RESEARCH ARTICLE OPEN ACCESS

Adaptive overcurrent relay for the rural Agricultural feeder Based on Niranthara Jyothi Yojana

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ABSTRACT
In certain states like Karnataka and Gujarat of India, farmers are provided with free 3-phase power supply to run their irrigation pump-sets under schemes like Niranthara Jyothi Yojana (NJY). Under this scheme, the rural feeders were bifurcated into agricultural feeders and non-agricultural feeders in order to facilitate 24 hours Supply for Non-agricultural Consumers and 8-10Hrs Supply for Agricultural Consumers. Due to power shortage, the 3-phase supply at the agricultural feeder is given only during the off-peak hours. Rest of the time, the supply is either 2-phase or the feeder is under Load Shedding. 2-phase supply at the station is given exclusively for lighting purpose at Farm houses. But, this 2-phase supply is being illegally tapped and converted to 3-phase by using condensers. Although, this is reflected in the sub-station load curve, it often takes time to detect such misuses.
The conventional Overcurrent relay fails to respond to this misuse, unless the set points or pick up values are changed appropriately by human intervention, often the locals influence the substation personnel to keep the set points in such a way that the misuse is not reported. This, at times, may cause cascading disasters in the power system.
The proposed relay would not only act as a protective element at the feeder, but also detect the misuse and trip the respective feeder by changing the set points appropriately without involving any human activity, eventually increasing the security of the system. Proposed relay has two working states namely active state and the event log state. The Event log keeps record of the events with real time and date by making use of Real time clock (RTC). This relay also consists of a GSM module which sends SMS to farmers and utility heads regarding the supply status.
***Keywords* –**Adaptive protection, Open delta Operation, Group operated switch (GOS), Irrigation pump sets (IP sets), Numerical Overcurrent relay, Special Design Transformers(SDT)

I. INTRODUCTION

With the increasing loads, voltages and short-circuit duty of distribution substation feeders, distribution overcurrent protection has become important in today's scenario.

The rural feeders were bifurcated into agricultural feeder and non-agricultural feeder through Innovative Programme called Niranthara Jyothi Yojana in the utility of Karnataka as shown in Fig1.

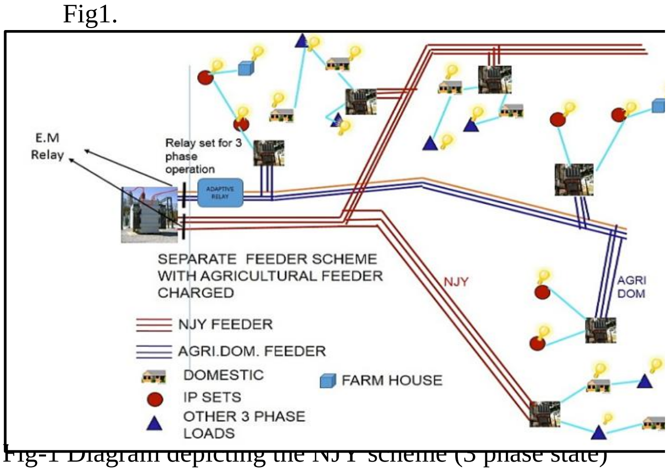

Fig-1 Diagram depicting the NJY scheme (3 phase state)

The above Innovation Programme helps to get 24 hours Supply for Non-agricultural Consumers and 8-Hrs Supply for Agricultural Consumers [1] as shown in Fig- 2. The following were the problems faced by Niranthara Jyothi Paper, Duration of interruption was increased in NJY feeder due to unauthorized loads in the agricultural feeder (IP set feeder), transformer failure rate increased and quality of power also has decreased.

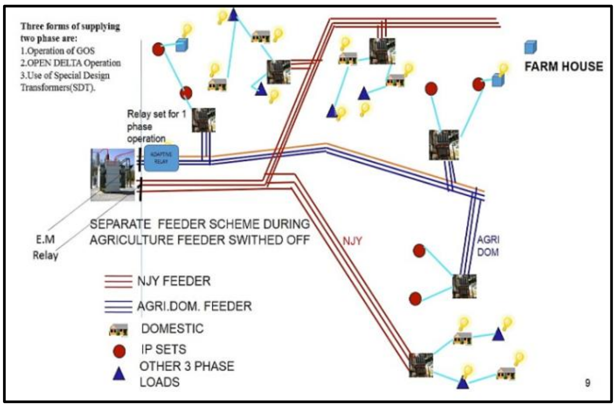

Fig-2 Diagram depicting the NJY scheme (2-phase state)

The proposed relay will be used in serieswith the existing electromechanical relay whose set points are that of three phase supply and remain unchanged throughout.

The proposed relay comes into picture with its adaptive nature, that is, it changes its set points according to the type of supply given(2-phase or 3-phase). It can be used only for GOS and OPEN DELTA operations as shown in fig3.

