Proceedings of the 2006 IASME/WSEAS International Conference on Energy & Environmental Systems, Chalkida, Greece, May 8-10, 2006 (pp362-366)

Design and Implementation of a Primary Digital Relay

YAZDAN ASHGEVARI, *IRAJ HASSANZADEH, ALIREZA MALEKI and MEHRDAD MEHRPOOR
Department of Electirical Engineering, Islamic Azad University of Ardebil and MONA CO. LTD, Iran
*Faculty of electrical and computer Engineering, University of Tabriz, Tabriz, Iran

Abstract: Due to a poor protection the distribution system always suffers a large amount of non – distributed energy. The relays now used in 20 kv network are either electromechanical or electronical each having its own problems. To eliminate these problems a primary digital relay has been designed and constructed. In this paper the overall design of this relay is explained.

Key-Words: Digital relay, Distribution system, None distributed energy, Digital control

1 Introduction

Considering the high costs of producing electric energy, the production , transmission and distribution divisions , each, need to do their best to make electric energy be satisfactorily delivered to the consumers. Protection of the distribution system is one of the most important issues in distribution division.

The electromechanical and electronical relays now used have their own problems. The electromechanical relays work somehow slowly, remained unchanged for a long time and are imported from other countries. On the other hands the electronical ones, as reported by the distribution system officials of many areas, are not faster and more sensitive than the electromechanical relays, and this makes it difficult, often impossible, to create a time coordination among them.

In an attempt to eliminate the foregoing problems we started to design and construct a primary digital relay, having the following presuppositions in mind:

1- being economical
2- high accuracy in measuring and comparing the current
3- high acceptable operation speed
4- not being affected by environmental factors
5- easy-to-mend in case of malfunctioning
6- Considering the electromechanical relays' capability of being converted into digital relays.

To obtain satisfactory results in designing a digital relay, an electromechanical relay was converted into a digital one and tested.The test results have been completely satisfactory.

In this paper the overall design of the constructed relay is explained.

2 Constituent Components of the Relay

The main function of a relay is to operate a warning signal in the case of a fault and to activate circuit breaker so that the smallest faulted portion be isolated and the rest of the system remain unhurt.

The constituent components of a relay are as follows:

Measuring component: this component measures one of the line parameters, which is current for this relay.

Comparing component: this component compares the amount measured by the measuring component with the reference current.

Time delay component: this component is mostly used for two purposes: first, to avoid deenergizing when the fault can be cleared from the system very soon; second, to back – up and be coordinated with other relays in the network.

Operating component: once the fault was detected, and the time delay came to its end, the operating component sends a warning signal or activates the circuit breaker.

The constructed relay also has the foregoing components and its measuring, comparing and time delay components are changed in comparison with the relays used now, but its block diagram, shown in fig.1 is the same as the other relays.

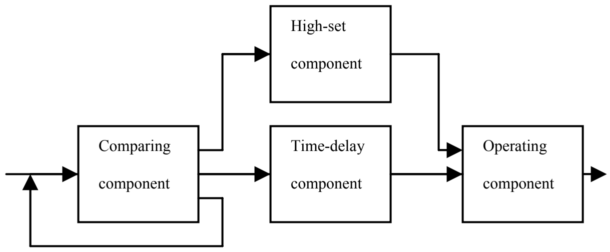

Fig.1 Block diagram

3 Testing the Electromechanical Relays

To design a digital relay, electromechanical relays were tested. For this purpose some relays with 20_A rated current were chosen. The following results were obtained.

1. Although the tested relays all had the same time setting, the time delay of each relay, due to the mechanical nature of their system, was different from others.

2- The time delay of the relays was not the same as the time set for them.

3- The time delay of the relays was longer than the set time, and even when the time delay was set for zero, the operation time of relays reached to 1 second or more.

4- Some environmental factors such as temperature and dust affected the relays' operation.

The foregoing reasons have created uncertainty towards the protection system of distribution network.

