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Design and Implementation of O/C relay using Microprocessor.

Dr.Abdul-Sattar H. Jasim
Lecturer

Shakir M. Faisal
Ass. Lecturer

Electrical Engineering Department-University of Tikrit

Abstract

This work presents the design and implementation of a versatile digital overcurrent (***O/C***) relay using a single microprocessor. The relay is implemented by a combination of a look-up table and a counter. The software development and hardware testing are done using a microcomputer module based on a 8-bit microprocessor. The digital processing of measured currents enables a separate setting of operating values selection of all types of inverse or constant time characteristics overcurrent protection. This protection provides reasonably fast tripping, even at terminal close to the power source were the most serve faults can occur excluding the transient condition. So this method has an excellent compromise between accuracy hardware and speed.

Key Words: Over current relay , microcomputer module , Pickup current .

تصميم وتنفيذ مرحلات زيادة التيار باستخدام المعالج الدقيق

الخلاصة

يشتمل هذا البحث على تصميم واستخدام مرحلات زيادة التيار باستخدام دائرة معالج دقيق ومنفرد. المرحل تم تنفيذه عن طريق استخدام جدول مخزون في ذاكرة المعالج وعداد. تم فحص الجانبين البرامجي والعملي باستخدام نموذج من حاسب دقيق يعتمد في عمله على نظام 8-bit . تقوم الدوائر العملية بقراءة التيار ومقارنته مع قيمة تيار الالتقاط ليتم على ضوئه اختيار نوعية مرحلات التيار إما عكسية أو ثابتة مع الزمن. هذا الاختيار سوف يوفر الحماية الكافية للنظام بالإضافة إلى أنها سريعة ومناسبة ومتوائمة مع الدوائر العملية. كما إن هذه الحماية تكون شاملة وتغطي كافة أجزاء المنظومة بما في ذلك الأجزاء القريبة من المصدر حيث تكون الأعطال مؤثرة ، وتستثنى من ذلك الحالات العابرة.

الكلمات الدالة: المعالج الدقيق ، مرحلة زيادة التيار ، تيار ألالتقاط

Introduction

Hardwired schemes of overcurrent relays suffer from the defect of inflexibility which causes difficulties when dealing with following points.

1) The introduction of special control features which differ from the standard systems.
2) The implementation of unforeseen operational changes after installation of equipment.
3) The recent trend to depart from standard substation configurations.
4) Successive stages in the development of a substation which may require radical changes in automatic switching facilities.

In such cases relatively high engineering charges and development cost may be incurred [1].

The over current relay design described in this work is provided with various features. The following features which can be programmed in the initialization routine [2].

1. Pickup setting
2. Time dial settings
3. Operating characteristics
4. Reset characteristics
5. Protection of multiple circuits

Unlike distance and differential relays , over current relays have not received much attention in digital relaying research .This is mainly due to the low cost of electromagnetic relays and their simple construction. Some earlier researchers have investigated digital over current relays , and some of these have considered implementation on a microprocessor[1,2,3,4,5]. These designs are based on 8-bit microprocessor which is suitable to be used for over current relay.

This paper describes the design of such a general purpose hardware. The designed hardware has been used in microprocessor based relay for three-phase inverse time over current protection.

More than one analogue quantity is to be converted into digital form by using only one A/D converter, analogue multiplexers are used to select any one analogue quantity at a time for A/D conversion. For time varying voltages such as AC voltage, a sample and hold circuit is used to keep the desired instantaneous voltage constant during conversion. Analog prefiltering of the current signal is not used in the present design. If the current signals contain significant amount of harmonic, then analog prefilters should be used to minimize the aliasing problem.

The objective of the work to be described in this paper was to develop the computer assessment algorithm so that it could be used, on any form of power system network with any combination of O/C relay.

In this work, a single board micro computer TK-85 built by NEC around the Intel's 8-bit 8085 microprocessor with the corresponding hardware circuits are implemented as several independent over-current relays. The microprocessor checks and serves each relay in turn [6].

Each relay is implemented by a combination of a look-up table and a counter, getting experimental results with better relay characteristic.

Overcurrent Protection

The application of inverse definite minimum time (IDMT) overcurrent relays to the protection both of power transmission and distribution system is attractive for several reasons .One of the several important is that, although IDMT relays are a form of non-unit protection, discrimination between adjacent protections zones can be achieved by an appropriate selection of each relays adjustments, i.e. its plug setting and time setting multiple[7,8].

