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Design, Construction and Simulation of a Circuit-Breaker Based Feeder Pillar with over current And Earth-Fault Protection Cum Digitalized Voltmeter

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Abstract -This research embodies the design, construction and simulation of a feeder pillar (415VAC) with over-current, overload and earth-fault protection with the aid of a phase sequence relay, contactor, earth-leakage circuit breaker and three-phase overload relay. The analog voltmeters in the various bus-bars (red, yellow and blue phases) in a conventional feeder pillar is replaced with a digital panel voltmeter indicating the voltage across a phase (240V) or line-to-line (415VAC) flowing through the bus-bars. The major reason for this research study is to prevent the constant changing of fuses. It also provides sufficient protection in electric power distribution, and easy identification of faults when encountered. The feeder pillar not only distributes power through the channels but also protects the transformer against damage through the use of the earth-leakage circuit breakers as well as miniature circuit breakers. The panel of the feeder is well earthed against lightning surges that can bring about damage to the distributing system.

I. INTRODUCTION

A feeder pillar is essential in a power system distribution network to distribute electric power (three-phase, 415V ac) from a step-down transformer to the low-tension (LT) lines for the consumers. A default feeder pillar consists of a panel which embodies all other sub-units of the feeder pillar, bus-bars in which are connected the incoming and outgoing lines, an ammeter which records the voltage across the bus-bars, the fuse holders holds the fuses, high-rupturing-capacity fuses for making contact and for protection purposes [1,2]. This project consists of all mentioned above but with a digitalized voltmeter and a phase sequence relay, earth-leakage circuit breaker, three phase overload relay and a contactor used for over-current, overload and earth-fault protection. This will solve the problem of constantly changing the fuses when it blows due to excessive current. The circuit breakers will operate on all conditions (on-load and no-load conditions). This set up protects the transformer from direct faults from the feeder pillar and from the feeder pillar to the 415V LT lines, protecting the bus-bars (incoming and outgoing circuit) [2].

II. DESIGN OBJECTIVES

The purpose of the design of the feeder pillar is to enhance power system protection by introducing relay and breaker instead of high-rupturing capacity fuses, then change the analogue meter to a digital meter and finally introduce a phase monitor to observe the power in the three-phase in case there is a phase failure in the system.The design of the feeder is done in such a way that restoring of power after fault has occurred will be easy such that after fault is cleared, breakers can be put in normal position to restore power. Also, the system is designed in such a way that there will be easy discrimination. After the source, the bus bar is connected next, then the contactor controlled by a switch.The contactor feeds the phase monitor and three-pole circuit breaker which in turn supplies power to the electric-leakage circuit breaker.Itis then referenced to the single pole circuit breaker which then controls the load and the overload relay [3]. The phase monitor indicates the sequence of the three lines of the source. The feeder pillar is made up of some major parameters that enables it performance. These parameters include the phase sequence relay, the overload indicator, the contactor which energizes the load, the three-pole circuit breaker which injects power into the earth-leakage circuit breaker, the earth-leakage circuit breaker used to indicate faults, the digital panel meter for reading voltage ranges, the two-pole switch for the ON and OFF of the voltage meter, the bus chamber which contains the bus bars, the glands used to pass the wires and the cables used for interconnections of these components in the feeder pillar [4]. All these components are used to achieve the purpose of the feeder pillar construction that is to ensure the availability of an appropriate protection.

III. DESIGN SPECIFICATIONS

The design specification include the bus of the bus bars which is 54.5cm by 33.5 cm by 23cm and the steel plate for mounting the earth-leakage circuit breakers, contactors, breakers, phase monitors and overload relay is 55.0cm by 11.5cm, the base holder is 111.0cm by 3.5cm which is in two pairs and the bus bars are 9.0cm by 2cm. The ratings of the electric leakage circuit breaker is 60A, for single-pole circuit breaker is 10A, the three-pole miniature circuit breaker is 15A, a phase sequence or phase monitor is included, a three-phase digital meter is also used to indicate single phase with 220V-240V and line-to-line with a value of 415V. Overload relay is added, the cable ratings and capacity for the three core armor is 6mm^2. The electric leakage circuit breaker outlet is 1.5mm^2, from the contactor to the three-pole circuit breaker is 2.5mm^2, the earthing cables are 6mm and 1.5mm and the earth rod length is 121cm.