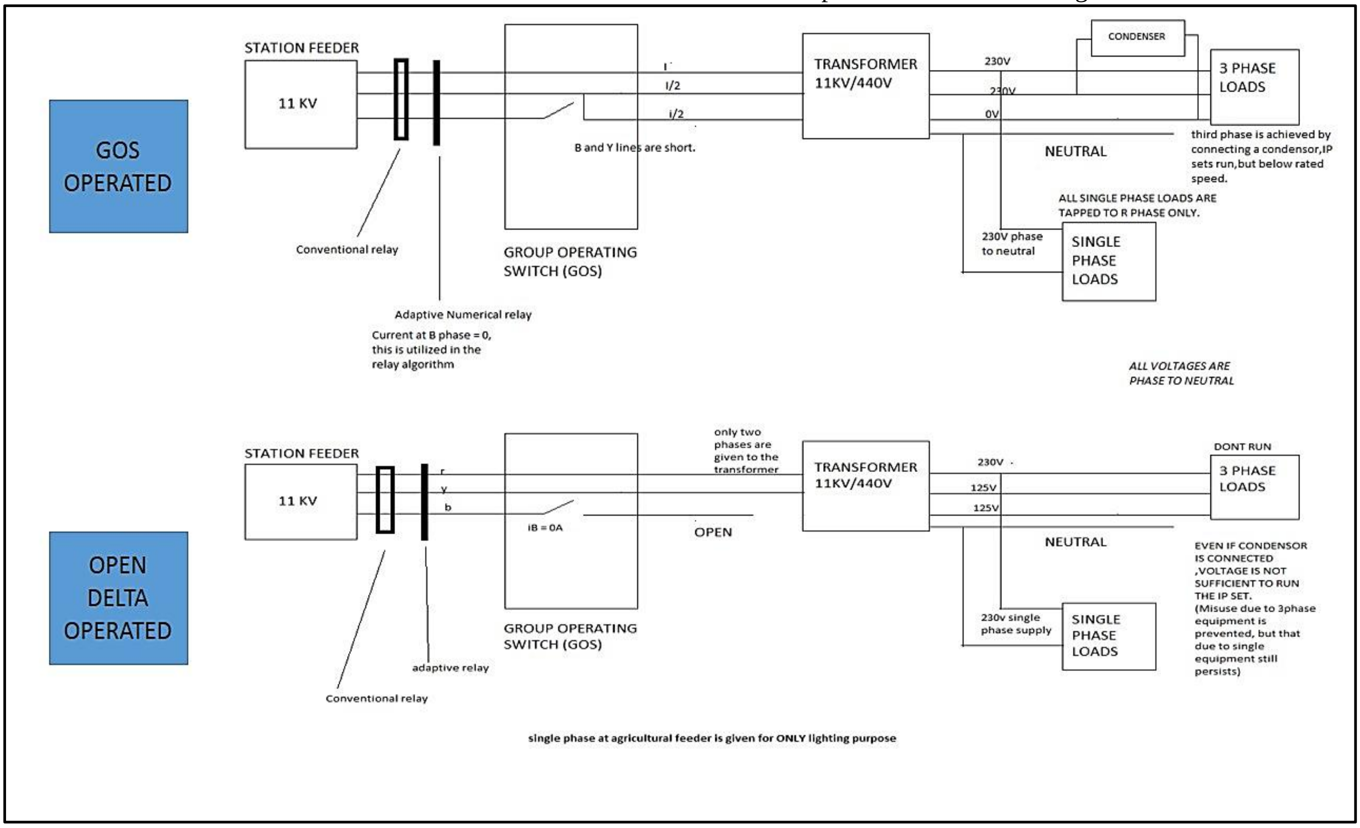

Fig-3 Diagram depicting the ways in which 1phase is given at the load end.

It checks if any of the line currents are zero, if yes it changes the set points to that of 2-phase supply, if not, it remains at the set points for 3-phase supply itself. The proposed relay is in default, set at 3-phase pick up value upon reset or upon charging the feeder.
All the pick-up values are set by testing it on the feeder, by the relay testing unit of the distribution company.

So, this relay can be used to trip the feeder automatically when the load increases than what is estimated(when there is misuse) during 2-phase.
When the proposed relay is placed along with the conventional relay, this relay takes care of any misuse at the agricultural feeder, and conventional type takes care of all line faults. Their time of operation differs as they are set at different time settings [2-5]. The conventional electromechanical relay follows the standard 1.33 sec IEEE IDMT curve or extreme inverse curve [6-8], whereas the proposed relay is a definite time relay in 2-phase supply state. The Objectives of this paper are as follows:

- The proposed relay will replace the currently used costly Special Design Transformers current being used, this is more simple, economical and beneficial in all aspects.
- This relay will be used in series with the existing electromechanical relay whose set points are same as that of three phase supply which remains unchanged throughout. The proposed relay comes into picture with its adaptive nature, i.e. it changes its set points according to the type of supply given (2-phase or 3-phase).
- This relay can be used for both GOS and OPEN DELTA operations [Appendix 1].So, proposed relay can be used to trip the feeder automatically when the load increases than what is estimated (when there is misuse) during 2-phase.
- When it is placed along with the conventional relay, proposed relay takes care of any misuse at the agricultural feeder during 2-phase supply state, and conventional type relay takes care of clearing all the faults.
- Their time of operation differs as they are set at different time settings. Proposed relay will also act as a control unit for EM relay i.e. any trip

signal generated by the conventional relay will pass through the proposed relay as an external interrupt.

