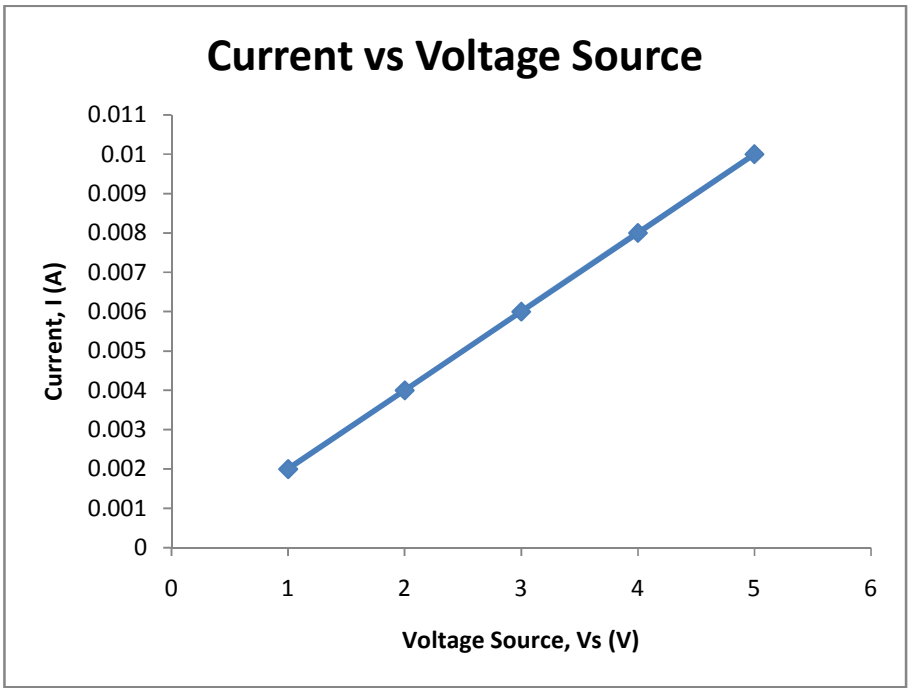

Figure 1(a): Current-Voltage Relationship of Basic Circuit

Based on Figure (a1), diagram of Basic Circuit, data from Table 1(a) produces Current-Voltage Relationship as shown in Figure 1(a). It shows that current, I (A) is directly proportional to voltage source, V (V). In this case, as double voltage value is increased, the double current values also linearly increase consistently. Increasing ratio is same between of them.

This is happening when variable voltage source from 1V to 5V and fixed resistance of 470Ω was applied onto the Basic Circuit diagram in Figure (a1).

b. Relay to Basic Circuit Comparison

Table 2(a): Output Parameter with Variable Voltage of All Circuit

Vinput	Relay Only		Relay With Applied Load				Current of Basic Circuit, I (A)
			Parallel		Series		
	Current, I (A)	Output	Current, I (A)	Output	Current, I (A)	Output	
1 V	0.009	Passive	0.079	Passive	0.006	Passive	0.002
2 V	0.016	Passive	0.162	Passive	0.014	Passive	0.004
3 V	0.023	Active	0.256	Passive	0.021	Passive	0.006
4 V	0.03	Active	0.335	Active	0.028	Active	0.008
5 V	0.03	Active	0.416	Active	0.035	Active	0.01

