Electronic Dash-pot System Development for Power Electronic Circuit Protection using the Current Sensor

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Abstract

This paper presents the development of an electronic dash-pot(EDP) system for protecting the power electronic circuit. The EDP play role of protecting an equipment by disconnecting between voltage source and load system. Also, converting the existed electrical system into an electronic mechanism, it can reduce the power consumption and prevents the system damage due to over current.

1. Introduction

Since 1960's, up to now, a oil-dash pot(ODP) system have been used to protect the driving system from the over current[1]. The ODP system is established into the input part of the system. If the over-current is flow into the system, then the equipment will become damage. So, the ODP play role of protecting the equipment by disconnecting the system and voltage source.

Such a oil-dash pot isolate the equipment from voltage sources, but requires long time to segregate the driven system.

The development of an electronic dash-pot(EDP) system equivalent to the function of a electric oil-dash pot can disconnect rapidly the system from the over-current, and reduce the power consumption. In addition to, it is additive the function of observation and the alarm of an over-current.

In this paper, we develop the EDP, and explain their functions. The EDP having the same function to a ODP are composed of current sensor, driving parts, switching part, and comparator part.

2. The electronic dash-pot

The electric oil-dash pot(ODP) are composed of a coil, the oil-tub, the magnetic bar within oil tube, and switch parts. If the over current on oil-dash pot connecting the voltage source line and a system is flowed, then the coil winding a oil-tube is heated, and the magnetic material within the oil-tube is moved to upper[2, 3]. So, the magnetic field in the oil-tub top by an influence of magnetic core take place, and cut the voltage source from driving system by the movement of the switch. Fig. 1 shows the structure of the ODP.

In fig. 1,the oil-tube is usually filled with an oil in solid form. The coil heated by over-current make flexible the oil in solid form. Then the movement of magnetic material have magnetic induction, it make attracts the cap. The movement of the cap touches the voltage source switch of the output load, and the source is isolated by it.

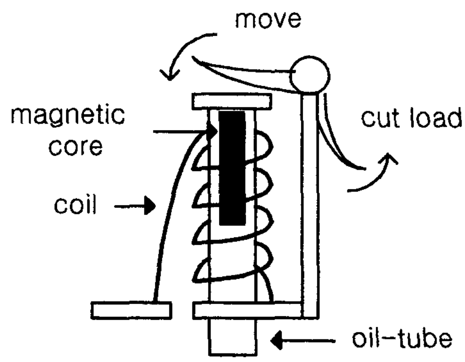

Fig. 1. Block diagrams of an ODP system.

In order to develop the EDP, we consider a type and the specification of current sensor detecting ac current. The form of current transformer(CT) sensing ac current is closed form, and it has the leakage magnetic flux.

A component driven from the current sensor be constructed of the input part of the EDP. Fig. 2 shows the detailed circuit of the EDP.

In fig.2, the input of the EDP divides the current status into three parts of alarm, unstable and stable. The alarm state means the over-current occur in the system[2]. The unstable status means also initial state of over-current.

Such as three states of signals are displayed by red, yellow and green LED.

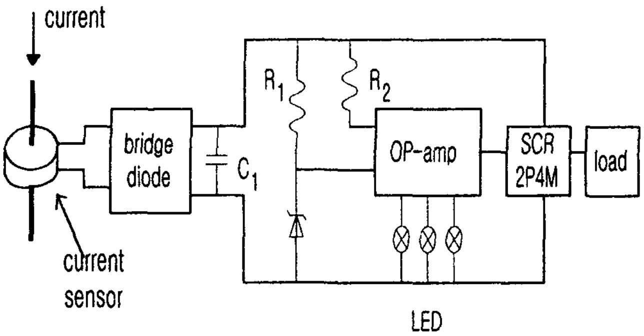

Fig. 2 The circuit diagram of the EDP.

The fig. 2 estimates the driven output voltage v_{o1} through bridge diode and resistor operating the I-V converter. If the n is the turns of the CT sensor, then the current i_{o1} is calculated as follow[3, 4].

The driven voltage from the CT sensor, v_{o1} is as follows ;

$$v_{o1} = i_{01} \times R_{1L},\ i_{o1} = {i_1}/{n} \tag{1}$$

Really, v_{01} became the smaller voltage size by leakage magnetic flux. Also, considering the source frequency of the 60 Hz, the driven voltage due to the frequencies can be changed. But it can ignore the error in 1/1000 ratio to R_L < 10 Ω size which include the temperature limit of sensor specification.