- It also comes with a RTC and a GSM module to keep real time event log and to send messages about the status of the feeder to concerned authorities.

II. SIMULATIONOF A MODEL FEEDER

Simulations were conducted to analyse the nature of faults that the proposed relay would come across at the feeder.

MATLAB- Simulink was used for this purpose [9-11].

Considering a simple feeder system with total 3-phase load of 900KW and Total 1phase load of 70KW.The Orange block in fig 4 is the proposed adaptive relay where the set points change automatically with the change in system parameters.This system is a 11KV agricultural feeder, where the max load current during 3-phase is 9A (relay setting = 130%) and maximum load current during 2-phase supply is 4.3A (relay setting = 60%) , 3 locations are taken, where location2 is close to the station and other 2 locations are 10KM away from the station. Each location block will have a transformer of 315KVA, 400/11000V, 1phase loads and 3-phase loads tapped accordingly as shown in fig 5.The distribution parameters are mentioned in table I.

TABLE I. Distribution parameters [11]

Positive sequence resistance R1, Ω/KM	0.01809
Zero sequence resistance R0, Ω/KM	0.2188
Positive sequence inductance L1, H/KM	0.00092974
Zero sequence inductance L0, H/KM	0.0032829
Positive sequence capacitance C1, F/KM	1.2571e-008
Zero sequence capacitance C0, F/KM	7.8555e-009
Length KM	10

