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Design and Implementation a New Real Time Overcurrent Relay Based on Arduino

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Abstract. This paper presents the new design and implementation of single phase overcurrent protection relay based on an Arduino NANO.. The relay is an electromagnetic switch which operated depending upon the input signal that can turn it (ON/OFF) when the measuring current is greater than of the sitting current. The proposed relay provides greater operating flexibility, high sensitivity, reliability, high speed, simple controller. This relay is designed and tested on the electric system, depending on the use of the controller. The experimental results from the electrical system test emerged efficiency and speed of the response system to protect it from any fault .

Keywords: protection circuit, overcurrent relay, Arduino NANO, One Channel Relay, ACS712

1. Introduction

The electrical power system protection (EPSP) is very important for protecting the user and electrical and electronic system equipment to protect them from fault, hence for electrical system is not allowed to work without any type of protection devices installed.

Any undesirable condition that appears in any power system is defined as a power system fault. These undesirable conditions are (overcurrent leakage current, short circuit problem, line to ground short faults, over voltage and over current.

The "overcurrent relay protection circuit" is one of the types of protection relay that works when the load current exceeds a predetermined value. The proposed application system of the overcurrent relay in this paper is used for over current protection circuit, connected to the single phase power line calibrated to operate at or above a specific current sitting value.

The proposed system in this paper is a closed loop leads control circuit to fast short circuit levels. The overcurrent protection is used as a circuit protection in case of communication Faults, [1]-[2]. This



work will attempt to design overcurrent protection relay by using Arduino NANO as a micro controller, ACS712 Current sensor module for 30 A, solid-state relay, resistor and bottoms for setting values for coding the digital signal processing.

This paper arranged as follows: section 2 discusses relevant (overcurrent problem statement), section 3 presents the low cost of overcurrent relay, section 4 discuss practical system description, finally section 5 offers conclusions and further work.

2. Overcurrent Problem Statement

Overcurrent protection relay is very important circuit to protect any transition branch in the power system. The proposed system in this paper is presented in Figure (1), the protection unit of the load in this system consists of three main parts, current sensor unit, overcurrent relay for protection circuit and microcontroller. In this work, a new circuit is design of an overcurrent relay by using Arduino NANO. The main properties of the proposed system have been designed with very low cost and high response speed with good accuracy.

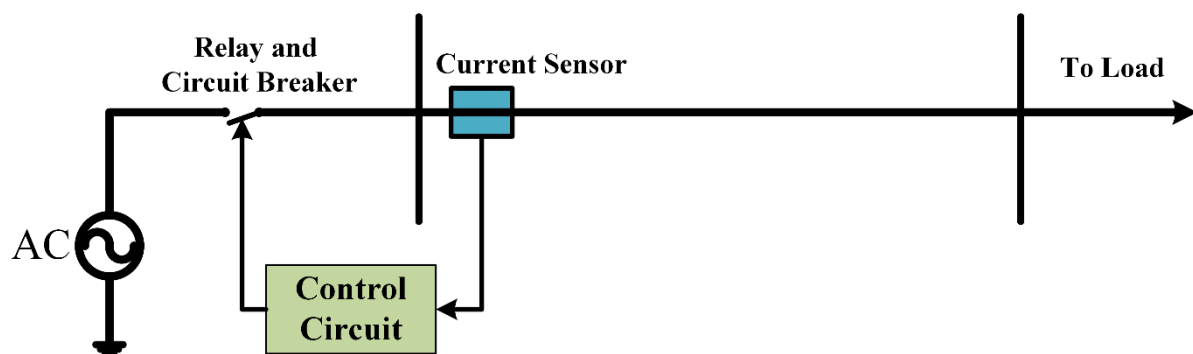


Figure 1. The proposed overcurrent protection relay circuit.

3. Low Cost of Overcurrent Relay

The overcurrent relay circuit in this paper is designed by using the Arduino NANO as a microcontroller. The software program of the practical system was created through the C language. To ensure the performance of the proposed overcurrent protection circuit on the single phase system branch. The software emulator is configured to simulate overcurrent reflective properties. The full circuit board hardware is designed and fabricated using the Arduino NANO board. The inverse properties were typically tested and verified by using a full hardware system for AC single phase load line.