In a system for which the fault current is practical determined by the fault location without being substantially affected by changes in power source impedance, it is advantageous to use inverse definite minimum time (IDMT) over current protection. this protection provides reasonably fast tripping ,even at terminal close to the power source were the most sever faults can occur. This type of a relay gives an inverse-time current characteristic at lower values of the fault current and definite-time characteristic at higher values of the fault current. Generally, an inverse-time characteristic is obtained if the value of the plug setting multiplier is below 10.For values

of plug setting multiplier between 10 and 20 the characteristic tends to become a straight line.
The inverse-time overcurrent protection elements have the characteristics defined by equation [5,9] :-

$$t = TMS \times \left\{ \left[\frac{k}{\left(I/_{Is} \right)^{a} - 1} \right] + c \right\} \quad \ldots\ldots(1)$$

Where:-
t= operating time for constant I (seconds)
I= energizing current (amps)
Is= over current setting (amps)
TMS= time multiplier setting
k ,a ,c= constants defining curve[2,5].
The relay pick up value is commonly set to a value where between 125-135% of the maximum load current and 90% of the minimum fault current. These values help to minimize unnecessary responses from the relay , the following formula is used to calculate the pick up value.
1.2 max load current ≤ pick up value ≤ 0.9 min fault current [7].
Four curve types are available as defined in table (1) , and they are illustrated in figure-1.
A static relay or microprocessor- based relay can be designed to give special characteristic, for "a" non-integer.

Microprocessor based design

To implement the algorithm of o/c relay under fault or transient conditions a prototype of Intel 8085 microprocessor based system has been designed. developed and successfully tested in the laboratory .The hardware and software design of the proposed microprocessor based system are described as below .

Hardware design

Schematic block diagram of the microprocessor based system is shown in figure-2 the current signal stepped down to electronic range using current transformer [9], then converted in to proportional voltage signal by using current to voltage converter. The data acquisition system (DAS), which is shown in figure (3) consists of rectifier circuit, sample & hold circuit, multiplexer, and A/D converter.
In the laboratory test, an active low pass anti aliasing filter is used in this design to attenuate a significant part of noise in signal for improved result. The data acquisition system is interfaced to the microprocessor through Intel 8255 programmable peripheral interface. The current is connected to the input port of the 8255 PPI [4, 5, 11, 12].

Interface of DAS

ADC takes a definite time, depending upon the clock frequency, for conversion of analog signals in to digital form. The analog voltage should remain constant during the conversation period. For this purpose a sample and hold circuit is used .The S/H circuit samples the instantaneous value of the ac signal at the desired instant and holds it constant during the conversation period of ADC. Sampling interval can be obtained by S/H circuit from the signal. An analog multiplexer is used to select signal of any one channel from the multi input channels and transfer this signal to its output. The circuit for interfacing of ADC800 to the 8085 microprocessor is programmable I/O port 8255. An ADC takes a finite time, known as conversion time to convert an analogue signal into digital form. If the input analog signal is not constant during the conversion period , the digital output of ADC will not correspond to the starting point analog input, a sample and hold (S/H) circuit is used to keep the instantaneous value of rapidly varying analog signal constant during the conversion period[4].
Input & output programming ports of TK-85 microcomputer are as follow:
Port A, port Cu are input ports

Port B , port CL are output ports

The addresses for ports of 8255 are as follows:

Port A -00, port B-01 ,port C-02, control word-03.

The digital output of the ADC is stored in memory location FC50.the digital values corresponding to analog voltages of 0 and 5v are 80 and FF respectively [4,6,12].

Software Design

The relay software is developed using 8085 assembly language and the flowchart arrangement for the software design is given in figure-4. Microcomputer sends a signal to the ADC for starting the conversation. Then microcomputer receives the current signal in digital form and then compares it with the pickup value.

In case of definite time over current relay, the microcomputer sends the tripping signal to the circuit breaker after a predetermined time delay if the fault current exceeds the pickup value. In case of instantaneous over current relay there is no international time delay. In order to obtain inverse time characteristics, the operating for different values of currents are noted for particular characteristic. These values are stored in the memory in tabular form. The microcomputer first determines the magnitude of the fault current and then selects the corresponding time of operation from the look up table. A delay subroutine is started and the trip signal is sent after the desired delay. Using the same program, any characteristic of IDMT very inverse, extremely inverse or special characteristic can be realized by simply changing the data of the look up table according to the desired characteristic to be realized. The microcomputer consciously measures the current and moves in a loop and if the measured current exceeds the pickup value, it compares the measured value of the current with the digital values of current given in look-up table in order to select the corresponding count of time delay.

Then it goes in delay subroutine and sends a trip signal to the circuit breaker after the predetermined time delay. The program flow chart is shown in fig. 4 .

