# DESIGN THREE PHASE OVERCURRENT RELAYS BASED ON MICROCOMPUTER

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## ABSTRACT

A new design of three phase overcurrent relay described in this paper. The performance of the new design shows the ability to obtain any shape of characteristic with high accuracy and distinguish between transient and steady state fault. This design used more precise and flexible model Sachdev linear model for get any characteristic, also fast measurement theory to measure load current for less than half cycle and good hardware system design controlled by Pentium version 4 processor.

**KEY WORDS**: pickup current, time multiplier setting, programmable peripheral Interface, operating time.

## INTRODUCTION

The fundamental concept of protective relaying is to detect and isolate faults and other destructive phenomena in the shortest possible time consistent with economics and security. Oververcurrent relays are widely used for the protection of radial transmission and distribution system [1]. These devices are used to isolate the section of the system affected by a fault so that the remaining system can continue to operate normally. The basic approach of this device is clearly distinguish between abnormal fault current and normal full load current, and is designed to respond to overcurrent by operating the affected circuit rapidly. There are two basic types of overcurrent relay, the first type is instantaneous relay and the second type is time-delay relay [2]. The time-current characteristics of the overcurrent relay is shown in fig.(1) , and the equation that describes the nature of the time current relation is :

$$I^n t = K \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

I is the fault current in ampere.

t is the time operation of the relay in second.

k is a designed constant.

n is the exponent that specifies the type of overcurrent relay.

A typical inverse time overcurrent relay has two values to be set, the pickup current value ($I_{PU}$), and the time dial setting or time multiplier setting (TDS or TMS). The pickup current minimum current value for which the relay operates. The time dial setting defines the operation time (t) of the device for each current value, and is normally given as a curve t versus M, where M is the ratio of the relay current I, to the pickup current.

The relay characteristic can be modeled by equation (2) [3]:

$$T = f(I_{PU}, I) * TSM \quad \ldots\ldots\ldots\ldots(2)$$

$$f(I_{PU}, I) = a_0 + a_1/(M-1) + a_2/(M-1)^2 + a_3/(M-1)^3 + a_4/(M-1)^4 \quad \ldots\ldots\ldots\ldots(3)$$

The more precise and flexible model sachdev linear model is used in this design and shown as equation (3) [4].for different types of overcurrent relays the coefficients, $a_0$, $a_1$,….$a_4$, are obtained using curve fitting technique[5,6]

Where $M=I/I_{PU}$, T, I and $I_{PU}$ are relay operation time, current flowing the relay and relay pickup.

This paper use sachdev linear model to get precise model of time-current characteristics and a good hardware system design to detect the fault current and protect the system from the undesirable current. Good results are obtained compared with the standard published results [3], for the variation of the time with respect to the multiple of pickup current.

## Measuring Relay Current

The current signals taken from the CTs connected as in appendex B [7,8,9]. To detect the fault current, the maximum value of the sinusoidal waveform current should be measured [10].The instantaneous equation of the sinusoidal waveform current is:

$$i(t) = I_m \sin(\omega t) \quad \ldots\ldots\ldots\ldots(4)$$

Where $I_m$ is the maximum value

The maximum value can be calculated by taking three samples from the waveform as shown in fig(2).The samples are at: $t=t_1$, $t=t_1+\Delta t$ and $t=t_1+2\Delta t$.

The three samples can be taken anywhere in the signal waveform and the sampling frequency at least twice the signal frequency.

The instantaneous equation becomes:

$i_1 = I_m \, Sin(\omega t)$……………………….........(5)

$i_2 = I_m \, Sin(\omega t_1 + \omega \, \Delta t)$………..…………(6)

$i_3 = I_m \, Sin(\omega t_1 + 2\omega \, \Delta t)$ ………………..(7)

From the above instantaneous equations, the final equation of $I_m$ is [11]:

$$I_m = \left( (i_1 + i_2)^2 - 2(1+\cos\alpha) i_1 i_2 \right)^{1/2} / \sin\alpha \; \ldots$$
……………………………….(8)

Where $\alpha$ is $\omega\Delta t$.