3.1. One Channel Relay Module

The relay is an electromechanical device that allows a processor like Arduino to control loads at a voltage or intensity level much higher than its electronics can withstand. For example, with one relay output in the Figure(2), we can turn ON/OFF 240V alternating current loads and 10 Ampere currents, which covers most household devices that we connect at home to the electrical power grid. Relay

outputs are very frequent in the field of process automation, and almost all PLCs includes relay outputs to drive loads such as motors, pumps, air conditioners, lighting, or any other type of installation or machinery. Physically, The relay behaves like a "conventional" switch, but, instead of being operated manually, is activated electronically. The relays are suitable for driving loads of both alternating and direct current.

The Figure (2b) shows the circuit diagram of relay, this driver is an electronic circuit that uses a transistor to activate the relay coil so that with a small current we activate the circuit that feeds the relay from an external source. The Figure(2a) shows the one channel Relay module, the properties of this module are: the relay consumes 80mA at 5V, and has a simple inverter contact of 10 A at 250VAC or 30VDC and the channel has a status indicator LED, the board also has a general power indicator LED.

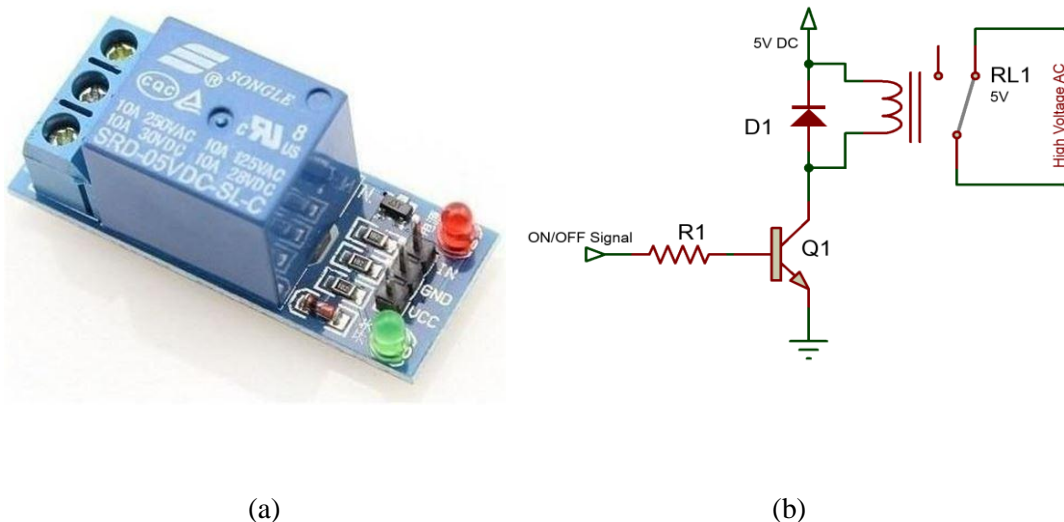


Figure 2. One Channel Relay: a) Relay module and b). Circuit diagram

3.2. Current Sensor Module

In this proposal, we used the ACS712 Current sensor module 30 A. This sensor is an economical solution to measure AC or DC current, it works with a Hall effect sensor that detects the magnetic field that is produced by the induction of the current flowing through the line being measured. The sensor delivers a voltage output proportional to the current, depending on the application, we can use the ACS712-05A for 5 Ampere, ACS712-20A for 20 Ampere or the ACS712-30A for 30Ampere.

Figure (3a) shows the ACS712 module, which facilitate their connection, brings a terminal block to connect the line we want to measure and 3 pins, two to connect the power and a pin for the Analog output. Figure (3b) shows the full circuit diagram of this module.