Using a type of inverting OP-amp, the output voltage of OP-amp v' is as follow ;

$$v' = -\frac{R_1}{R_2} v_2 = -\frac{R_1}{R_2}\left(\frac{i_1}{n} R_L\right) \tag{2}$$

If we use secondary OP-amp to amplify the signal, the output voltage v'' of secondary OP-amp is

$$\begin{aligned} v'' &= -\frac{R_5}{R_3} v_2 - \frac{R_5}{R_4} v' \\ &= -\left[\frac{R_5}{R_3} + \frac{R_5}{R_4}\frac{R_1}{R_2}\right] v_1 \end{aligned} \tag{3}$$

Finally, the switch takes play the controller to control the load circuit of over-current state. Then output voltage v_0 between gate and source of the connected FET is controlled by the characteristics of channel resistor. In the circuit, the TLR106× 3 presents stable, unstable and alarm state in the current state. The thyrister plays a switching have the cut function in the results of ac current signal.

3. Experimental Results

Until now, we have explained the development of the EDP system disconnecting the source from the over-current. The benefits of the EDP are that play the rapid protection function and can reduce the power consumption.

In the experimental results, the measured voltage v_{o1} from the connected 0.1 Ω(5 W) is 0.034 V, and this is related to the current size of 3.4 A. In addition to, the output of current sensor CTL6P is connected to the input part of OP-amp. In this case, the property is improved, but the offset voltage of OP-amp is amplified. To remove the offset voltage, it connects the condenser to the OP-amp output.

Fig. 3 show the detected waveform from current sensor operating electronic heater(920 Watt). Where the vertical axis is voltage level and the horizontal axis is time scale.

In order to estimate the offset voltage, it connects the condenser to the OP-amp input part. Using a type of inverting OP-amp, the output voltage of OP-amp is obtained from the lower equation.

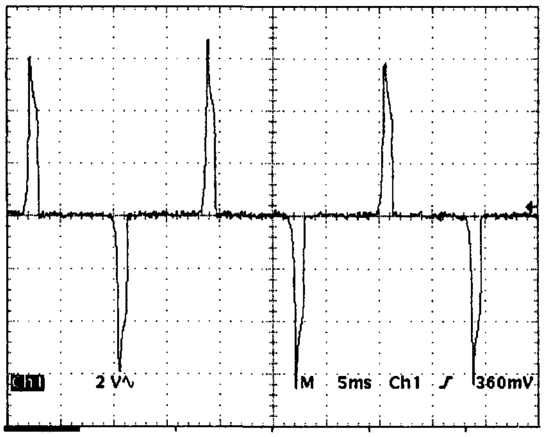

Fig. 3. Signal waveform from sensor

Fig. 4 shows the signal waveform of v', in case of $R_1 = R_2$.

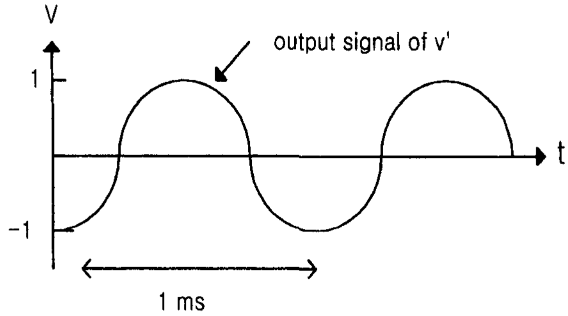

Fig. 4 Signal waveform of v'

Fig. 5 presents the output waveform v_0 in case of $R_3 = R_4 = R_5$ using the Pspice.

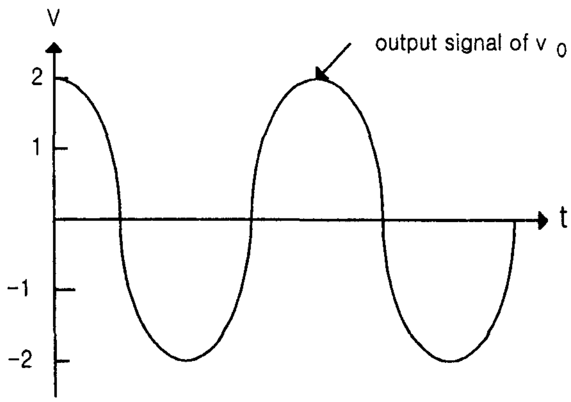

Fig. 5 The signal waveform of the v_0

4. Conclusion

The EDP presents the system for protecting the output load from over-current. If the current flow constantly, the load of an output operates correctly. Unless the voltage source of an output is isolated, it can not protects a power system. But we can also reduce the power dissipation.

References

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