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Design and development of cost-effective hybrid remotely Password & ZCC Based Operation for Commercial and Industrial Lineman Safety

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ABSTRACT: To create an efficient communication and protection system for line man security during faulty conditions is the primary objective of this paper. The paper concentrates on improving the traditional circuit breaker by including a password system to improve security and safety conditions for linemen. This proposed system provides a solution that ensures safety primarily of the lineman who is given the control to turn the circuit on and off. Secondly, the term, zero crossing is the instantaneous point at which there is no voltage or current present. It is a device for detecting the point where the voltage crosses zero in either direction. Applying zero crossing detection, switching devices for ON and OFF can reduce the spark. The whole project is implemented both in MATLAB software and hardware implementation.

KEYWORDS: Circuit breaker, Zero Crossing Current, Switchgear, Efficient Communication, System Security.

I.INTRODUCTION

Electricity is hazardous: an electric shock from a current as low as 35mA is sufficient to cause fibrillation of the heart in the vulnerable individuals. At high voltages it is unnecessary to come into direct contact with charged equipment to be shocked. An electric field surrounds all the charged devices. Bringing a conducting object such as a human into that field can intensify the field enough for electrical breakdown of the air and a n arc to jump from the equipment to earth via that person.

A line man, power line technician is a tradesperson who constructs and maintains electric power transmission, telecommunication lines (a cable, internet and phone) and distribution lines. One of the primary objectives to save line man by making such a protective system controlled through one-time password, who is given the control to turn the circuit on and off. In this paper, it proposes efficient communication and protection system is proposed which also take care of sparking in the circuit breaker which is controlled by zero crossing system.

II.SYSTEM OBJECTIVES

This paper offers lineman safety and time saving system. It is a rigid, secure, less spark, and highly efficient device compared to the ever-reported designs. When correct password is accessed, proposed system checks the following condition.

- 1) System checks the status whether switchgear is in ON or OFF condition. If it is in ON position, then it will get switched off, if it is in OFF condition, then it will get ON.
- 2) System checks the status of power factor whether it is lagging or in- phase.
- 3) If the power factor is lagging, system cuts off the supply by using zero crossing current method.

If the power factor is in-phase, system cuts off the supply by using zero crossing voltage method. The input is taken from the software which is further fed to the arduino and contactor for optimizing the output through zero crossing detector.



III. ESSENTIAL COMPONENTS OF SWITCHGEAR DEVICE

1. ARDUINO MICROCONTROLLER

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button etc. It is basically a firmware software which can control hardware by sending the command using compatible software. Software which can control hardware is known as Firmware programmer. Arduino comes in varieties of hardware models, for example – Uno, Mini, Micro, Mega, Arduino Due etc. In this project, Arduino UNO is used for controlling the switchgear automatically. Arduino UNO has 13 number of Input/output pins. These pins are also called Port. Out of 13 ports, some ports are special purpose use. Port numbers are mentioned in respective pins. All pins work in +5volt DC. It has one pair of serial communication port or pins, 0 and 1 pins are designated to serial pins.

Table 1: Summary of Arduino UNO board

Component Name	Ratings
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

2. Introduction to Contactor Relay

Control relays and Contactors are electrically operated switches used for switching the loads and for controlling the electrical circuit respectively. Generally, the medium of quenching of arc is air, so they are called air brake contactors & air brake control relays. Mitigation of air sparking in between contact points of contactor is a big issue in circuit breakers because spark is directly proportion to the load current.

3. Terminal Bushings

In electric power, a bushing is an insulated device that allows an electrical conductor to pass safely through a grounded conducting barrier such as the case of a transformer or circuit breaker.

4. REASON OF SPARK IN CONTACT POINTS

When some potential difference between across two contacting metal pieces, some little resistance is developed. When



the metal is forced apart slightly, there is a small air gap of high resistance, and it becomes ionised by the high voltage. This allows current flowing to travel through it like an arc welder and atoms of metal are carried as well across the arc. **This produces the spark as the air gap increases.** There is also a collapse of magnetic field that adds to the process. The higher the voltage, the more spark is produced. If a capacitor is placed across the switch, the abruptly collapsing field is stopped because the voltage has somewhere else to go, and there is no spark. The same happens when switching on but in such a short time that ionisation is absorbed by the quickly closing metal and the spark is not seen.