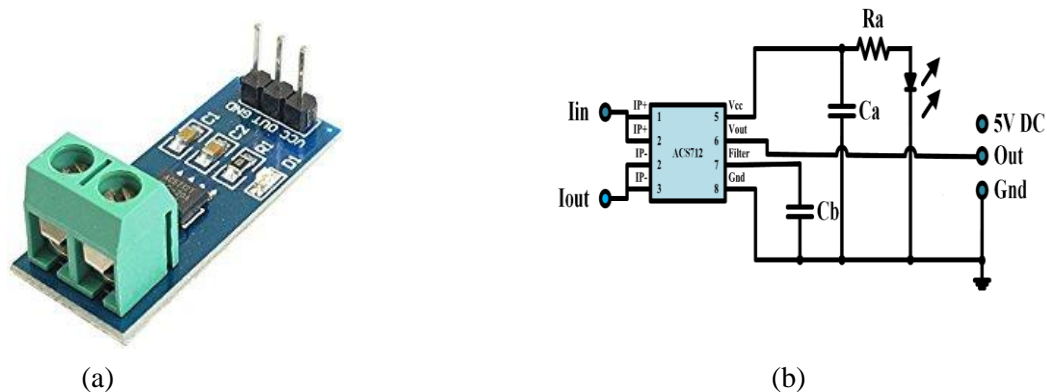


Figure 3. ACS712 Current sensor: a) the module and b) full circuit diagram

3.3. 16*2 LCD

The 16x2 Character LCD has an outline size of 80.0 x 36.0 mm and a size of 66.0 x 16.0 mm with a maximum thickness of 13.2 mm. The 16x2 LCD displays the built-in ST7066 controller or equivalent. It is optional for power supply + 5.0V or 3.0V. The main interfacing pins comments of this LCD are present in Figure (4). This type of unit can be operated at temperatures ranging from -20 °C to + 70 °C; storage temperatures range from -30 °C to + 80..



Figure 4. 16×2 LCD with interfacing comments.

3.4. Arduino NANO Module

The Arduino NANO is an open source microcontroller platform. The Arduino we will use in this paper is an Arduino Nano. It has dimensions of 43 x 15 mm. It has a USB port that allows you to connect directly to a computer (no adapter required), and also provides 5V power while connected. Once programmed and disconnected from the computer, it can be independently powered by 7 to 12V applied to the VIN (connected to positive battery or source) and GND (connected to negative) pins. The Arduino Nano also has 3.3V (Pin 3V3) and 5 V (Pin 5V) voltage outputs. Pins A0 to A7 are

Analog input (receive values between 0 and 5V), and D0 to D13 support digital input (recognize two values: 0V - LOW logic level or 5V - HIGH logic level). Analog output is simulated via PWM only via digital pins D3, D5, D6, D9, D10 and D11. The other digital pins, as well as pins A0 to A5, can operate as digital output. The diagram in the Figure (5) illustrates the Arduino Nano pinout:

Arduino pins support a maximum of 40mA (plugging in a circuit that lets more current through can burn the pin). Resistors must be calculated to limit current. The entire Arduino provides a maximum of 200mA. But it is possible to control circuits that consume much more current, since the signals sent and received by the pins are intermediated by circuits that reduce currents and voltages to levels supported. This can be done with resistors, capacitors, transistors, relays and other devices.

Care must also be taken not to short the outputs (5V or 3V3 connected directly to GND). Analog and digital pins can be connected directly to 5V or 0V only if used as inputs. These values are treated as information (logical level HIGH and LOW) by an Arduino. To use them as outputs, you must configure this functionality in programming, and take the same care as outputs 5V and 3V3 (do not connect directly to GND), and use resistors to keep current flowing within the limit.

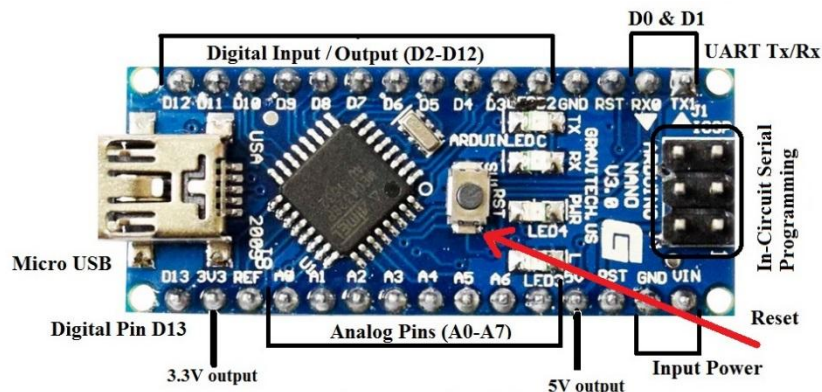


Figure 5. Arduino NANO pin layout

4. Practical System description

The final practical circuit for the overcurrent relay is shown in the Figure (6a). The hardware system in Figure (6b) consist of six components connected together, (1) Arduino Nano with base board, (2) ACS712 Current sensor module, (3) one channel relay module, (4) input and output socket (5) 16*2 LCD and finally (6) bottoms for sittings values. The hardware system has been tested in the lab by checking the sensor measuring the line current and compared it to sitting value, The results presenting on the LCD screen. Figure (6a) presents the final system design and Figure (6b) present the full hardware system .