4 The Constituent Components of the Primary Digital Relay

Primary Coil: Electromechanical relays have a primary coil through which the feeder current passes and produces a magnetic field. This type of coil was used in the digital relay.

Magnetic Core: The electromechanical relay's magnetic core was used to direct the magnetic flow in the digital relay. The air gap in the core guarantees the linearity of the generated flow with regard to the current Passing through the primary coil.

Supply Coil: in electromechanical relays, magnetic field is used to produce mechanical force or torque, but in this project the intra – core a.c. magnetic field has been used to produce electric voltage, in other words, the magnetic field is a mediator which converts the current signal into the voltage signal.

The number of coil turns is 400 (depending on the rated current amount, the number of coil turns changes). The voltage produced by the coil has a linear relationship with the current passing through the primary coil. The a.c. voltage of the coil is rectified by a diode bridge, and its ripples are highly decreased with the help of a capacitor filter. The rated current of the diode bridge is 1_A, and the capacitor filter has a high capacity.

The voltage of this capacitor is used for four purposes:

1- to feed the circuit

2- the reference signal to start the high – set system

3- the reference signal to start the time delay system

4- to feed the attracting coil

5 Power Supply Circuit

To supply a digital circuit we need a 5_v stable voltage. Considering the fact that relays work with 20_{kv} voltage, it's impossible to supply it with an external source. Using a battery as a supply source also has its own problem which is regular services.

The coil or transformer output enters a diode bridge. In the case of a fault a diode bridge along with a capacitor filter produce a $15_v – 25_v$ voltage. If the supply voltage of ICs has some ripples , they won't function properly . To eliminate this problem a regulator is used. The circuit resistance is about 330_Ω ,so the series resistance is considered to be 56 $_\Omega$. An ordinary 1.4 w z- diode is used because the length of time the current passes through it is very short. The 7805 regulator stabilizes the voltage at 5_v.

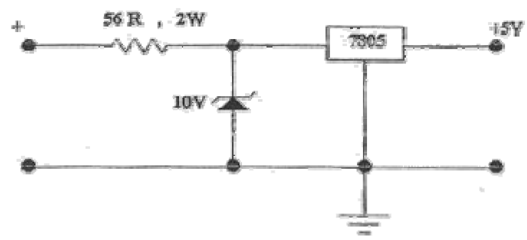

Fig.2.Power supply circuit

Reference voltage : using the z-diode , resistance and the stabilized voltage of the regulator , we obtain a stable 3.3_v voltage.

Signals: The current passing through the feeder is converted into voltage to be compared with the former stable voltage. With the help of two potentiometers the filter capacitor voltage is also sampled to be sent to the time delay and high – set components. The time delay circuit resistances are calculated for the rated current and twice as much it.

$$V_s = 8_v \qquad V_o = 3_v \qquad R_3 = 2_{K\Omega}$$

$$V_s = (R_1 + R_2 + R_3)I_o = 8_v \qquad (1)$$

$$V_o = (R_2 + R_3)I_o = 3_v \qquad (2)$$

$$8/3 = [R_1/(R_2 + R_3) + 1] \qquad (3)$$

$$V_s = 16_v \qquad V_o = 3_v \qquad R_3 = 2_{K\Omega}$$

$$V_s = (R_1 + R_2 + R_3)I_o = 16_v \qquad (4)$$

$$V_o = (R_2)I_o = 3_v \qquad (5)$$

With regard to the foregoing calculations R_1= 8.2 $_{k\Omega}$ and R_2= 2.2 $k\Omega$. when the potentiometer is in its highest rate in the high – set component , the output voltage becomes 3_v, the feeder current becomes triple as much the rated current , and supply voltage equals to 24_v.

$$24 = (R_1' + R_3')I_o' \qquad (6)$$

$$3 = R_3' I_o' \qquad (7)$$

$$24/3 = 8 = (R_1' + R_3')/R_3' \qquad (8)$$

To solve the above equations , R_1 is considered to be 15 $k\Omega$ and R_2 = 1.8 $k\Omega$

If the potentiometer rate becomes zero, the high-set is set for infinite current.