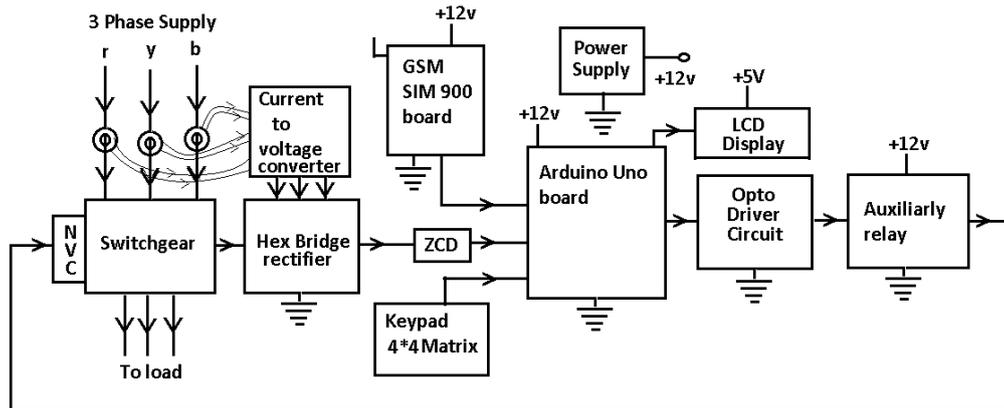


Fig1: Block Diagram Representation of the proposed System

Three phase supply is given to unsymmetrical load with a switchgear. Three numbers of current transformer are used to detect the current status. This current is further converts into voltage form for correct analysis through analog input to Arduino. Hex bridge output is fed to zero crossing current detector by means of optocoupler. Optocoupler output is connected to arduino analog pin for reference voltage. 4*4 matrix keypad connection are made with Arduino digital ports for accessing the password, while programming in Arduino, correct password is stored in EEPROM. GSM sim 900 is used to receive text sms which is connected to Arduino serial transmitter and receiver pins. After completing the maintenance work, line man send the password sms to GSM Sim 900 module number. GSM send the signal to Arduino, Arduino compares the password which is sent by lineman, if it is matched correctly, Arduino generates a HIGH signal to attached optocoupler circuit, this further gives the signal to auxiliary relay to energised. This auxiliary relay will give rated voltage to NVC of switchgear. Hence load will connect to three phase supply. If another signal is received by SIM 900, it will do the same job and lastly NVC get de-energized.

V. RESULT AND DISCUSSION

For evaluating performance of less sparking between the switchgear points using the Zero crossing concept, simulation practice and study is performed in MATLAB/Simulink model. The displayed screenshot result was obtained by using the MATLAB/Simulink. In this model, three phase supply voltage source is taken in three individuals phase degree angle with response to different power factors parameters. In first phase R is taken in zero degree with pure resistive load i.e. $\text{COS}\Phi = 1$, second, Phase Y is taken 60 degree or power factor = 0.5, Third, Phase B is taken 50 degree or power factor = 0.7. In this model three phase half wave rectifier output is configured for observing output current for reference purpose. This was very useful to made the algorithm and program in which decision could be taken for giving the exact instant time to give High logic into auxiliary relay. Various Simulation has been done taken different power factor values have been put in all voltage sources.

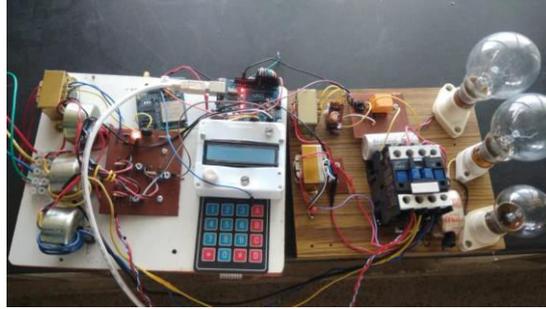


Fig 2: Hardware Model of ZCD with different power factors in three phase load.