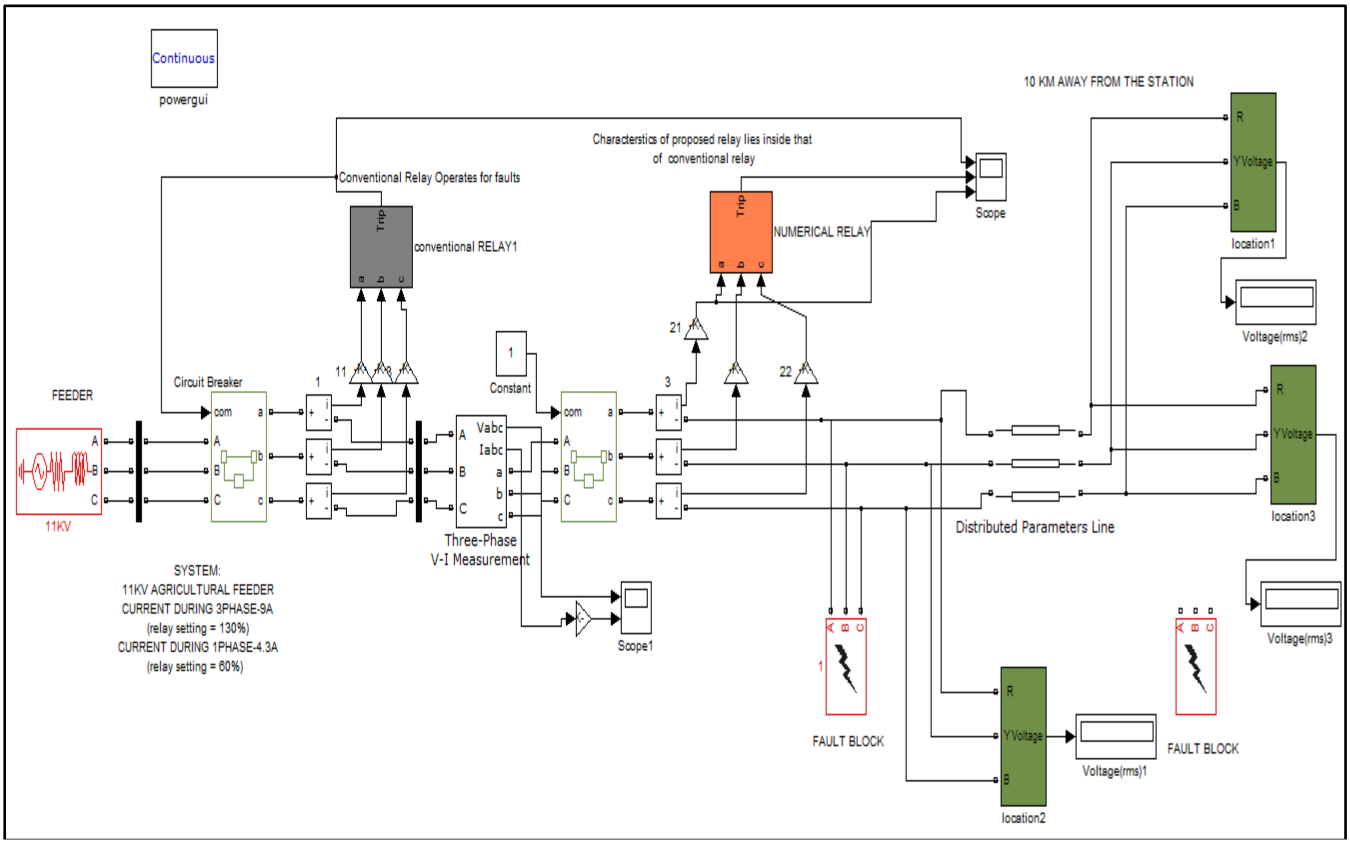

Fig-4 Simulated circuit on Simulink-MATLAB

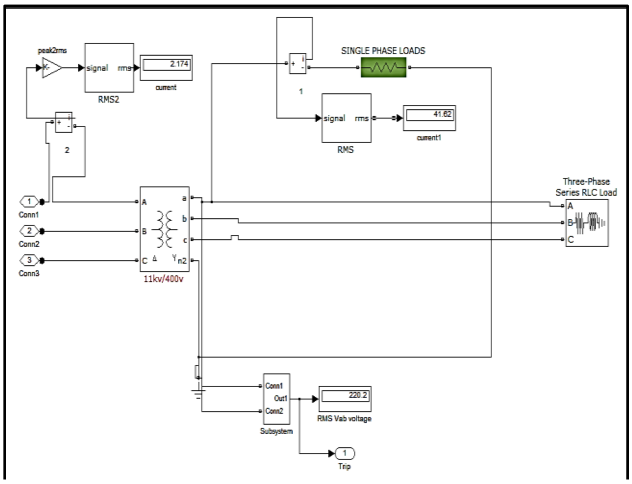

Fig-5 Blocks inside the Subsystem-Location

III. Simulation results:

When a 3 phase fault occurred, peak value of current was 790A. RELAY OPERATION TIME found to be =0.027sec(in accordance with the formula- t=80/((I/Is)^2-1) [2],where I=790/sqrt(2)A and Is=9A Only the Electromechanical relay reacts to the fault instantaneously, the proposed relay also reacts to the faults, but as it is a definite time relay, it gives out a trip signal after the electromechanical relay.

Load Current is 9A, a 3-phase fault is timed to occur at t=0.2sec, currents shoot up to 790A (peak), Relay operation time = 0.027sec.

Similarly, different faults were simulated near the station and 10KM away from stationfor three phase faults and double line faults shown in Fig-7 and Fig-8.Suppose any fault occurs after the transformer, the protection at the transformer clears it and the proposed relay is in inoperative state[12] as shown in Fig-9.

When any misuse happens during 2-phase operation, the proposed adaptive relay automatically changes its set points to that of single phase pick up values(60%) as seen in fig 10, conventional relay set points are at that of 3-phase pick up value itself (135%).Thus adaptive relay generates a trip signal when current in the line exceeds the pick-up value during 2-phase state.