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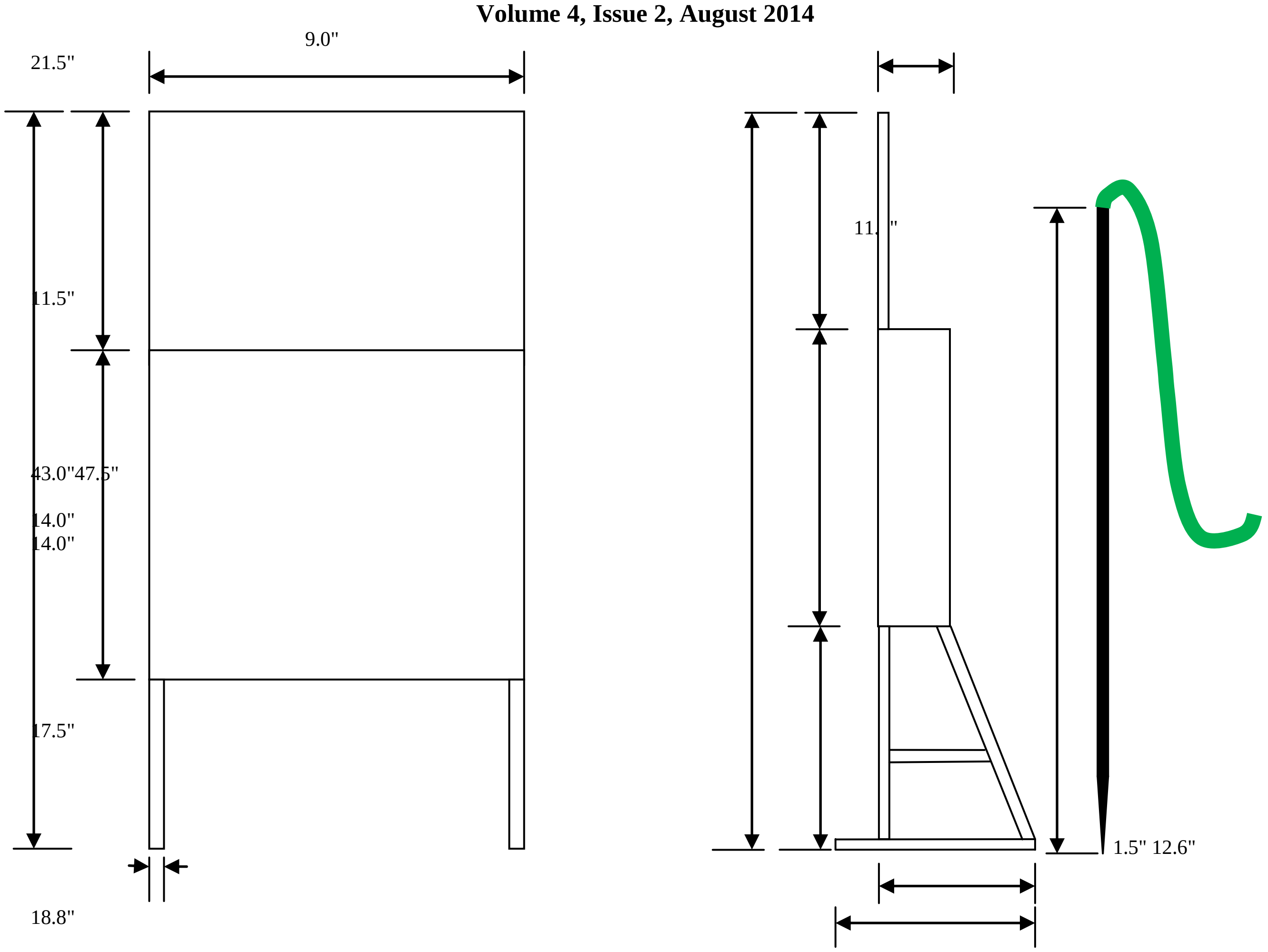

Fig 1: Side view of project work and earth rod.