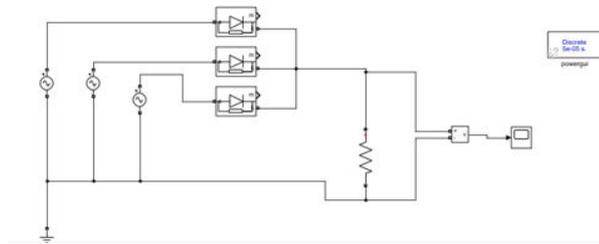


Fig 3 Simulation Model of ZCD with different power factors in three phase load.

In above figure it is clear that individual three phase load current is obtained by three individual CTs. Microcontroller is programmed to analysis the pulse magnitude in terms of analog form. It takes some sample of input analog signal. Among received analog signals Arduino measures as soon as input signal is almost near to zero, it gives instruction to high logic signal to energise auxiliary relay. This will turn on or off the entire three phase supply.

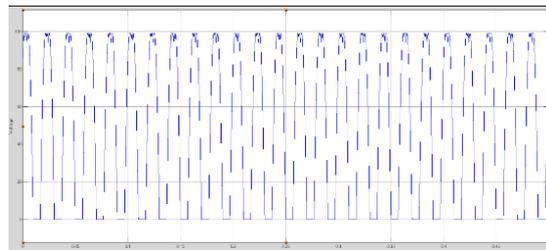


Fig.4: Input Signal from MATLAB

DISCUSSION

Initialize the SIM number into Arduino program for getting the text SMS, then enter the password by using Mobile phone and send it to GSM SIM number, if the correct password is entered, Arduino Uno recognize this correct password and give HIGH signal to auxiliary relay, which is shown below:

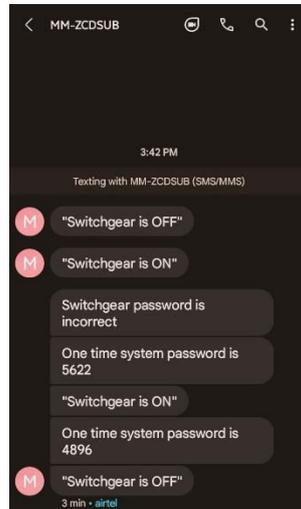


Fig-5:Screenshot OTP for Substation Switchgear System

Arduino Uno will check the pulse of three phase half wave rectifier output which is connected in analog pin A0 by means of opto-coupler. The below table shows the input given to Arduino and which is further received by the real time unbalanced load and the three phase load current is further converted into voltage with the help of current to voltage converter. The values received is AC is converted into DC with the help of rectifier. Output result is in serial monitor. Raw values of Phase A , Phase B and Phase C from Analogy input A0, A1 and A2 PORT respectively. Raw value mapping = max 1024 = Max 5volt.This is shown in Table 2.