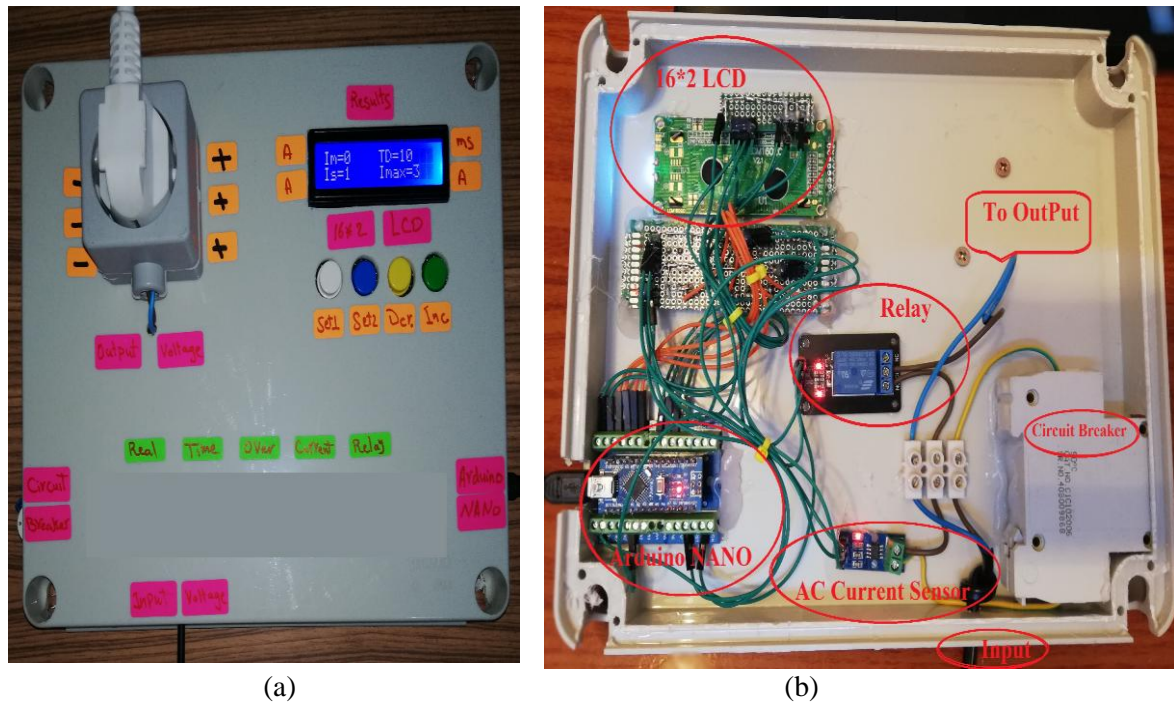


Figure 6. Final Hardware design of the overcurrent relay circuit: a) final system design and b) full circuit hardware circuit

Figure (7) present the main platform window for open source programming window that is used to program the Arduino NANO as a microcontrollers .

