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King Fahd University Of Petroleum and Minerals Electrical Engineering Department Negative Sequence Digital Relay



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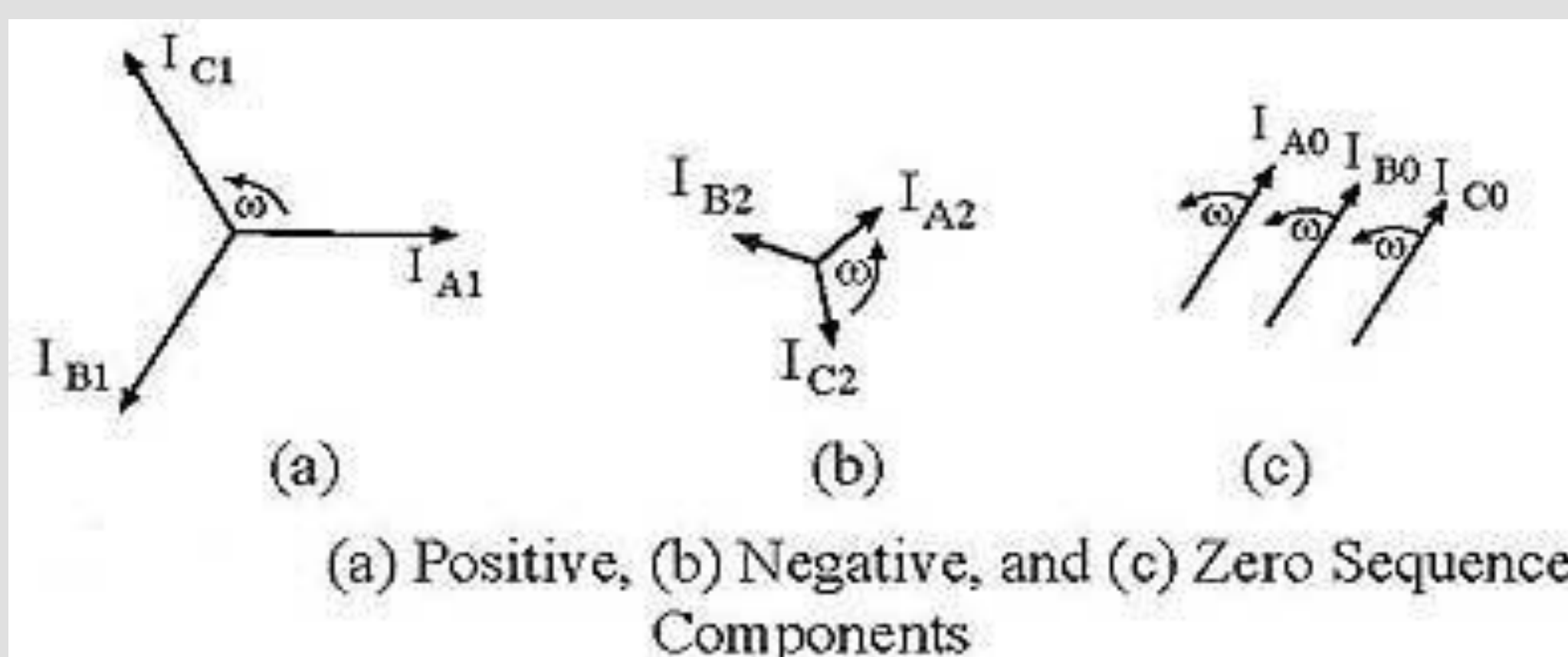
Objective

The goal of this project is to build a microcontroller-based negative sequence relay for protecting power system from unbalanced conditions, specifically, negative sequence current. The digital relay mainly consists of a conditioning circuit and a microcontroller. A long with the digital relay, designing and testing of the current transformer, conditioning circuit and the circuit breaker was done successfully. An algorithm of the protection scheme was developed. Finally, the protection scheme results were discussed and verified.