PhaseA = 83	PhaseB = 52	PhaseC = 86
PhaseA = 151	PhaseB = 47	PhaseC = 74
PhaseA = 157	PhaseB = 30	PhaseC = 128
PhaseA = 92	PhaseB = 64	PhaseC = 17
PhaseA = 213	PhaseB = 0	PhaseC = 127
PhaseA = 7	PhaseB = 63	PhaseC = 58
PhaseA = 184	PhaseB = 34	PhaseC = 97
PhaseA = 134	PhaseB = 45	PhaseC = 103
PhaseA = 128	PhaseB = 54	PhaseC = 54
PhaseA = 176	PhaseB = 18	PhaseC = 128
PhaseA = 43	PhaseB = 64	PhaseC = 7
PhaseA = 202	PhaseB = 13	PhaseC = 116
PhaseA = 60	PhaseB = 54	PhaseC = 79
PhaseA = 167	PhaseB = 43	PhaseC = 80
PhaseA = 157	PhaseB = 35	PhaseC = 125
PhaseA = 105	PhaseB = 63	PhaseC = 27
PhaseA = 208	PhaseB = 3	PhaseC = 123
PhaseA = 9	PhaseB = 64	PhaseC = 44
PhaseA = 213	PhaseB = 29	PhaseC = 100
PhaseA = 113	PhaseB = 50	PhaseC = 98
PhaseA = 152	PhaseB = 51	PhaseC = 64
PhaseA = 163	PhaseB = 25	PhaseC = 129
PhaseA = 65	PhaseB = 64	PhaseC = 5
PhaseA = 210	PhaseB = 3	PhaseC = 113
PhaseA = 27	PhaseB = 57	PhaseC = 68
PhaseA = 169	PhaseB = 39	PhaseC = 89
PhaseA = 156	PhaseB = 40	PhaseC = 113
PhaseA = 112	PhaseB = 59	PhaseC = 42
PhaseA = 207	PhaseB = 9	PhaseC = 128
PhaseA = 6	PhaseB = 64	PhaseC = 29
PhaseA = 213	PhaseB = 21	PhaseC = 108
PhaseA = 98	PhaseB = 51	PhaseC = 90
PhaseA = 154	PhaseB = 48	PhaseC = 72
PhaseA = 155	PhaseB = 31	PhaseC = 128
PhaseA = 89	PhaseB = 64	PhaseC = 16
PhaseA = 209	PhaseB = 0	PhaseC = 127
PhaseA = 12	PhaseB = 63	PhaseC = 60

Table 2: Raw values of Phase A , Phase B and Phase C from Analog input A0, A1 and A2 PORT



Fig-7 shows the raw values of Phase A , Phase B and Phase C from Analog input A0, A1 and A2 PORT in a plotted waveform at 100 m sec The output ranges from 30-5A. and which is further received by the real time unbalanced load and the three phase load current is further converted into voltage with the help of current to voltage converter. The values received is AC.