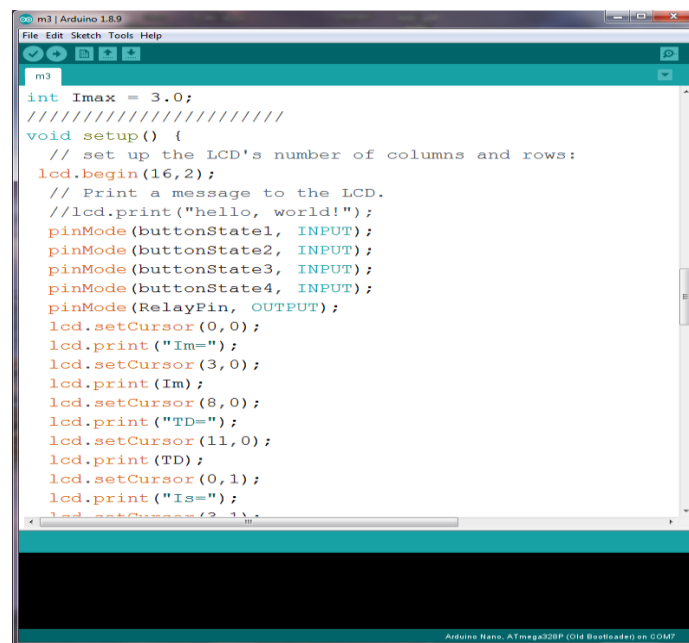


Figure 7. Arduino platform programming window

According the full circuit designed in the Figure(6), the flowchart in Figure (8) shows the full practical working system. It shows the Arduino NANO (the microcontroller) senses the single phase current in a transmission line . the first case, If the measuring current greater than the max current sitting value, then the Arduino NANO send signal to turn the Rely ON without any delay or waiting. The second case, If the measuring value exceeds the value of setting value, the microcontroller waiting (TD ms) to check if the measuring value is a Fault or just a sudden increase in measuring current. Then, if the measuring vale continued more than (TD ms), the microcontroller send signal to the overcurrent circuit relay to turn The relay ON. After 5 minutes the Relay turn OFF and the system returns to measure the line current.

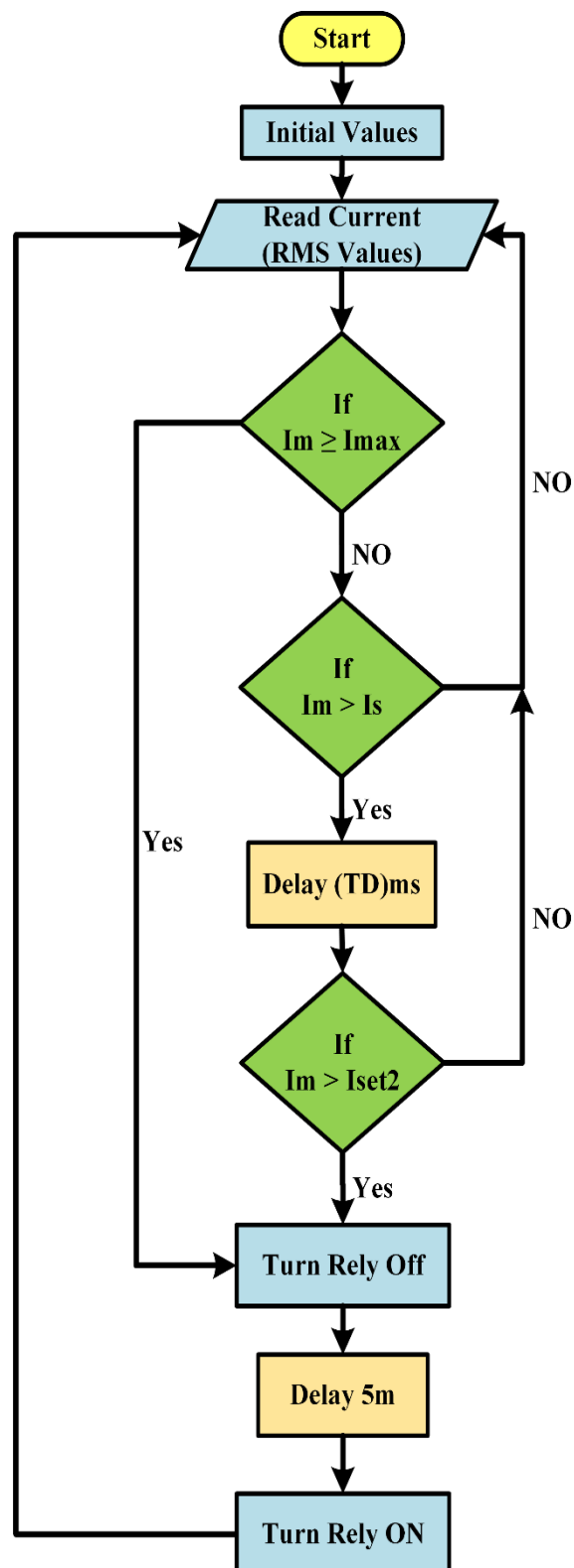


Figure 8. The Flowchart of the Arduino NANO program

5. Conclusions and Future work

The overcurrent relay circuit in this paper is designed by using the Arduino NANO as a microcontroller. The software program of the practical system was created through the C language. To ensure the performance of the proposed overcurrent protection circuit on the single phase system branch, the software emulator and solid tool circuit were developed. The software emulator is configured to simulate overcurrent reflective properties. The full circuit board hardware is designed and fabricated using the Arduino NANO board. The inverse properties were typically tested and verified by using a full hardware system for AC single phase load line.