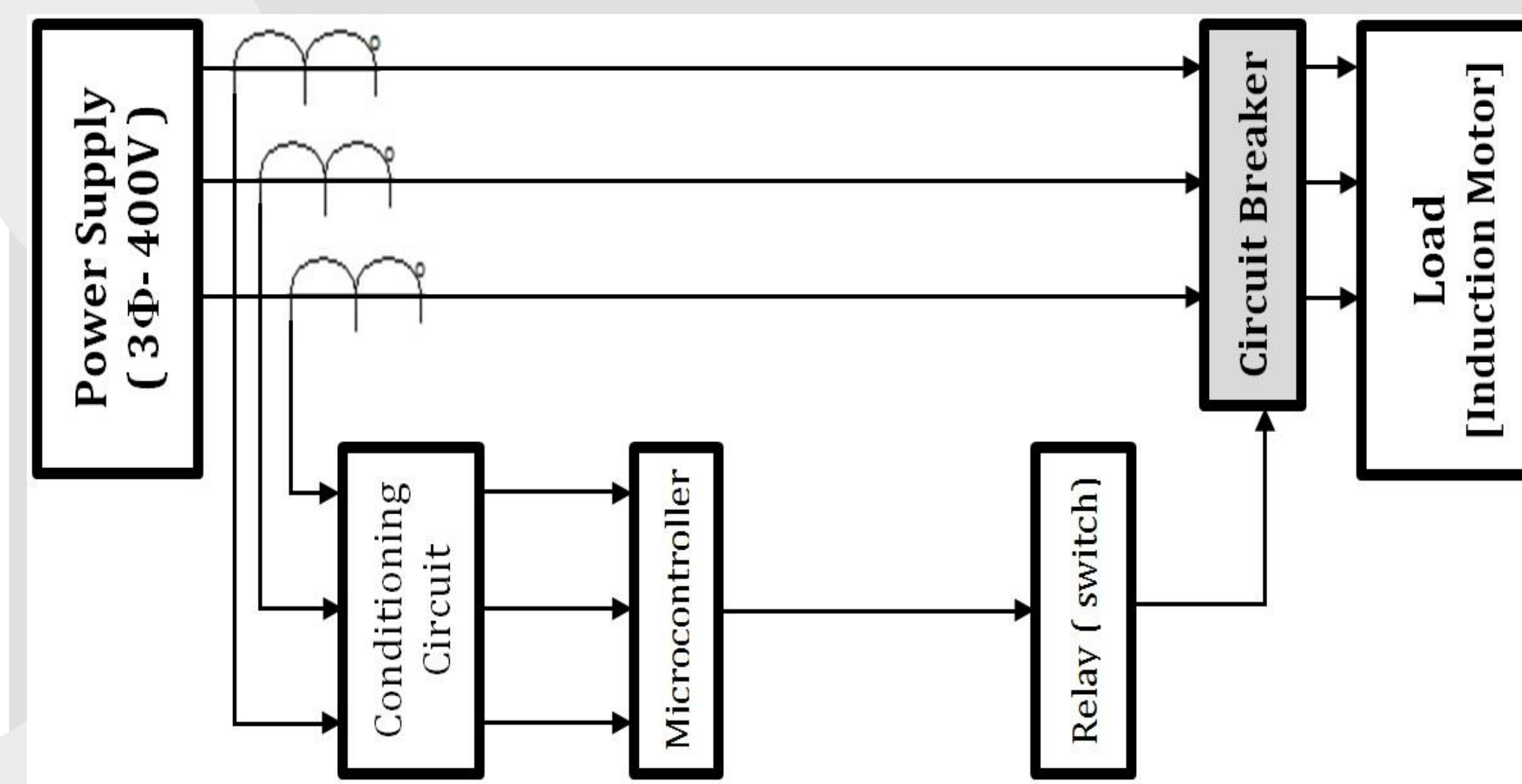
Negative Sequence Current in Focus

- In three-phase system, a fault may involve one or more phases and ground, or may occur only between phases.
- A fault may affect all phases equally which is a "symmetrical fault. However, if only one or two phases are affected, the resulting "unsymmetrical fault" appears. The calculations for this type of fault is made on assumption of three phase balanced systems.
- When actual faults occur In electrical power system, the system becomes unbalanced. Meaning, the conditions of voltages and currents in all phases are no longer symmetrical. Generally three phase vector diagram may be replaced by three sets of balanced vectors. One has opposite or negative phase rotation, second has positive phase rotation and last one is co-phasal.(see the figure below).

$$I_{a2} = \frac{1}{3}(I_a + a^2 I_b + a I_c)$$



The Integrated Protection Scheme



Equipment's Design

Current Transformer

As different Current Transformers were scrutinized, LEM (LA25-NP) was found to be the most suitable one.