**System Design:**

**1-Hardware System Design:**

Fig.(3) shows the block diagram arrangement of the practical circuit. In this design the programmable peripheral interface (PPI) 8255, is the main section of the system, which controls the input / output of the system that have 24 Input / Output ports grouped in three 8-bits parallel ports A, B and C. The computer program that specifies these ports by ordering write control word and storing it in the control register the connection details in appendix C.

In this system the control word was 82H, according to this, B is the input port, while A and C are the output ports. The analogue multiplexer used to integrate the three phase signals as shown in fig 3. The hardware system start with initial input channels by the decoder to the control word of PPI to enable port B for input data and enable port C for select phase number through multiplexer to convert one value at each time to digital through analogue to digital converter this A/D have two biasing voltage ±5V to convert the positive and negative signal, the conversion begin by start of conversion signal SC (Start of Conversion) from port A after the end of conversion the result enter to the computer through data bus by port B of (PPI).The buffer circuit was located before PPI to protect it from the undesired value.

**2-Software System Design**

Fig.(4) shows the flow chart arrangement for the software design of the overcurrent relay, the program written in C language which is given in appendix A, start with the initial input channels by the decoder then three samples to be taken at (1KHz) and calculating the peak amplitude (Im) using equation (4). The peak amplitude current is calculated (I) and then compare with the setting point $I_{pu}$ (pickup current value) .Tripping signal send ( after delayed time obtained from equation 2) when the measured value exceed the pickup current, else another phase check. The execution time of the overcurrent relay was 13 ms.

## DISCUSSION OF THE RESULTS

Fig.(5) and fig.(6) shows the time current characteristics get it for normal inverse and very inverse respectively at (TMS= 1 , 0.5 , 0.2) . It can be noticed that good agreement is achieved between the practical design results and the published curves [1], of the variation between the operating times in second with the multiple of pick up current for the coefficients a's of equation 3.

The advantages of the new design are:

The ability to obtain any shape of characteristic by changing the value of coefficients a's in equation 3. These changes can be done without need to change the hardware system, only change these values in the software program.

Fig.(7) show the operation of the over current relay under fault condition only. The time period between 4 and 7 cycle represent the transient condition, while the time period above the 9 cycle represent the steady state condition. The relay wait for 2 cycles before give a trip signal to distinguish between the steady state and the transient conditions. Note: in the experiment the value $I_{pu}$= 0.1A for testing at 20 multiple of pick up current. The given in table 1.

## CONCLUSIONS

The new design show the ability to detect the fault current at any phase and distinguish the transient condition, use numerical method to describe inverse time-current characteristic appears high flexible to get any type of relay only change the a's coefficients, it can use high range of TMS from 0.1 to 1 this important in radial protection system, also can get extremely inverse in the same method also the hardware design show high accuracy to detect the current signal, and high speed of measuring peak amplitude of the current and compare with pickup current not exceed half cycle give the new design high speed to isolate the section of the system affected by a fault.

coefficients of Sachdev model a obtained using curve fitting technique

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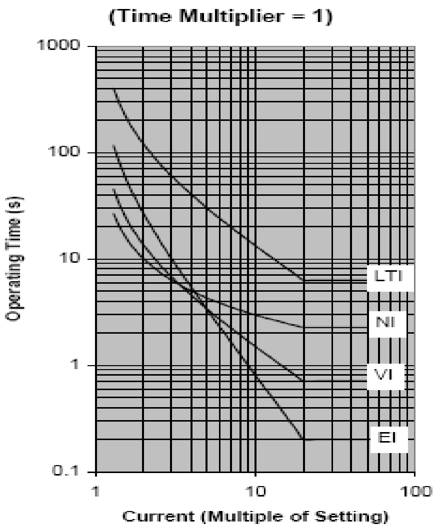
**Table (1) Coefficients of Sachdev model**

| Type | TMS | $a_0$ | $a_1$ | $a_2$ | $a_3$ | $a_4$ |
|---|---|---|---|---|---|---|
| Normal inverse | 0.1-1 | 1.0427 | 0.86124 | -0.36684 | 0.13002 | -0.014097 |
| Very Inverse | 0.1-1 | 1.6439 | 12.827 | -10.66 | 9.2134 | -2.566 |