For the future work, the proposed circuit in this paper can be developed and reprogrammed to provide further additional protection plan such as undercurrent and earth fault protection and can provide protection for single-phase AC motors and other electrical appliances. This circuit can also be innovated and programmed to provide comprehensive protection for three-phase systems and can be considered a future scope for this prototype.

6. References

- [1] Huang, A. 2010, July." FREEDM system-a vision for the future grid ". *IEEE PES General Meeting*, pp 1-4. IEEE..
- [2] SHARMA, Nitish. *Novel* , 2015 , *directional protection scheme for the FREEDM smart grid system*. Arizona State University.pp 1-149.
- [3] Rahmatian, M., Pourarab, M. H., Gholami, M., & Gharehpetian, G. B. 2014, May Optimal coordination of distance and over-current relays using ICA. *In 2014 19th Conference o Electrical Power Distribution Networks (EPDC)* pp. 106-109 IEEE.
- [4] Trivedi, I. N., Purani, S. V., & Jangir, P. K. 2015, June. Optimized over-current relay coordination using Flower Pollination Algorithm. *In 2015 IEEE International Advance Computing Conference (IACC)* (pp. 72-77). IEEE. .
- [5] Sahoo, A. K. 2014, September. Protection of microgrid through coordinated directional over-current relays. *In 2014 IEEE Global Humanitarian Technology Conference-South Asia Satellite (GHTC-SAS)* pp. 129-134. IEEE.
- [6] Tin, H., Abu-Siada, A., & Masoum, M. S. 2011, September. Impact of harmonics on the performance of over-current relays. *In AUPEC 2011* (pp. 1-4). IEEE. .
- [7] BOUGOUFFA, L., & CHAGHI, A. 2016 . THE IMPACT OF TCSC PARAMETERS ON DIRECTIONAL OVER-CURRENT RELAY SETTINGS. *Journal of Basic and Applied Research International*, vol **12** no 2 pp 79-84.
- [8] Moravej, Z., & Mohaghegh Ardebili, H. 2018 . A new objective function for adaptive distance and directional over-current relays coordination. *International Transactions on Electrical Energy Systems*, vol **28** no 9, e2592.
- [9] Aman, M. M., Khan, M. Q. A., & Qazi, S. A. 2011 . Digital directional and non-directional over current relays: Modelling and performance analysis. *NED University Journal of Research*, vol **8** no 2 .
- [10] Yacine, A. A., Noureddine, A. A., Hamid, B., & Farid, H. A. M. O. U. D. I. 2018, October. Implementation of a Numerical Over-current Relay Using LabVIEW and Acquisition Card. *In 2018 International Conference on Electrical Sciences and Technologies in Maghreb (CISTEM)* pp. 1-5 . IEEE.
- [11] Vijayakumar, D., & Nema, R. K. 2009. Simplified velocity MPSO for directional over current relay coordination. *International Journal of Recent Trends in Engineering*, vol **1** no 3,pp 76-80.
- [12] Dusang, L. V. 2008, October. A ground fault protection method for ungrounded systems. *In 2008 IEEE Canada Electric Power Conference* pp. 1-6. IEEE.
- [13] Kumar, P., Kumar, V., & Pratap, R. 2017, December. Digital design and implementation of an overcurrent relay on FPGA. *In 2017 14th IEEE India Council International Conference (INDICON)* pp. 1-5. IEEE.
- [14] Khan, B. A., Ashraf, H. M., Hamid, S., Asif, R. M., & Bashir, U. 2019, February. Implementation of Micro Controller Based Electromechanical Over Current Relay for Radial Feeder Protection. *In 2019 International Conference on Engineering and Emerging Technologies (ICEET)* pp. 1-6 . IEEE.