BLOCK DIAGRAM OF THE SYSTEM

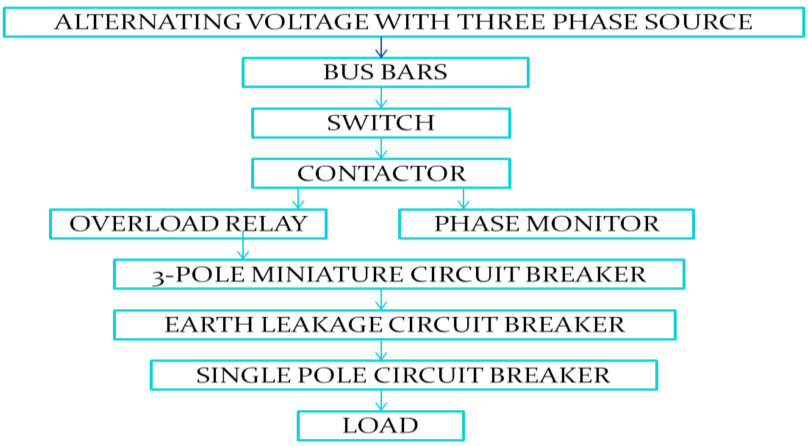

Fig 2: General Block Diagram of Project Work.

IV. METHODOLOGY

Faults occurring in the LT lines and feeder pillars of a distribution system necessitate the constant changing of HRC fuses. MCBs when used in place of these fuses do not require constant changing. This was the driving force for delving into this research.The first step made was to identify and to purchase the materials/components needed (with required ratings and sizes), followed by the detailed construction which included welding of metal parts, cable logging, cutting and sizing of cables (of different sizes), mounting of components and wiring [5,6,7]. After construction, different tests were carried out to ensure that the wiring and all, was okay. The behavior of the system was modeled using sim power systems software in

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MATLAB for normal and abnormal (fault) conditions and results were properly recorded. The alternating current source is got from the step-down transformer. This three-phase source is then connected to the bus bars.Next are the switch and then the voltmeter. The switch controls the contactor and the contactor supplies power to the three-pole miniature, the phase monitor and the electric leakage circuit.The ELCB is thereafter referenced to the single-pole circuit breakers for each phases, then the load and the over load relay are controlled by the electric leakage circuit breaker and single-pole breaker [8,9].

V. DESIGN OF EACH BLOCK OR MODULE OF THE SYSTEM

I. The voltage source, comprising of three-phase supply, is obtained from the transformer after being stepped down and collected from the secondary bushings of the transformer.
II. The design of the bus bar is such that the bars can withstand voltages with pressure from the secondary path of the transformer, mostly voltages of 220-240V without burning up.
III. The switch is present to control the whole contact and the whole system in large.It is designed to ON and OFF as a phase is connected to the contactor terminal.
IV. The design of the contactor is done in such a way that the contactor contains the main contacts and the auxiliary contacts which feed the whole set-up like the three-pole circuit breaker and three phase monitor.
V. The three-pole circuit breaker is energized to feed the different electric leakage circuit breaker with the same amperage rating.
VI. The phase monitor is designed in such a way as to designate the status of the three different phases and is indicated by showing the red light if the three-phase is operational, but it is not active if the three-phase is not active.
VII. Electric leakage circuit breaker is designed in a way as to detect earth fault at any interval of fault and discriminate immediately so as to isolate fault. Also over current and short circuit can be detected by this circuit breaker.
VIII. Single-pole circuit breaker is also referenced to the electric leakage circuit breaker so as to isolate with capacities of whatever load will be attached to the system.
IX. The load consists of the consumers in the different locations, with different appliances whether inductive, capacitive or resistive loads consuming power from the feeder.
X. The overload relay indicates overload which trips the electric leakage circuit breaker, that is used mostly where reservoirs is installed with automatic control as the float signals the circuit breaker to trip on its own [10,11].