LTI: Low Time Inverse
NI: Normal Inverse
VI: Very Inverse
EI: Extremely Inverse

**Fig. 1 Time-current characteristics of overcurrent relay [2]**

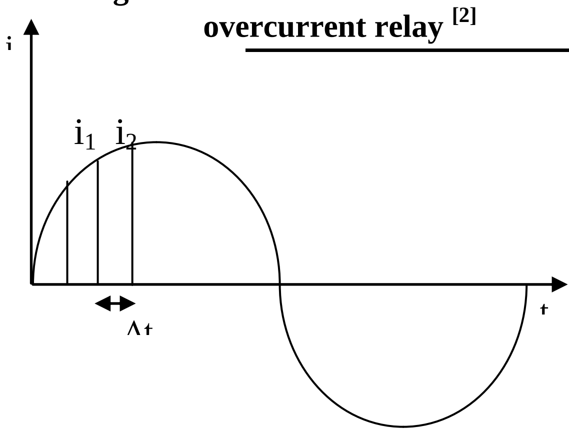



**Fig 2 Sampled sinusoidal signal**

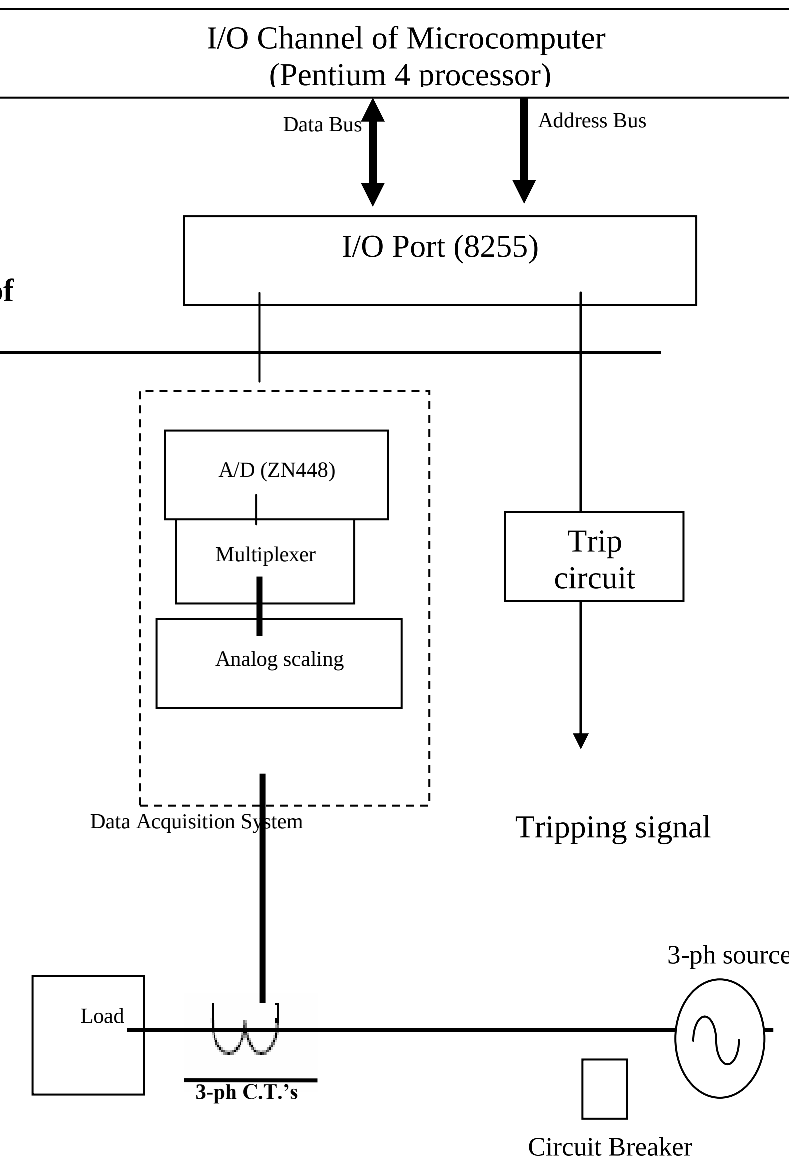



**Fig 3 Block diagram of the protection relay**

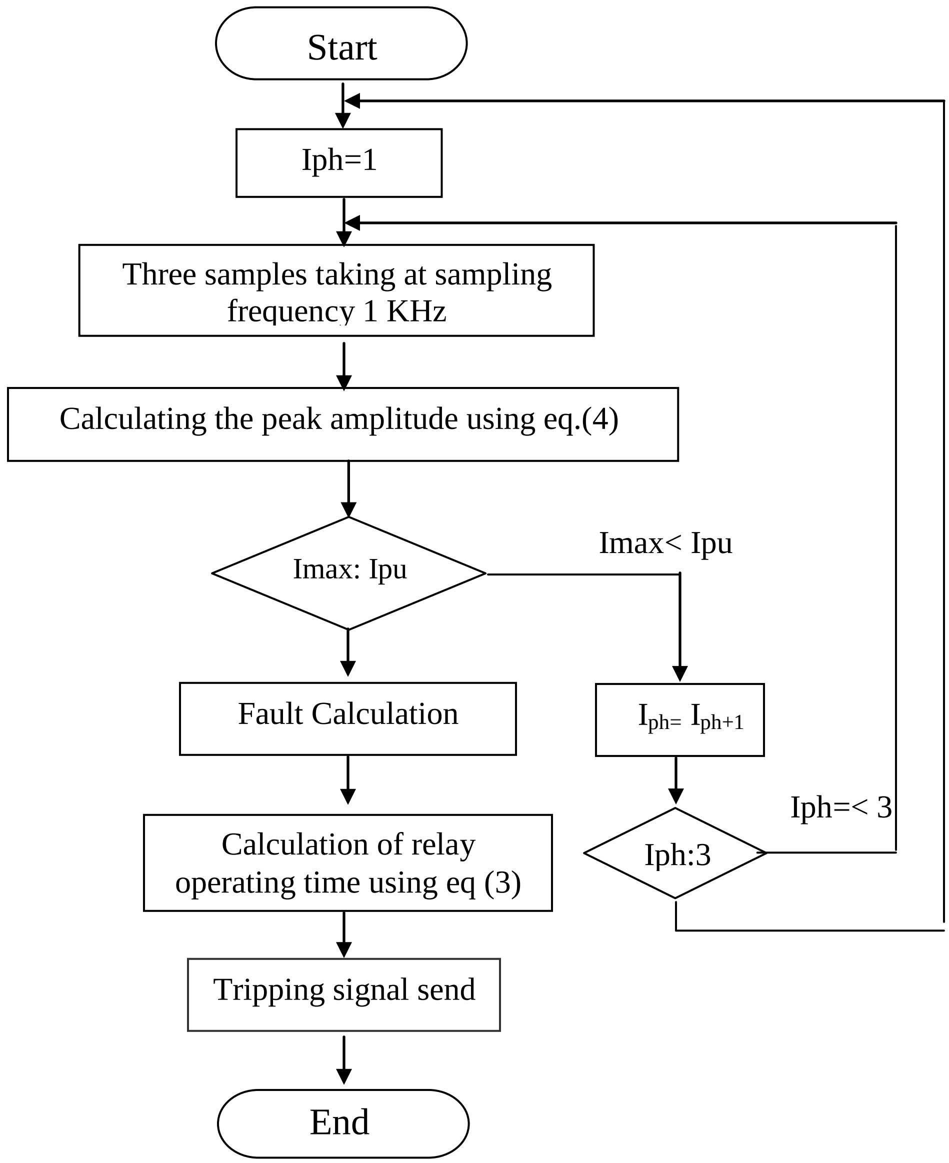
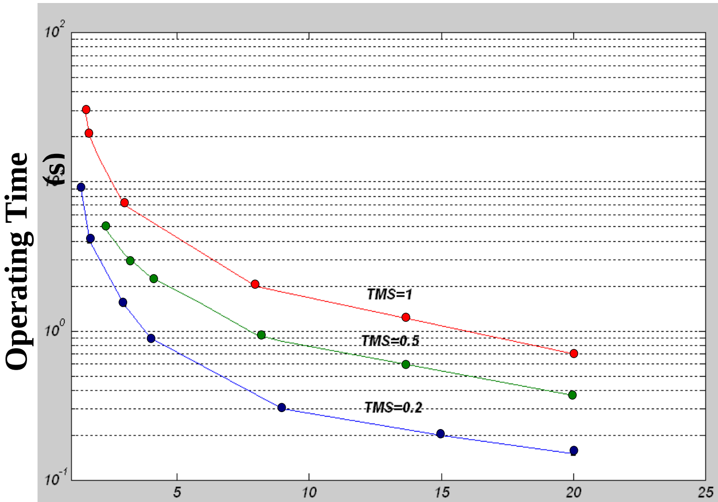
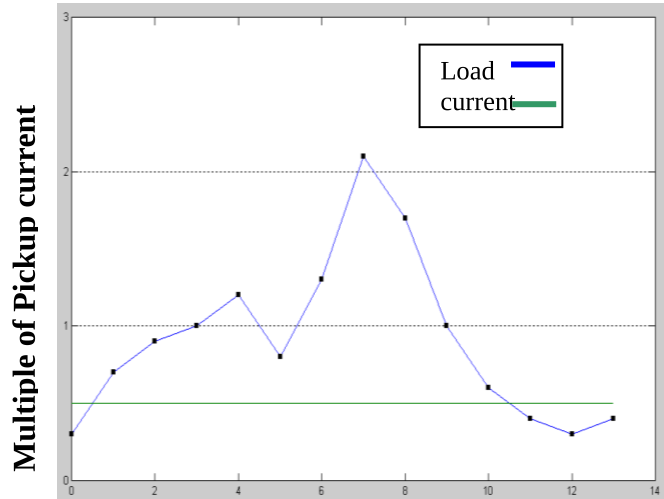