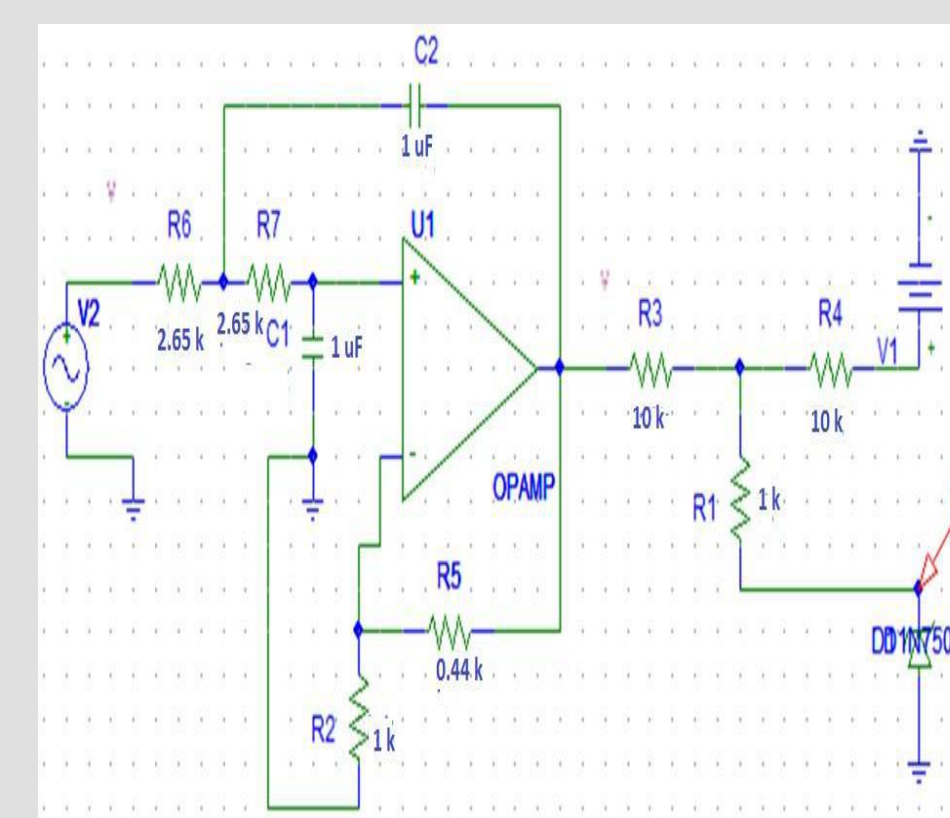
Circuit Breaker

As different circuit breakers were looked into, Allen-Bradley was found to be perfectly suitable. This circuit breaker needs a 120V as an input to trip.