SIMULATION OF THE DESIGNED SYSTEM USING SIMPOWERSYSTEMS (MATLAB)

1. Simulation with one breaker, three-phase measurement and no fault

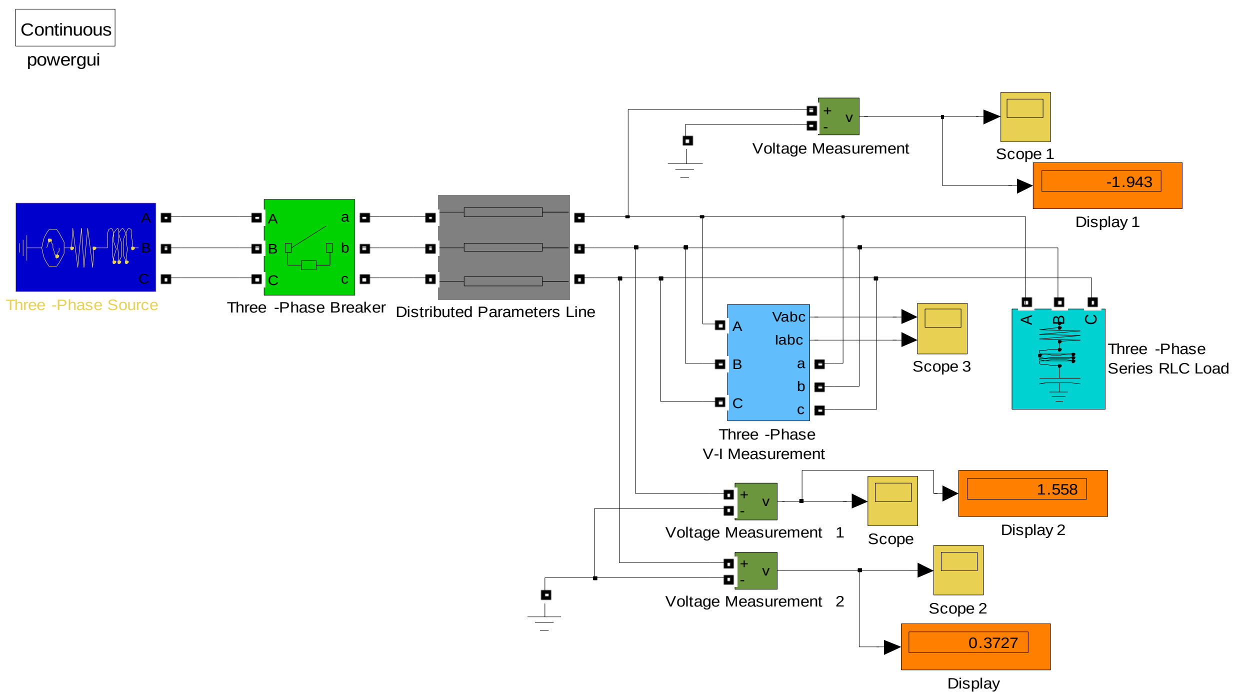

Fig 3: Simulation with one breaker and no fault.