**Fig (4) Flow chart of overcurrent relay**



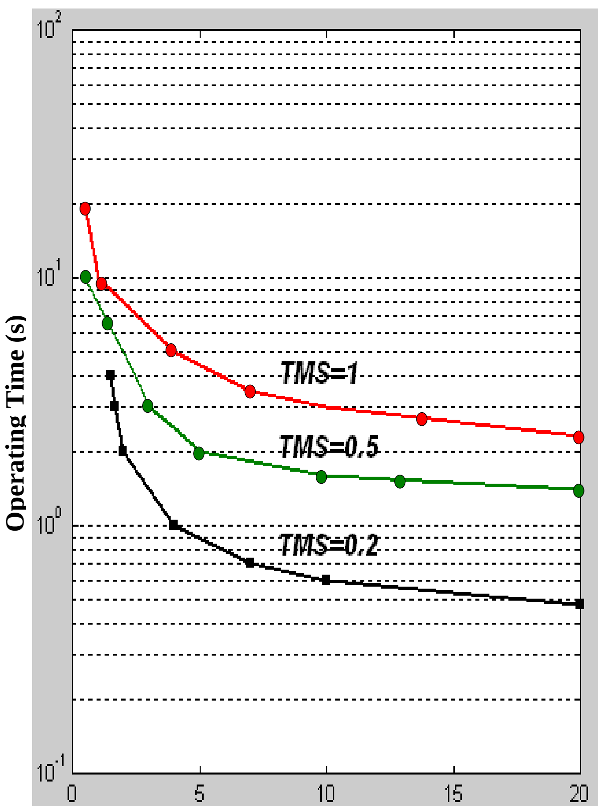

Current (Multiple of Setting)