In order to avoid false tripping of an over current relay due to transients ,the fault current is measured once again by the microprocessor to confirm whether it’s a fault current or transient .In case of any transient of short duration , the measured current above pick up value will not appear in the second measurement .but if there is an actual fault , it will appear again , and then the microprocessor will issue a tripping signal to disconnect the faulty part of the system.

Results and Discussion

In this proposed relay scheme, function generation is an important task achieved by microprocessor since it will decide the type of resulting time-current characteristics.

Two types of function generation software have been used here.

1. The integer type used mathematical operation through multiplication and division subroutine to obtain characteristics with integer values of "a" .
2. The flexible type used a look up table method in order to obtain the desirable value of "a" whether integer or non-integer, which cannot be obtained in any other type.

Time multiplier settings can be obtained through a change in the time-delay subroutine.

The software design shows the ability to obtain any slope of time-current characteristics by changing the value of the coefficients of equation -1 (k, a and c) which are listed in table- 1, without the need to change the hardware system.

An operational amplifier incorporates the S/H circuit shown in figure (5). The hold capacitor from is isolated any load, thus the load capacitor holds the instantaneous value of the applied input voltage.

Table-2 shows the acquisition time of S/H circuit which is the time required for the capacitor to charge up to the value of the input signal after the sample command is given.

Test result of time-current characteristics Very inverse (VI) , Extremely inverse(EI) and special characteristic are given in table-3 at two types of time multiplier setting (TMS= 1, 0.3),where P.S.M mean plug setting multiplier.

P.S.M= primary fault current / (C.T. * pickup current)

Where:

C.T.: current transformer ratio.

It can be noticed that good agreement is achieved between the practical design results and the published results in reference. [4].

Conclusions

This work gives the ability to obtain any type of inverse time-current characteristic by changing the coefficients of equation-1 in the software program with high range of time multiplier setting (TMS). This is important in radial protection system also it has the ability to isolate any type of fault in about 20 msec.

There are two settings that must be applied to all time-delay over current relays:

1. Pick up value
2. Time multiplier setting.

Time overcurrent relays are designed to produce high operation at high current, slow operation at low current.

Utilization of the available 8 bit 8085 microprocessor for overcurrent relay procedure is flexible instruction and more memory can be interfaced and it can be used to control multiple overcurrent relays also the cost is lower by replacing some of analogue hardware with dedicated software. It can be used for integer and non-integer values for the characteristics equation of the relay. The overcurrent relays can be implemented with other microprocessor like 8086.

This method has an excellent compromise between accuracy hardware and speed.

The S/H circuit is basically an operational amplifier which charges a capacitor during a sample mode and retains the value of the charge of the capacitor during the hold mode. The delay between the sample state and hold state is small and the typical value of this time being 10μs. A significant source of error in sample and hold circuit is the dielectric absorption in the hold capacitor. Therefore, the hold capacitor selected for SIH circuit should be made of dielectric with very low hysterics such as polystyrene, polypropylene and Teflon.

In the future, we expect to see more inventions and improvements that contribute to more reliable and lower cost electric power systems protection.

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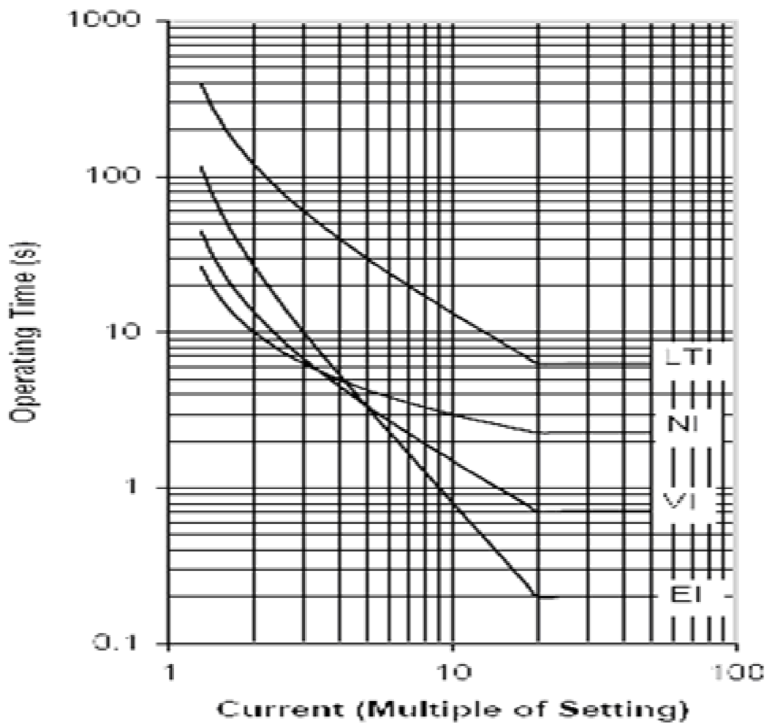

Figure (1)-Different types of inverse-time o/c characteristic for time multiplying setting =1[9].