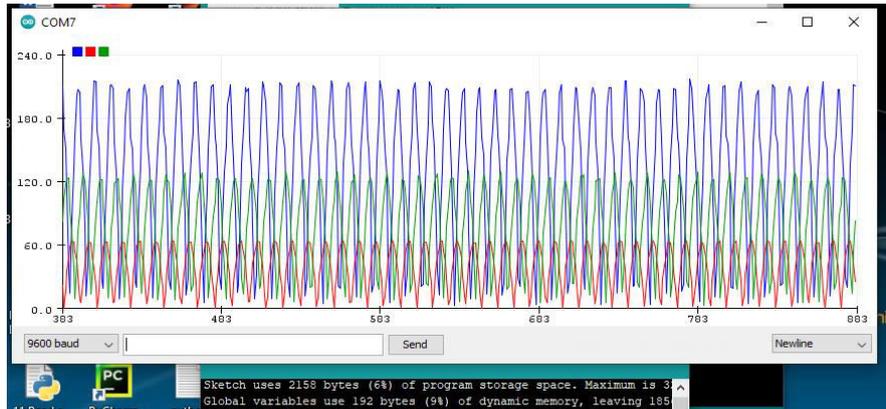


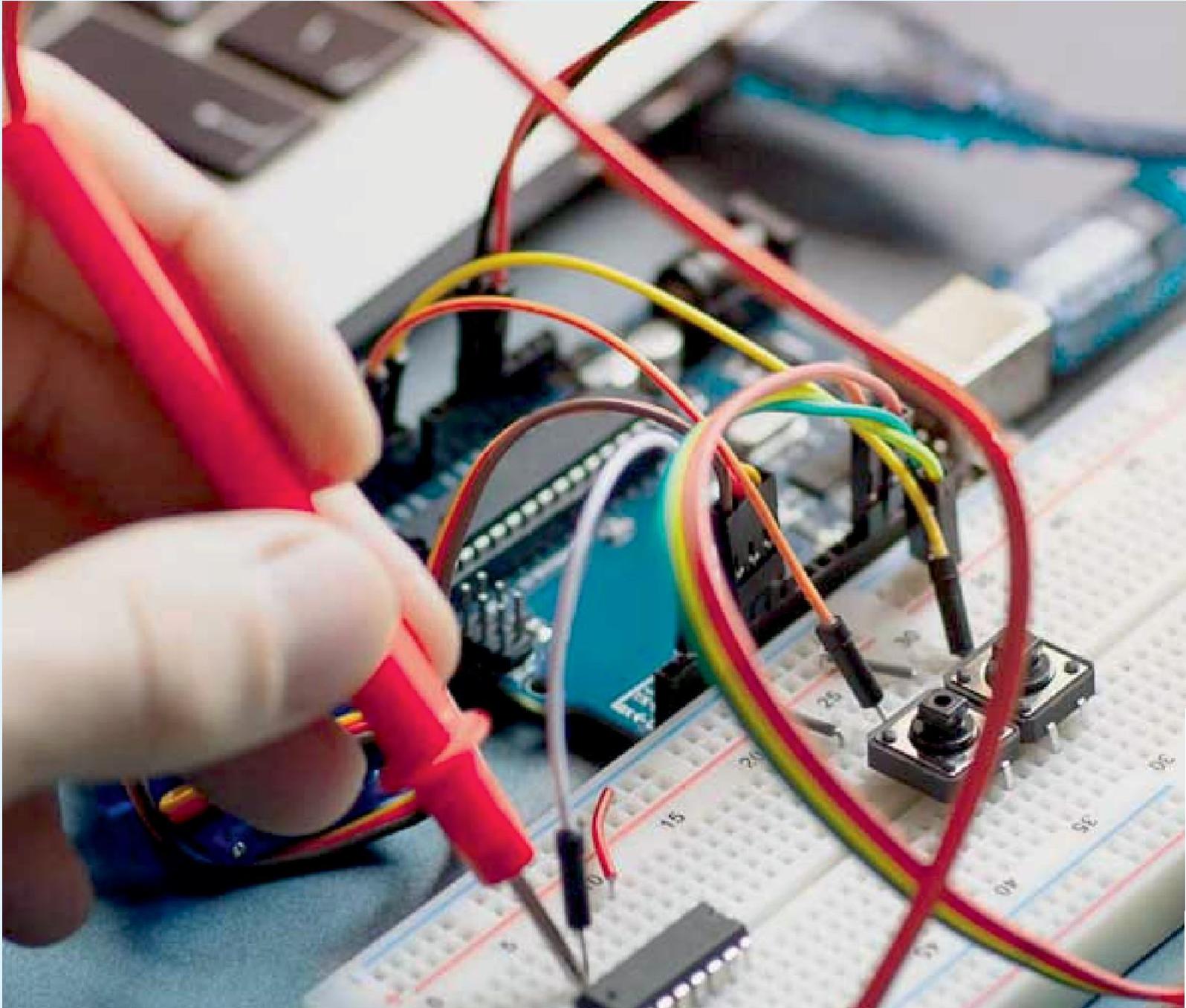
Fig - 6 : Given delay of 100 millisecond

VI. CONCLUSION

This project can be used to ensure the safety of the maintenance staff e.g. line man. The line can be only turned off/on by the line man. This system provides an arrangement such that a password is required to operate the circuit breaker (ON/OFF). The ARDUINO microcontroller and GSM based work demonstrate the security of the lineman as switching ON/OFF of circuit breaker and opening or closing of control panel door is done for the purpose of repair or maintenance. The method overcomes the deficiency of existing system of LC opening and closing request for the line which consumes travel time of the line man to reach the substation and also to ensure less sparking on switch gear terminals by taking account of ZCC positions of the load. The implementation of this project gives an idea of security. Thus proposed system can be used to maintain one time password that cannot be stolen. The control over power supply is maintained continually. It can be used with SCADA system to atomizes the operation and enhance the security.[8]

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