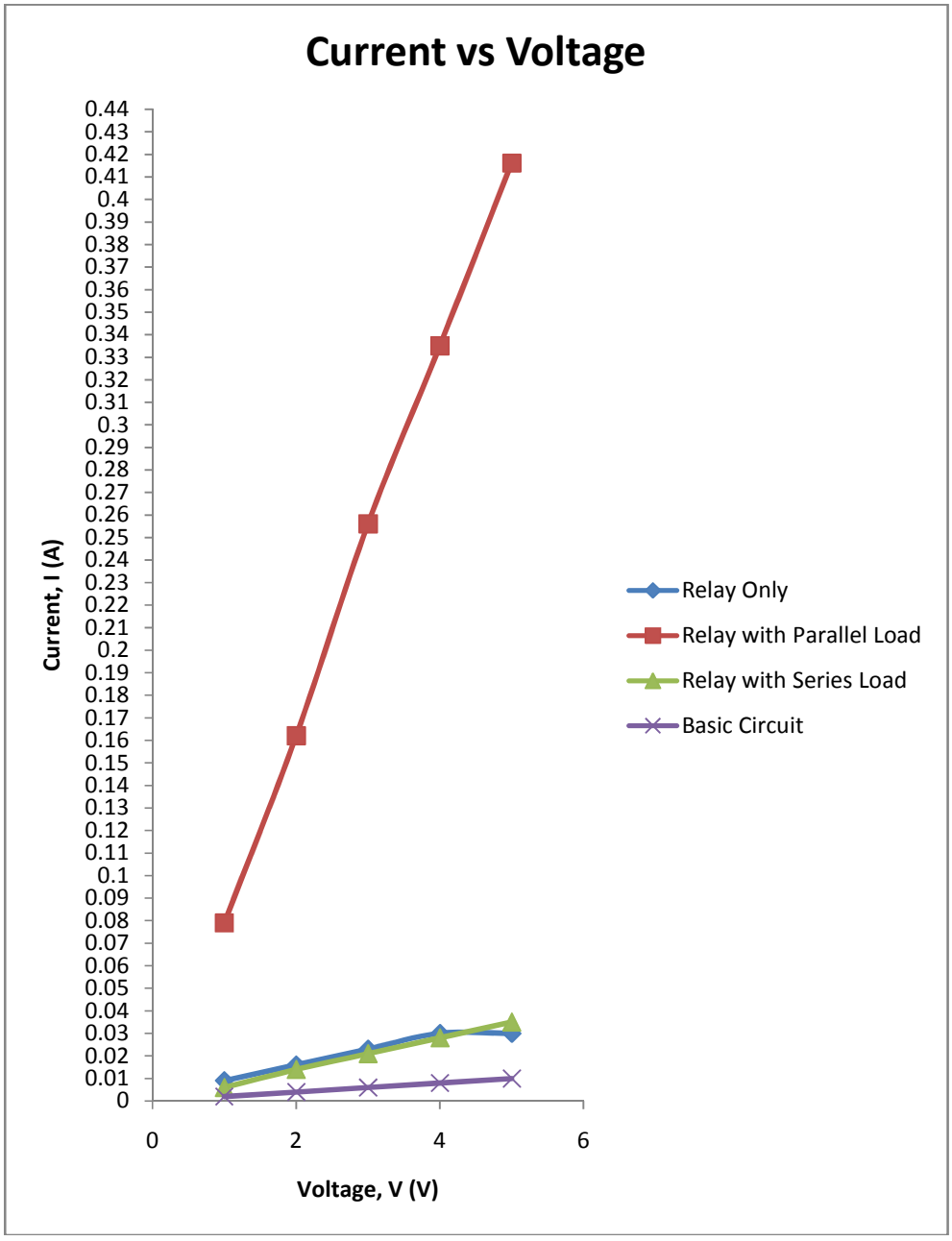

Figure 2(a): Current-Voltage Relationship of All Cicruit

Figure 2(a) shows current characteristics based on respective cases of Relay Only, Relay with Parallel Load, Relay with Series Load and Basic Circuit.

Based on diagram as shown in Figure (a2), (a3) and (a4), the first finding showing that increasing current coil of relay for all the third relay cases are not consistently proportional in linear with voltage input like in Basic Circuit in Figure (a1). This is caused resistance value of relay coil in the relay change as changing the value

of voltage input. This changing the resistance value is identified according the following equation, Ohm's Rule:

$$Resistance, R\ (\Omega) = \frac{Voltage, V(V)}{Current, I(A)}$$

As refers to the finding in Figure 2(a), current coil for case "Relay with Parallel Load" based on diagram in Figure (a4), as increasing the voltage input, result that current coil amount getting to increase higher among the other two of relay cases of "Relay Only" and "Relay with Series Load" based on diagram in Figure (a2) and (a3) respectively. This is happening because the more parallel connection between resistors to relay coil, the less resistance value belongs to the coil. According to the Ohm's Rule, resistance, R is inversely proportional to the current, I. That is why, as less resistance of the coil, the more amount of current is flowing through the coil. This show, the relay only can be activated at current amount as high as starting from 0.335A rather than the other two cases just can be activated as low as 0.023 and 0.028 for "Relay Only" and "Relay with Series Load" respectively.

For case "Relay with Series Load", result minor increasing on current coil amount that flowing through the relay because series connection the coil to the pure resistive load increase resistive value the whole wiring directly connected to the coil. High resistance value of a circuit reduce amount of current flowing through the circuit.

For case "Relay Only", current amount tend to be fix started from applied voltage of 4V at 0.03A. This shows that the "Relay Only", cannot regulating by itself of how much amount of current flowing through the relay coil by regulating the voltage input starting from 4V.

Conclusion

Basic relay function can be improved by connecting relay coil with regulated pure resistive load either in parallel or series or both of them. Series connection is favourable for Variable Applied Voltage Input supplying onto applied load that desires low current. It action is able to regulate current flowing through the relay from high to low rating current. While Series connection is favourable for Fixed Applied Voltage Input supplying onto Applied Load that desires low current. It action is able to regulate current flowing through the relay from low to high rating current. In overall picture, by connecting pure resistive load either in parallel or series to the relay coil, allow the changing of resistive and voltage input to influence current amount flowing through the coil can be regulated without limitation on operational properties except due to current rating of electrical conductor design for the coil.

Reference

1. Technical Guide for General-purpose Relays, CSM_GeneralRelay_TG_E_3_1