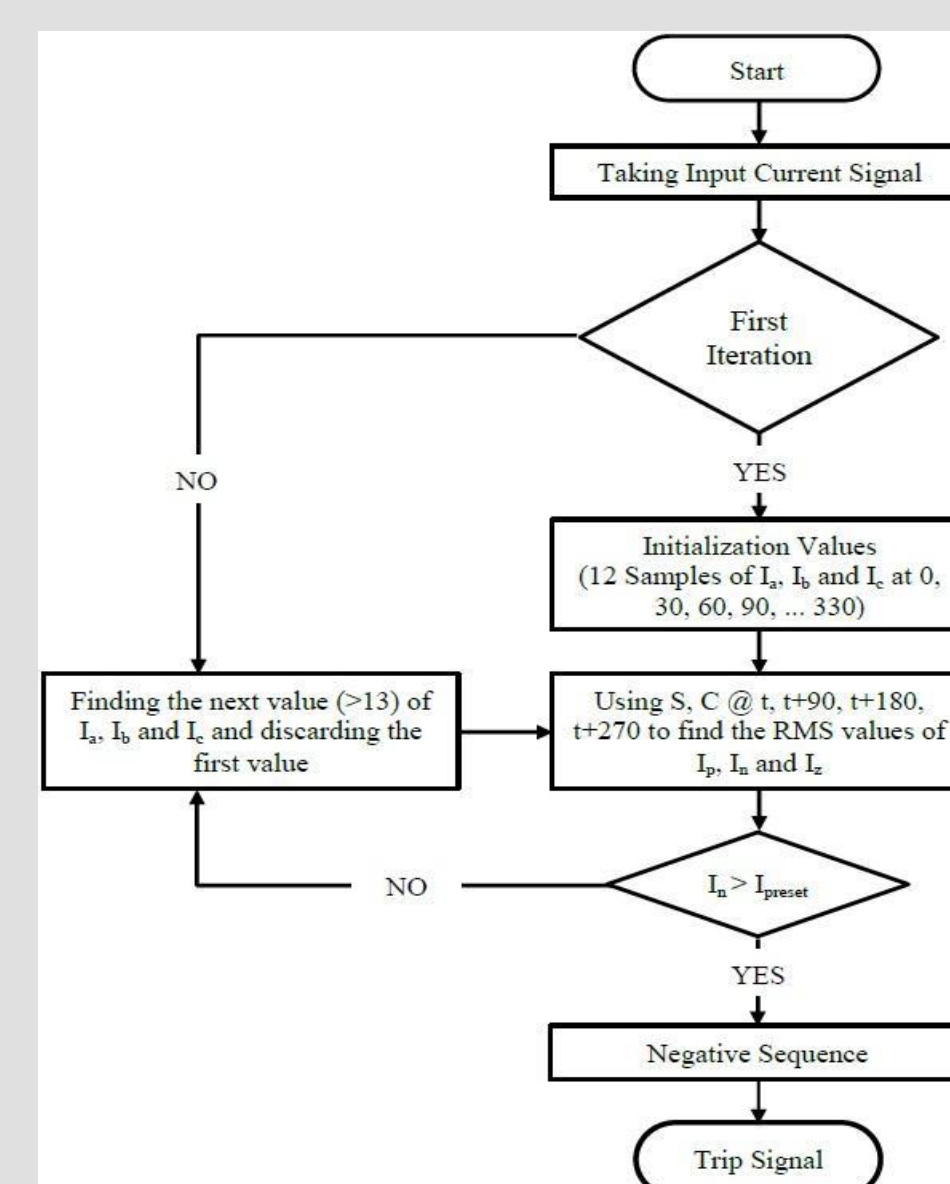
Conditioning Circuit

For designing the filter, a second order low pass filter was needed. Therefore, Sallen-Key topology was used as it was found to be the most suitable one for the design. The Sallen-Key topology, has a well damping ratio and a quality factor