Similarly, when a fault occurs at the station during two phase state, the proposed relay remains operates only after the electromechanical relay has cleared the fault as shown in Fig-11.

When current exceeded 4.3A(60% current setting) during 2-phase state,onlyThe proposed relay operates as seen in Fig 7. Electromechanical relay remains inoperative and feeder open is indicated by current in R phase.

IV. CONTROL PANEL AT THE 11KV FEEDER

The power supply required is 110V DC for conventional EM relay. Whereas 12V DC is sufficient for microcontroller based adaptive relay, both are available at the feeder. Both the voltages can be tapped at the panel.The Proposed relay will be in series with the conventional relay. Whenever a 3-phase fault occurs, the EM relay responds to the fault instantaneously and generates a trip signal. This trip signal acts as an interrupt to the microcontroller of the adaptive relay and in turn it generates a trip signal. This signal is fed to the contactors which initiate the circuit breaker to act accordingly. This is done so because circuit breaker takes only one input and hence two trip signals are avoided.

When any overload happens during single phase operation the adaptive relay senses and generates trip signal which activates the circuit breaker to trip the feeder.

Simulation Graphs:

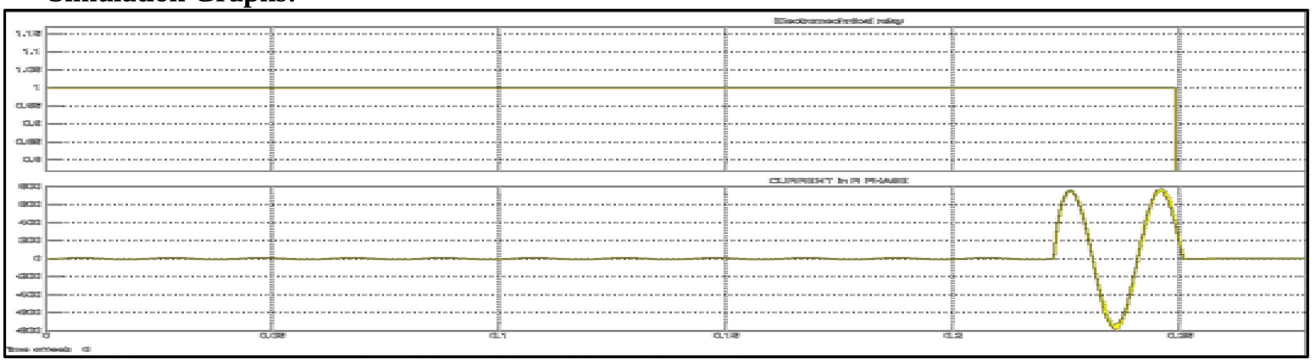

Fig-6 Scope showing the trip signal and current in R phase for 3 phase Fault at the station