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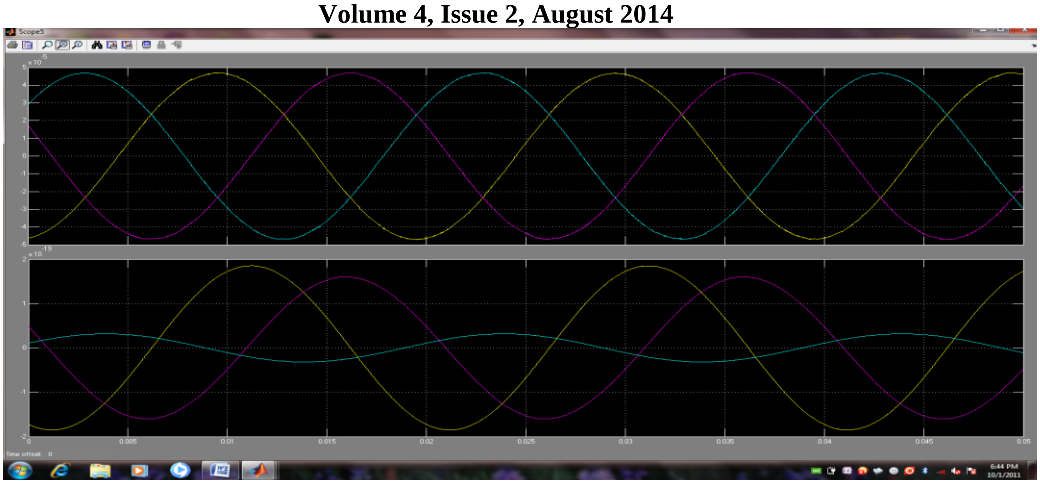

Fig 4: Voltage and Current signal for all three phases.

2. Simulation with one breaker, three-phase measurement and fault before first breaker

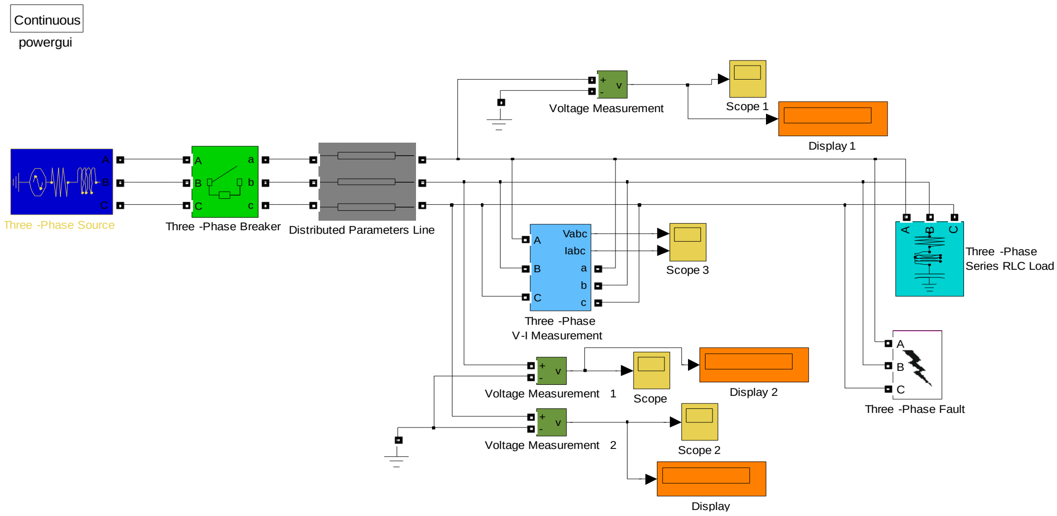

Fig 5: Simulation with one breaker, three-phase measurement and fault before first breaker.