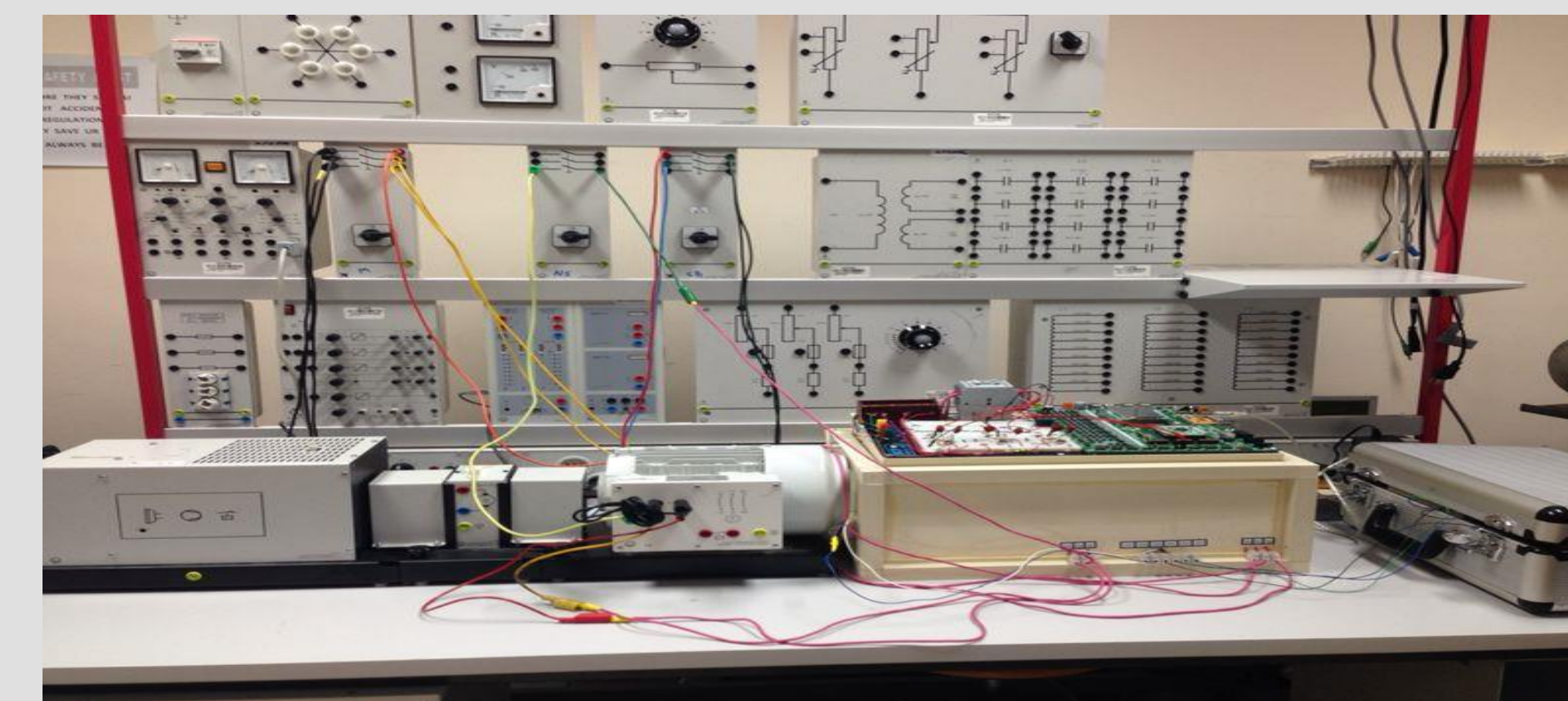


Microcontroller

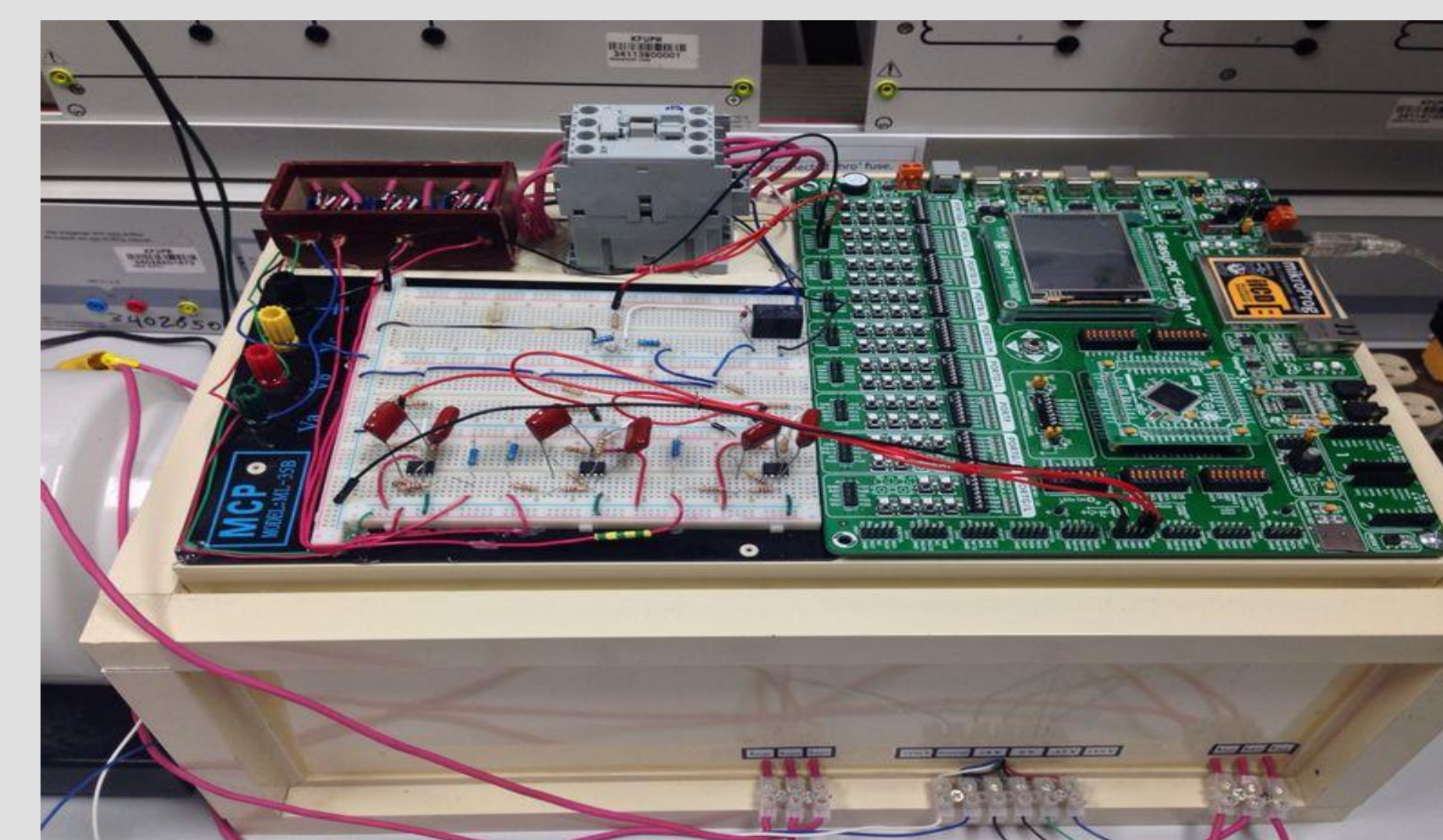
The microcontroller kit that was used is dsPIC 33FJ256GP710A.. The algorithm structure was programed into the microcontroller.



Results.



The digital relay connected to an input of 400v, output to an induction motor as load



A picture of the Digital Relay (Microcontroller and Conditioning Circuit) along with the Current Transformer and Circuit Breaker



As seen, when the circuit in in normal operation , the microcontrollers display indicates the status(Normal Operation)



When A fault occurs , the digital relay intervene and initiates a tripping signal to the circuit breaker. In the mean time, the microcontroller display indicates the circuit statuses which is tripped

Conclusion

In this project, the design and implementation of a negative sequence current relay was successfully accomplished. After that, the testing and verification of the validity of the components was done ,both , individually and in the integrated protection scheme. However, along the process of completing the project, several obstacles were challenging. Nevertheless, these obstacles were overcome successfully with a tremendous team-work effort.

Advantages and Disadvantages

- Advantages :
- I – Cheap Price
 - II – Easily Maintained
- Disadvantages:
- I – Inconveniencing in reprogramming
 - II – Occupation of large space

Cost Analysis

Component Name	Number of Components	Cost in SR
Conditioning Circuit	*****	
Capacitor(1 uF)	6	56
Resistors(440 Ω)	3	1.5
Resistors(1kΩ)	6	3
Resistors(2.7k Ω)	6	3
Resistors(10k Ω)	6	4
Zinler Diode	3	1
Current Transformer	3	410.58
Microcontroller	1	1864.8
Circuit Breaker	1	165
TOTAL(SR)		2508.88

Keeping in mind, a similar Digital Relay for, the market would cost around 40, 000 SR