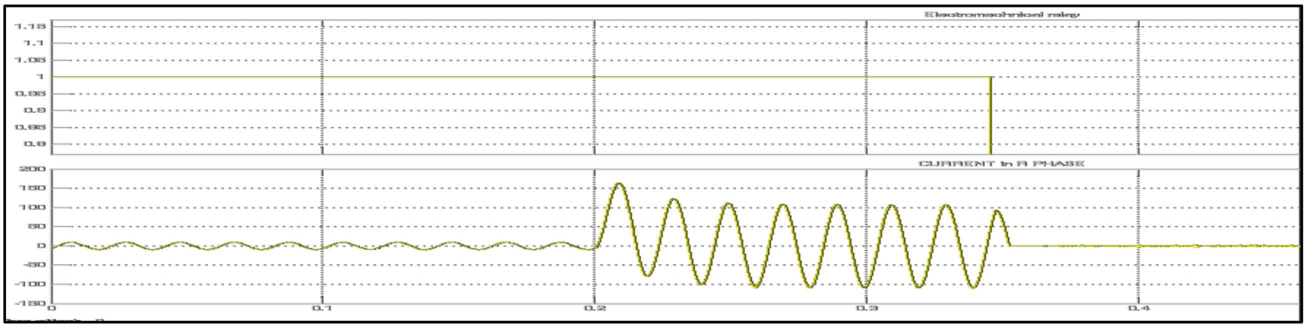

Fig-7 3-phase Fault 10km away from the station, Relay operation time = 0.15 sec

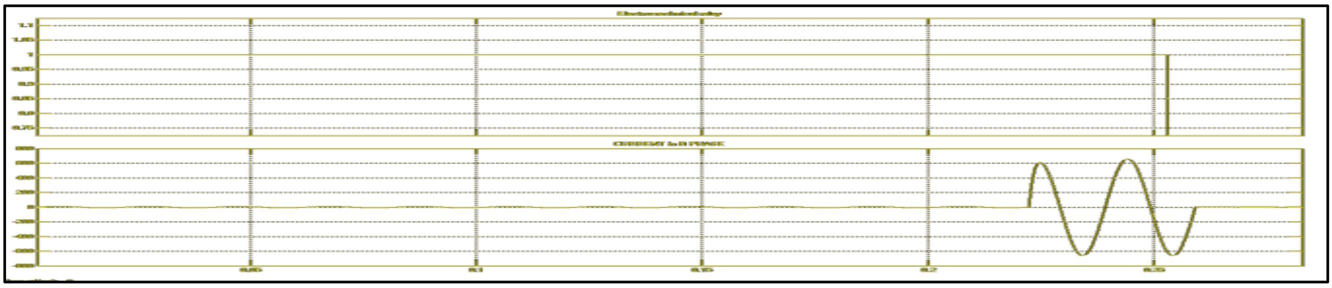

Fig-8 Double line faultoccurring at a location close to station

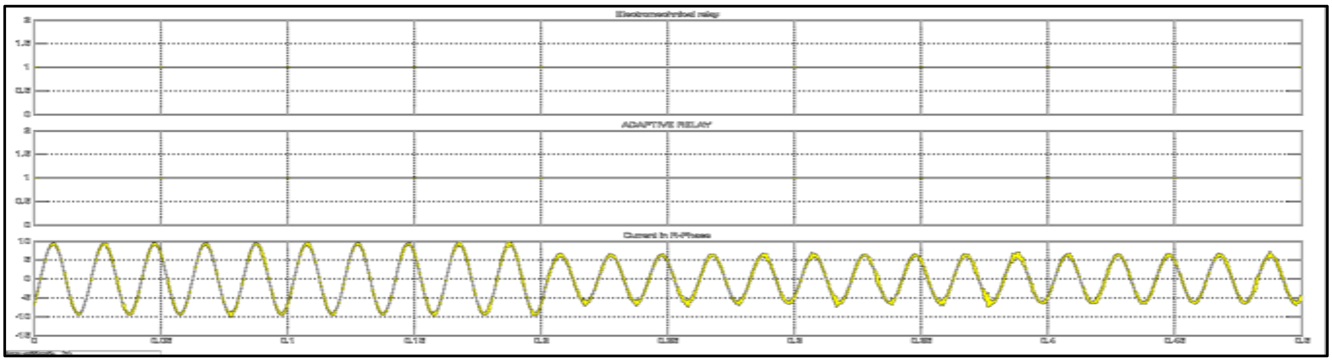

Fig-9 Fault after the distribution transformer

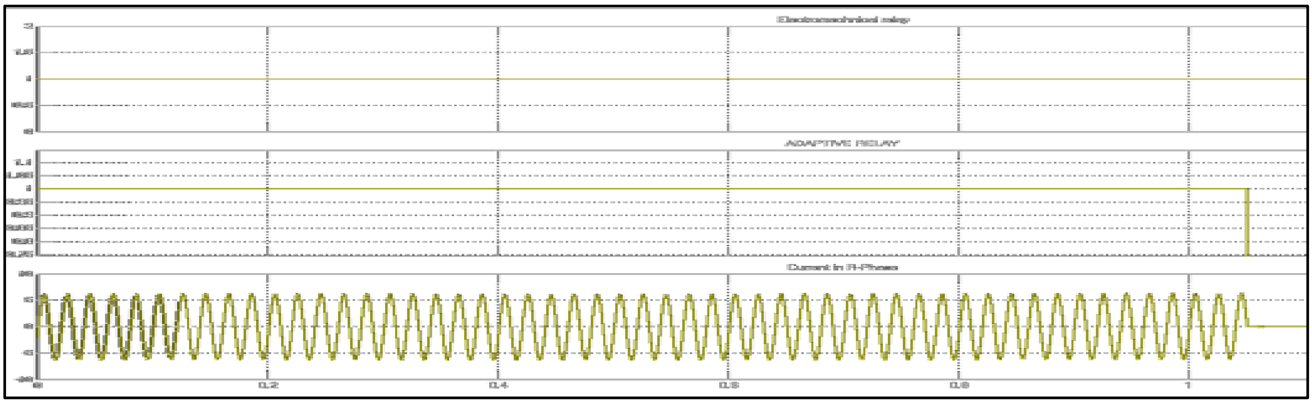

Fig-10 2-phase state (B phase OPEN): overloading(Electromechanical relay doesn't react)

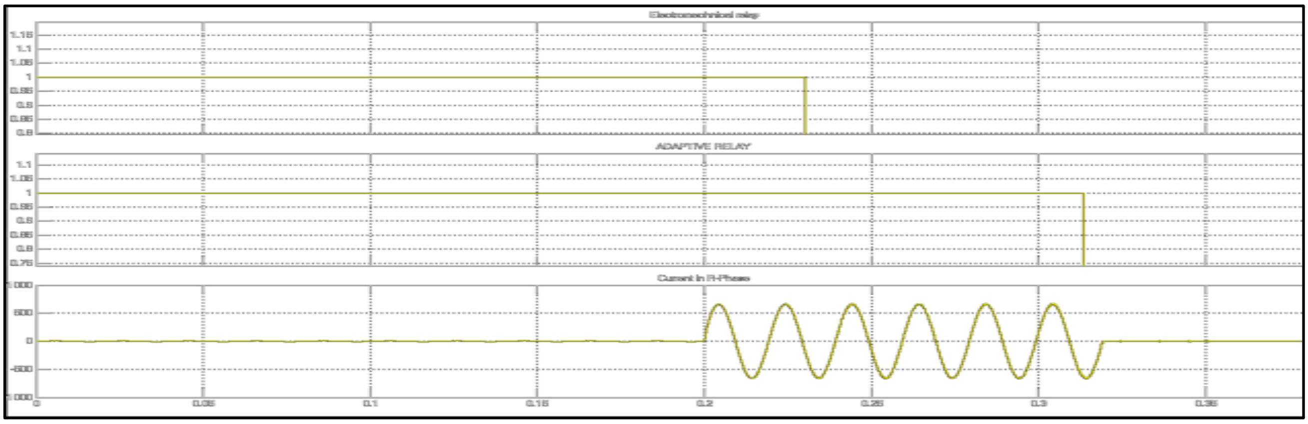

Fig-11 2-phase state: fault occurs near the station(by the time the proposed relay reacts- the electromechanical relay would have already cleared the fault)

V. DESIGN PROCEDURE AND WORKING

The above block diagram shows the overall operation of the prototype. Since the current flowing in the power lines are of alternating nature, they are not compatible with the microcontroller. Hence it has to be made compatible to the microcontroller. This is done using current transformers, I to V converters, and bridge rectifiers. I to V converter converts current into corresponding voltage signal. This is done so to provide input voltage to the Microcontroller through a rectifier. A 10 ohm, 25W wire wound resistor is used for this purpose.