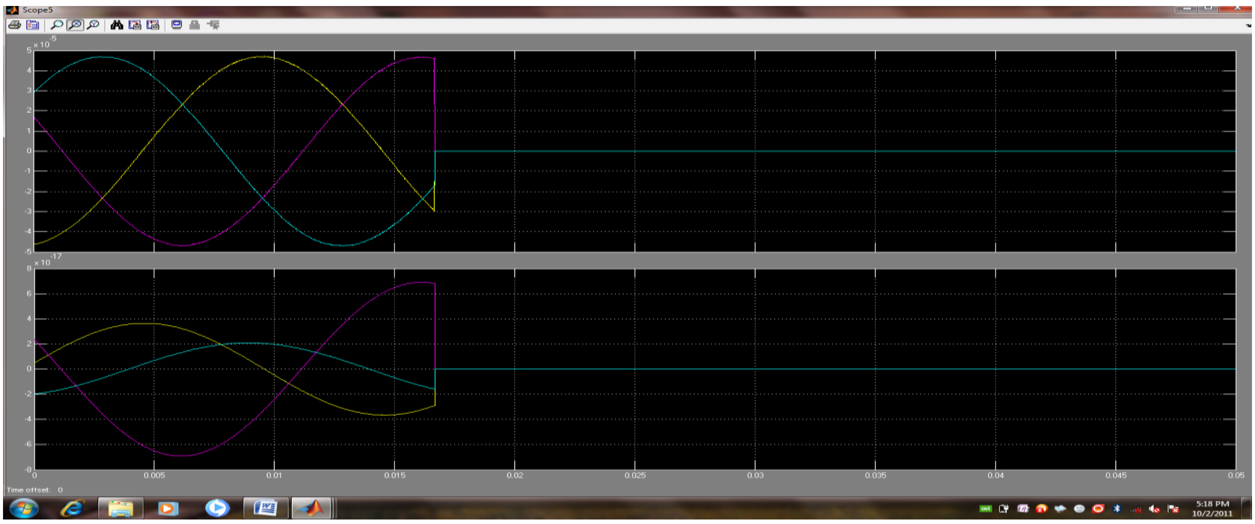

Fig 6: Voltage and current signal with fault before load.

3. Simulation with one breaker and fault before the breaker

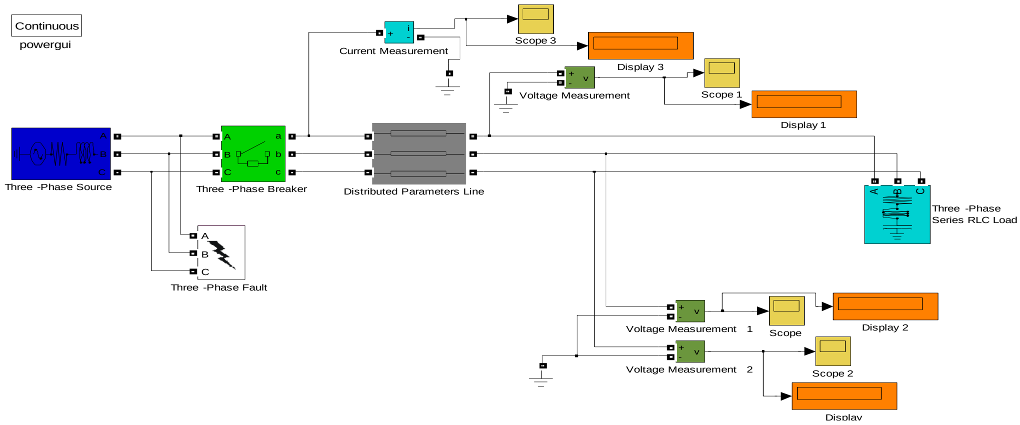

Fig 7: Simulation with one breaker and fault before the breaker.