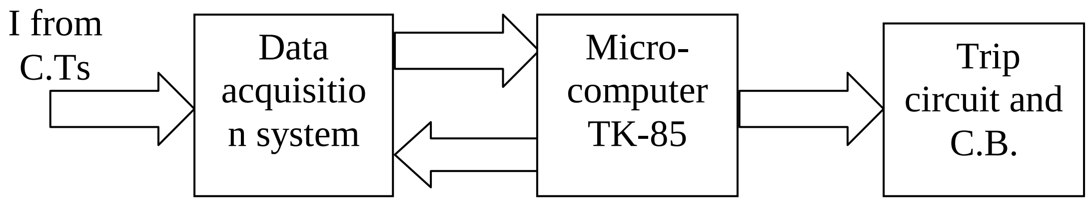

Figure (2) Block diagram of O/C relay.

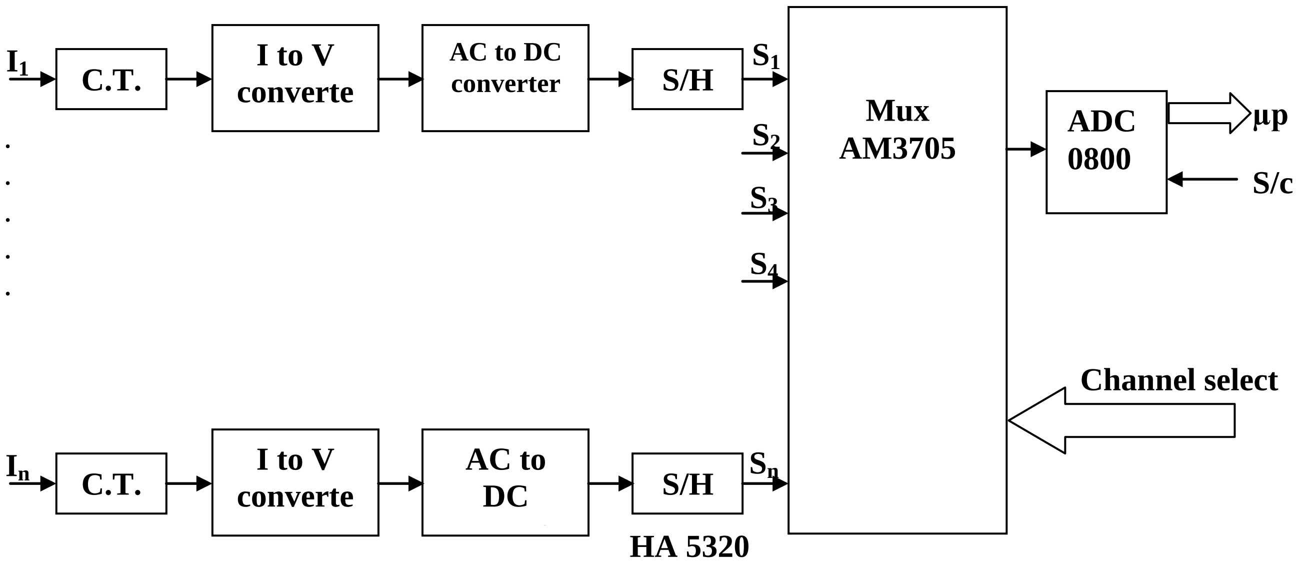

Figure (3) Block diagram of data acquisition system

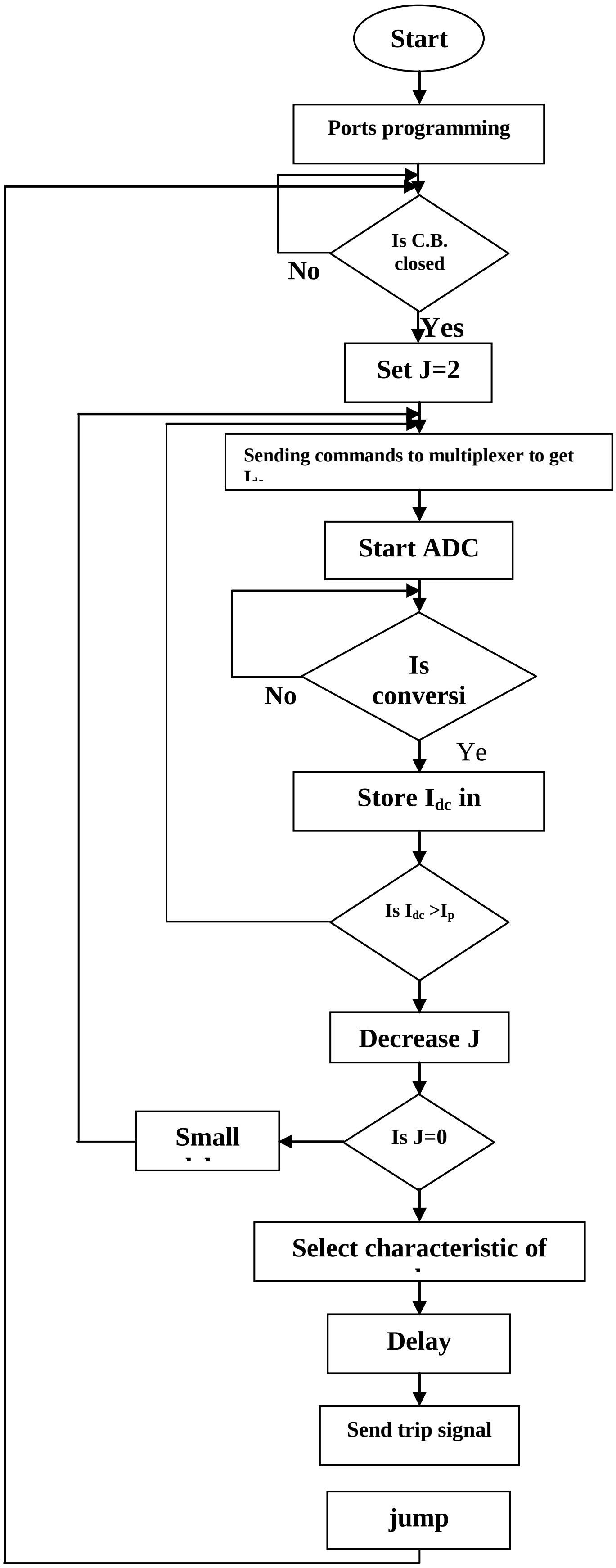

Figure (4) Program flow chart for IDMT overcurrent relay.

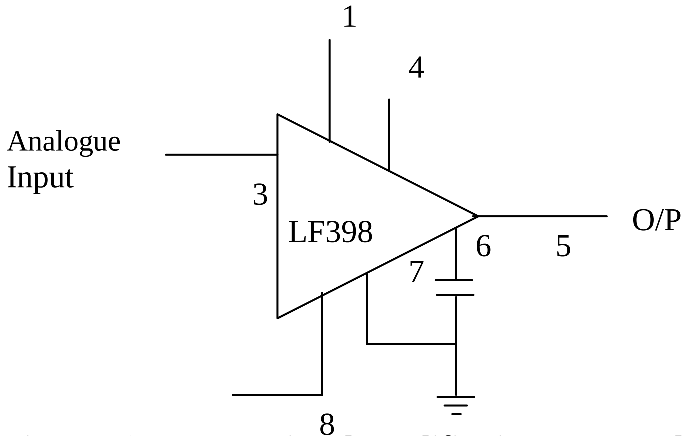

Figure (5) An operational amplifier incorporate the S/H.

Table (1) Types of inverse-time overcurrent protection [9].

Curve description	K	a	c
IEC normal inverse (NI)	0.14	0.02	0
IEC very inverse (VI)	13.5	1	0
IEC extremely inverse (EI)	80	2	0
IEC /UK long time inverse (LTI)	120	1	0

Table (2) The acquisition time of S/H circuit.

Acquisition time in μ sec	Value of hold capacitor in μ farad
2	0.001
5	0.005
20	0.01
50	0.05
250	0.1

Table (3) Experimental results

P.S.M	Time(msec.) VI		Time(msec.) EI		Time(msec.) Special Characteristic	
	T.M.S=1	T.M.S=0.3	T.M.S=1	T.M.S=0.3	T.M.S=1	T.M.S=0.3
2.5	130	25	60	20	75	22.5
5	70	22.5	30	17.5	50	20
7.5	50	21	25	16	25	18
10	35	20	20	15	23	17.5
15	33	20	17	15	22	17
20	32.5	20	15	15	22	17