**Fig( 5) Normal Inverse characteristic of overcurrent relay**




**Time in cycles**

**Fig (7) Result of over current relay to distinguish the transient condition**

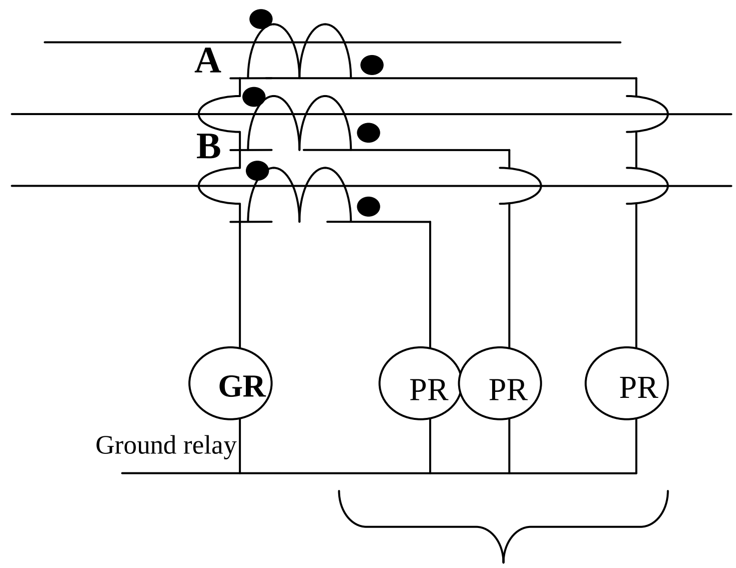



**Current (Multiple of Setting)**

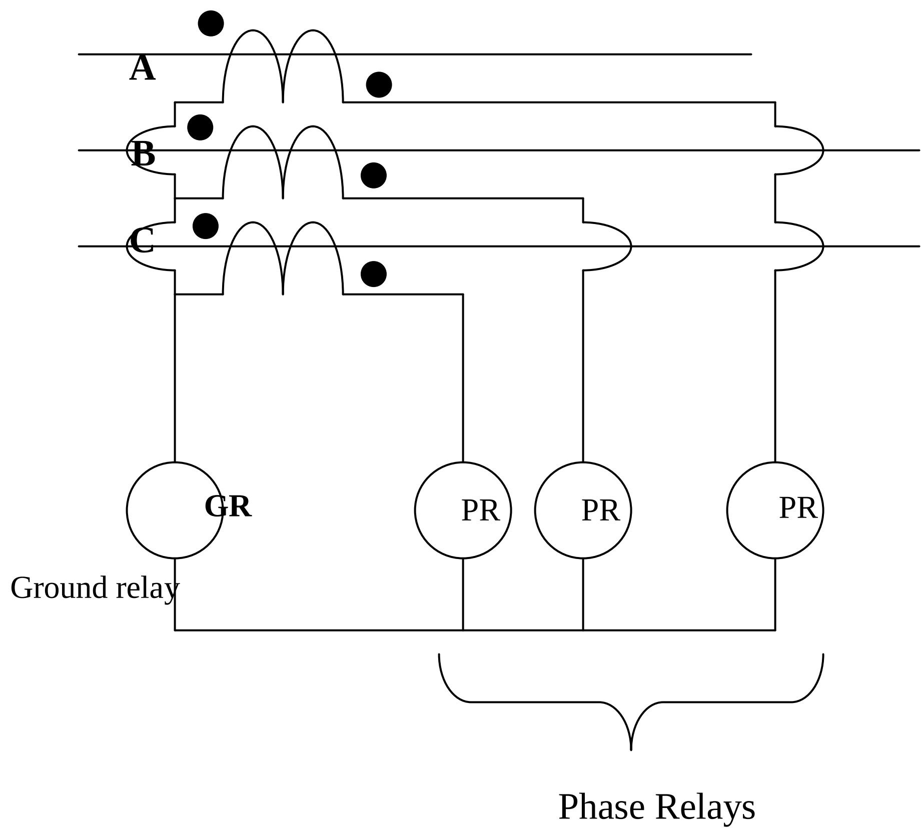
**Fig (6) Normal Inverse characteristic of overcurrent relay**