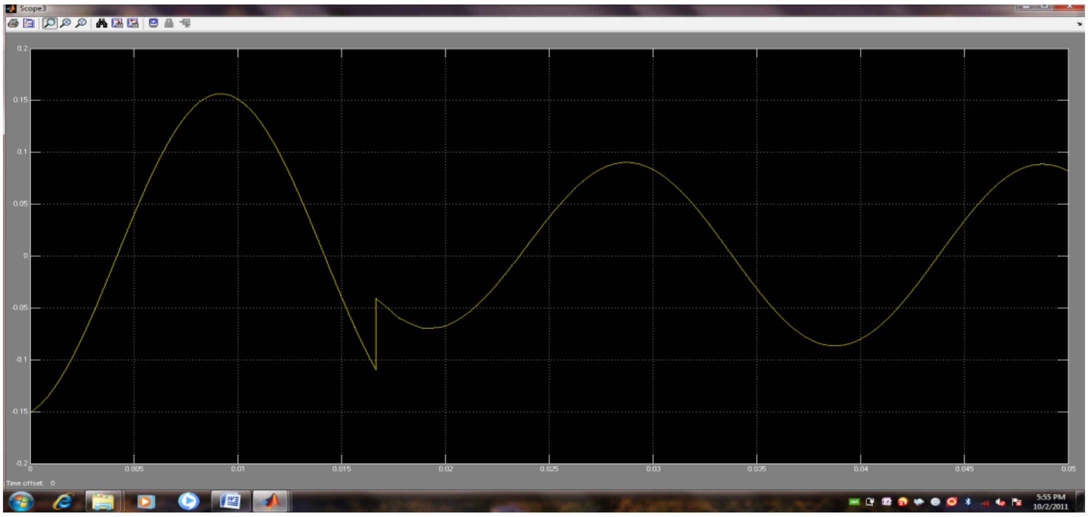

Fig 8: Current signal with fault before breaker.

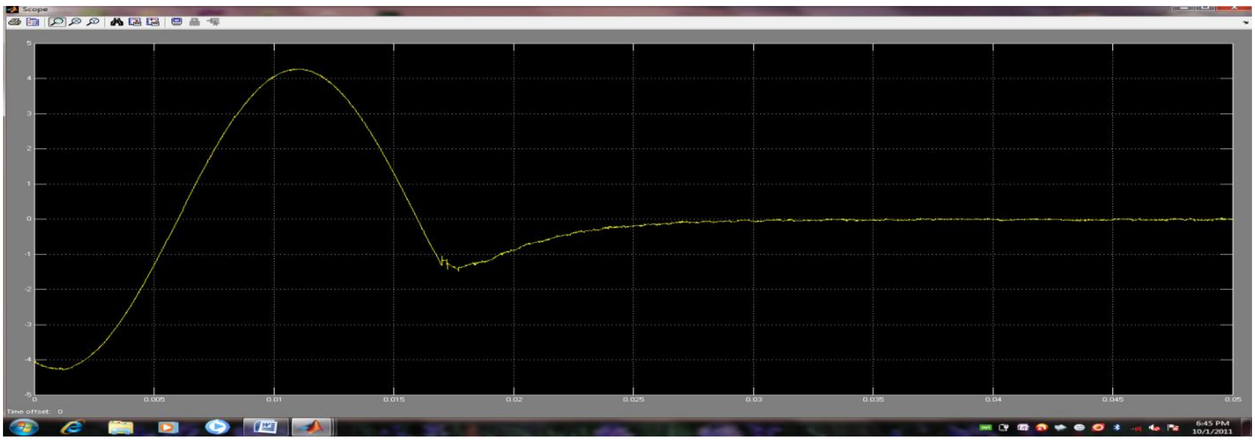

Fig 9: Voltage signal with fault before breaker.

VI. CONCLUSION AND RECOMMENDATION

The principal objective of this workwas to design a circuit-breaker based feeder pillar that will offer adequate protection to a transformer sub-station feeder pillar system. The constructed work must not only be reliable, but alsoefficient and cost-effective when utilized in the power system.Its protection must be total to include earth-leakage protection. With the best choice of suitable Miniature Circuit Breakers and ELCBs, the faults are well cleared and on time before it cause any damage

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ensuring a safe and reliable operation. This design is recommended to all students who wish to gain knowledge on the basic operation of a circuit breaker based feeder pillar and also to Power Distribution Utilities to mitigate faults occurring in transformer stations to a minimum level.

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