6 Operational Amplifiers

Two op - amp ICs are used for high-set and time delay components. To avoid signals disturbance at the op – amp's input, also we use capacitors. On the other hand , since the 741 and TTL ICs outputs are not zero and five volt , the Schmitt trigger is used to make The input rates reach to the logical zero and one.

7 High – Set Circuit Operation

The following figure shows the high- set component of the relay.

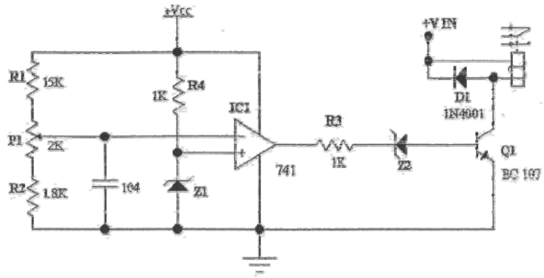

Fig. 3. High – set circuit

The input of op-amp's pin 2 is the stable voltage at 3.3_v , and if the pin3 becomes less than 3.3_v, the pin2 voltage appears at pin6. But the pin3 voltage becoming more than 3.3_7 makes the ICs output voltage at the pin 6 reach to v_{cc} and , after passing through the z- diode , stimulate and saturate the transistor's base. As a result of current passage the attracting coil is stimulated.

7 Oscillator

To creat a rectangular wave the 555 IC is used to have time delay of $o.ol_s$ the oscillator frequency should be set for 1600 Hz and for the maximum time delay of 10_s , a 1.6 Hz frequency is needed.

The oscillator circuit is designed as follows:

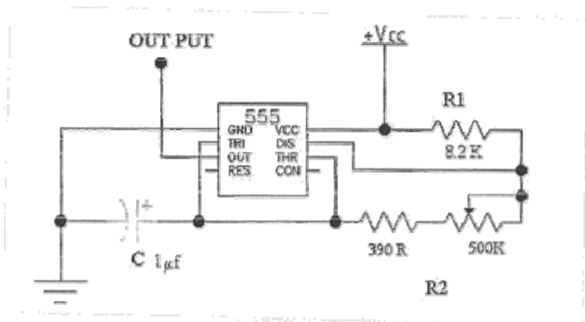

Fig. 4. Oscillator circuit

8 The Time Delay Component Operation

The following figure shows the time delay component of the relay.

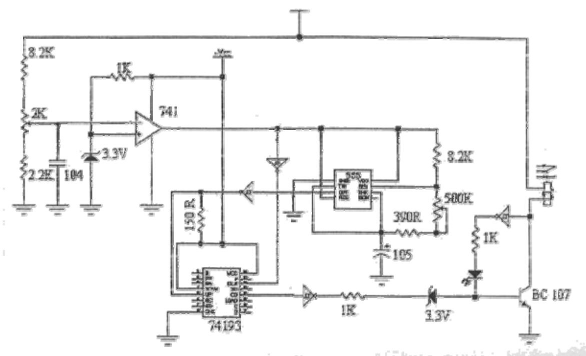

Fig.5. Time delay circuit

One pin of 741 IC is stimulated by the stable 3.3 input and the other pin by the potentiometer's middle pin. When the input voltage of the circuit becomes 15_v the op – amp output changes from v_z to v_{cc} , and , at the same time , the 555 IC starts working as pulse generator.

The op – amp output is also connected to the

74193 IC (reset) through a Schmitt trigger. When this pin's voltage becomes zero , the 74193 IC starts counting the 555 IC pulses and if the reset pin becomes logically one , all the 74193 IC pins become zero.