## Appendix A:The program of three phase overcurrent relay

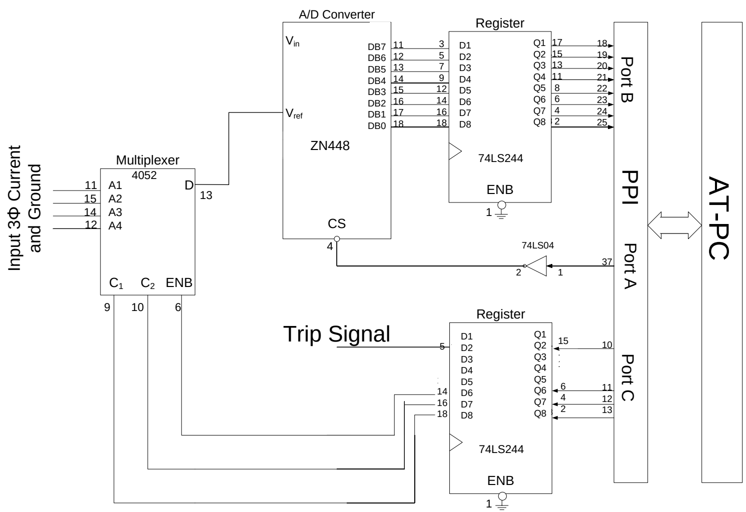
```
#include<stdio.h>
#include<dos.h>
#include<math.h>
#define pi 4*atan
#define cosec(x) 1/sin(x)
Main(){
Unsigned int a[3],c[3];
int z,I,h,l,he,g,j,l,sum,v,t,q;
float a0,a1,a2,a3,a4;
outportb(0x403,0x82)
for(he=0x80;he<=0x82;he++)
{ /* phase selection */
outportb(0x402,he);
label sum=0;
for(z=1;z<=3;z++){
a[z]=inportb(0x401); /* Input samples */
 c[z]=a[z]*0,039-5; /* convert to analog */ g=(c[1]+c[3])*(2*c[2]); if(g>=-
0.039)|(g<=0.039) goto label;
j=cos(g);
h=((c[1]+c[2])*(c[1]+c[2]))-2*(1+g)*c[1]*c[2];
l=cosec(j)*pow(h,1); /* eq. 4 */
sum=sum+1;
v=sum/5.5 /* setting pickup */
while(v>=1) {m=v-1; t=a0+a1/m+a2/pow(m,2)
+a3/pow(m,3)+a4/pow(m,4) ; /* time setting eq 3*/
delay(q);outportb(0x400,1);
goto end ; /* trip signal to circuit breaker */
end:
```



**Appendix B: The connection of the C.Ts of three phase overcurrent relay[10]:**




**Appendix C: The hardware connection of relay design**






# تصميم مرحلة فرط التيار باستخدام الحاسب الدقيق

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**الخلاصة**

مرحلة فرط التيار تستعمل للتمييز بين الزيادة المفرطة بالتيار و تيار الحمل فتقوم المرحلة بفصل الجزء العاطل مع إبقاء باقي أجزاء الشبكة تعمل بشكل طبيعي .

تم في هذا البحث تصميم مرحلة فرط التيار ثلاثية الطور ، تميز التصميم بالقابلية العالية على تحسس تيار العطل بالإضافة إلى إمكانية تمييزه عن تيار الحمل كما أن عن طريق تغيير البرنامج إمكانية تغيير نوع المرحلة (مرحلة فرط تيار أنية أو مرحلة فرط تيار بتأخير زمني) حيث استعملت تمثيل سكاديف لتمثيل منحنيات التيار–الزمن العكسي لما لهذا النوع من دقة عالية و مرونة في الحصول على إي نوع من المرحلة و ذلك بتغيير المعاملات فقط ، بالإضافة إلى استعمال طريقة القياس أظهرت السرعة العالية حيث تم قياس التيار في اقل من نصف دورة أي بحدود 10 ملي ثانية . تم اختبار المرحلة و أظهرت النتائج الكفاءة العالية للتصميم الكمي على جلب البيانات بسرعة عالية و على تحسس تيار العطل و إعطاء إشارة الفصل لقاطع الدورة و تمييزه عن تيار الحمل .