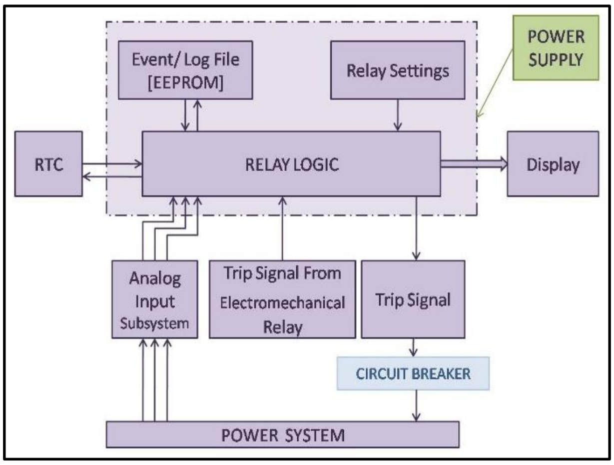

Fig-13 Structural design blocks of proposed relay

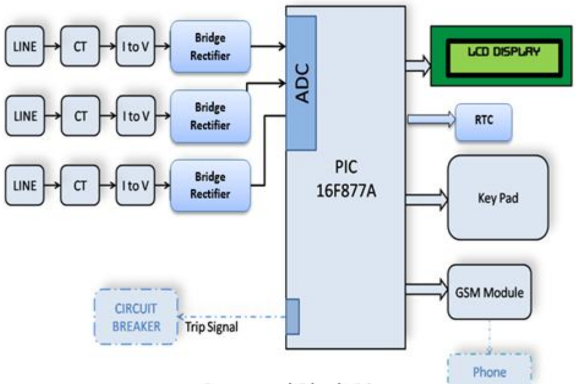

Fig-14Basic block of Proposed Relay

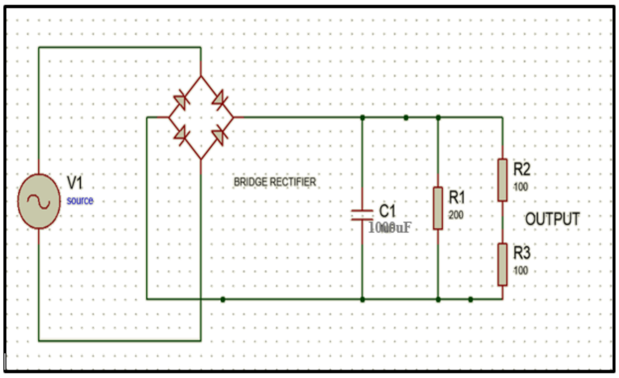

Fig-15 Bridge rectifier used

A capacitor filter is used in parallel with the bridge rectifier to reduce the ripple in the output voltage [13].

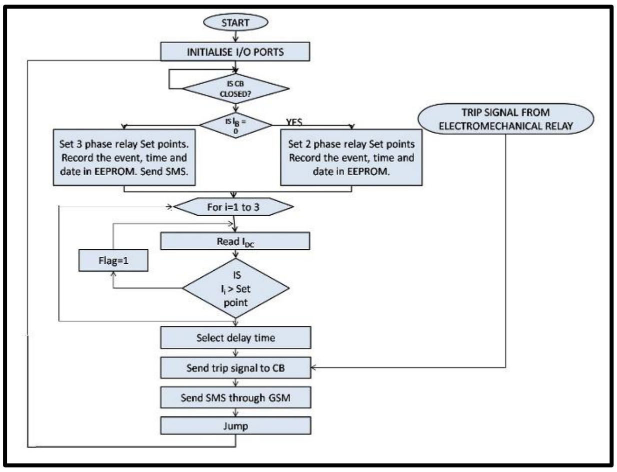

Fig-16 Flowchart depicting the algorithm used in the proposed relay

Table2: output values at the bridge rectifier

Vac in Volts (input voltage to rectifier)	Vc in Volts (Across capacitor)	Vr1 in Volts (Across the op resistor)
.6	.0332	.0165
.8	.226	.111
1.2	.66	.327
1.5	.982	.485
1.8	1.38	.683

Hardware was initially simulated on Proteus, and later on successfully implemented physically as well.

Proteus is a package for microcontroller/microprocessor simulation, schematic capture and PCB design. It is developed by Labcenter Electronics. This package helps to test the embedded code before the actual implementation [14-15].

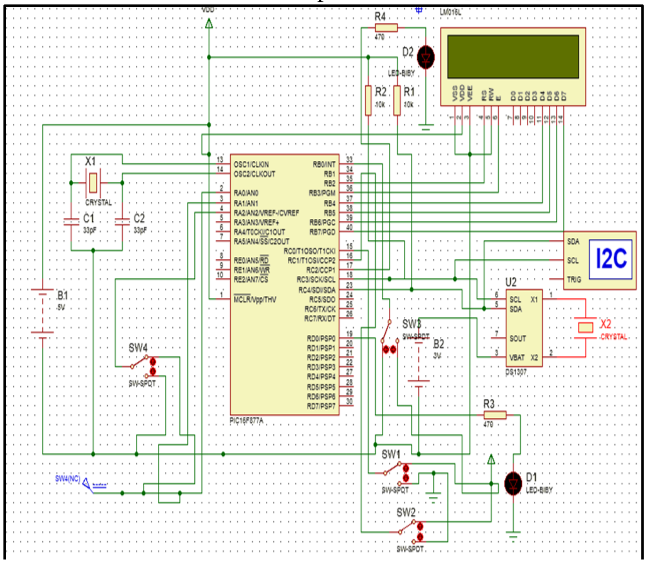

Fig-17 Proteus simulations of proposed relay

The major hardware components and software that were needed to make this paper see the light of day were:

- Current to Voltage Converter
- Bridge rectifier Circuit
- Microcontroller – PIC 16F877A
- 16X2 LCD unit
- GSM module SIM 900
- Current Transformers
- Real time clock(RTC) DS1307

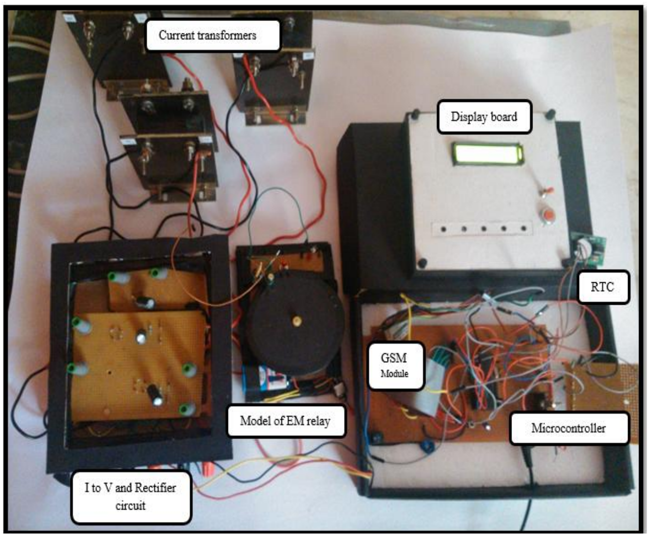

Fig-18 Hardware Implementation

Fig-19 Display on LCD when the feeder tripped during 2-phase

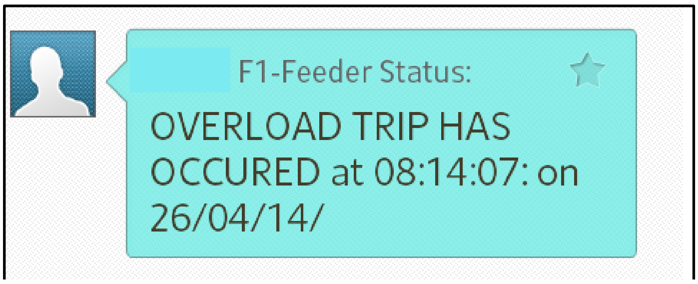

Fig-20 SMS received on mobile when feeder has tripped

This prototype was successfully tested in the laboratory and was found in accordance with the objectives of this paper.

VI. CONCLUSION

- Technology to design the adaptive distribution protection system, utilize computer over current relaying concept, is more expensive than the electromagnetic relays. Adaptive relaying protection being a new protection scheme is a recurring topic on every agenda.
- This proposed scheme helps to overcome the disadvantages of Niranthara Jyothi scheme by using a more economic and simple adaptive relay, this replaces the Special design Transformers, which are not cost effective, proposed relay costs 150 times lesser than the special design transformers.
- All the basic functions of this adaptive relay were checked for and found to be accurate to what was expected. 3-phase overload state, 2-phase overload state and the interrupt signal from the electromechanical relay, all generated a trip signal as expected.
- The proposed relay has two working states namely active state and the event log state. The Event log kept record of the real time and date by making use of RTC.
- The details of the state of supply mainly, 3-phase state was sent to the mobile/s with the real time and date through the GSM module. Also, SMS was sent to the respective mobile/s when the feeder tripped.
- The proposed relay keeps check on the excess load during two phase, this helps in Load management based on allocation given by ALDCs. At tail ends, distribution transformer failure can be minimized or can be even made nil. The set points are automatically changed during two phase (adaptive nature) and thus helps to keep check on excess drawl during 2-phase. Maintenance cost can be reduced by a large extent. Reliability of power supply can be increased.

It is the motive of this paper to bring simple and economic automation to the rural agricultural feeders to prevent misuse of power during 2-phase supply state, by proper implementation of proposed relay and increase the reliability of power to rural areas for betterment of the society.

VII. ACKNOWLEDGMENT

We thank all the faculty members and the laboratory staff of the Electrical & Electronics Department for their constant support in this endeavour. We also would like to thank the officials of the Distribution Systems Division (DSD). We would like to thank the field officers, Krishnappa V of Karnataka power Transmission Corporation Limited (KPTCL), Krishnarajendra and Vadiraja of Bangalore electricity company (BESCOM), who have directly or indirectly helped in execution of this paper and for guiding us through different aspects of this paper and helping us overcome all the setbacks, we faced in the implementation of this paper.We also are thankful to the local utilities for their cooperation and help to get valuable data and information in the field for the practical distribution network.

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