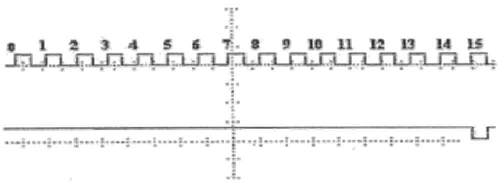

Fig. 6. Input and output of 74193

As showen in the figure(5) the pin12 of the 74193 IC becomes zero once , just when the 555 IC pulses change from 14 to 15 . This negative pulse is used to stimulate the transistor's base through a Schmitt trigger, a resistance and z – diode. Then transistor's base , through a resistance and Schmitt trigger , gets feedback from its collector to self – block itself and make the attracting coil do its attracting function properly.
two transistors of the high – set and time delay components become parallel to each other.

9 Attracting coil

One of the main objectives of this project has been converting the faulty electromechanical relays into digital ones, the operating mechanical component of the electromechanical relay is used in this relay , which requires some mechanical force; for this purpose an attracting coil is used. To prevent the transistor from being saturated and to control the base current , a resistance is put in the transistor's emitter.

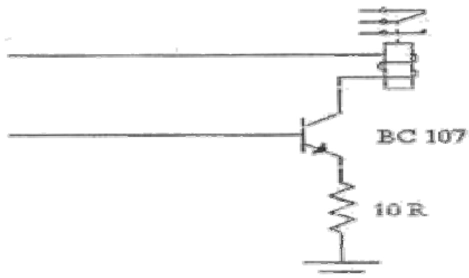

Fig. 7. Attracting coil circuit

The following figure shows the overall circuit of the digital relay.

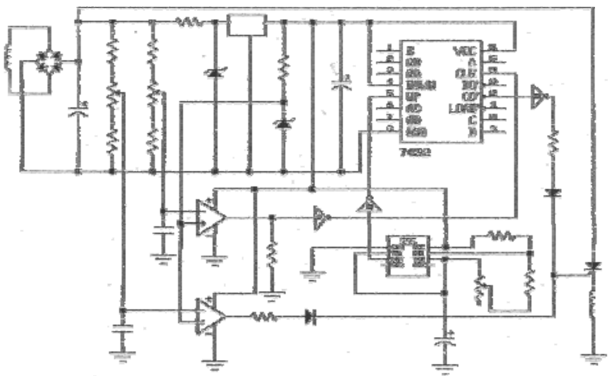

Fig. 8. The overall circuit of the digital relay

10 Conclusions

The controlling systems which first appeared in mechanical forms have been changed into digital and microprocessor systems these days. The same revolution which highly decreases costs and increases accuracy and speed is necessary for relays too.
The constructed relay has been successfully tested in the laboratory, and its accuracy and speed have been found to be about 0.5_s and 0.01_s which is completely comparable with the relays used now.
The following findings, which can also be considered as the advantages of the constructed primary digital relay, are obtained:

a) Since the system used in this relay is digital not mechanical , it works much more faster than the relays used now.
b) It is not affected by the environmental factors such as dust, moisture, temperature and so on.
c) Its components won't stop functioning in the passage of time.
d) It is easily repairable.
e) It can be produced in large quantities in the country.
f) The faulty electromechanical relays can be converted into digital ones just by putting a small circuit within them. This digital system , which replaces the disk, spirals and magnetic components of the electromechanical relays, is made the same size as a small circuit put into the metal cover of them.
g) Its components are not some thing particular and exclusive but available and cheap.
With regard to the foregoing findings (advantages) producing these relays is completely economical. The proposed circuit is not the last and the best design, rather there is still room for improvement.

We hope it could be the focus of the studies to be succecded in this field.

References

[1] Soltani, M. , “Relay and Electric Protection”
[2] Soltani, M. , “Generating Plant Apparatus”.
[3] Mano, M. , “Digital Designing”.
[4] Lancaster, D. , “CMOS Cookbook”.
[5] Lancaster, D. , “TTL Cookbook”.