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Research Article

Tap Changing of Autotransformer using Internet of Things

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Abstract

In the current scenario, power quality has become a fundamental aspect of the power system. Power system has been dealing with numerous issues due to discrepancies in loads. So, it is necessary to supply constant voltage to the load and this is accomplished by using a Tap changing transformer. Either using mechanical tap changers or solid state devices can be used to change the tappings of the transformer. In the proposed system the tappings of the transformer are changed based on the load variation using Internet of Things. The system has two modes, one which automatically changes the tappings according to the load and the other in which we have to give command to change the tappings. Both modes do not require any manual work to be performed

Keywords: Power system, load, voltage, tap changing transformer, Internet of things, mechanical tap changers, solid state devices

1. Introduction

The primary application of a tap changing transformer is to function as a voltage regulator i.e to maintain a constant output voltage irrespective of the changes in the input voltage or load conditions. Limiting the variance of voltage with respect to reference voltage of the bus is the primary working of the controller. Power quality is one of the main things nowadays.

The standard of the power supply is perturbed by both the consumers and power utilities. This requires the arrangements to be at its optimal regard so the cost is capable; in any case issues, for example, over voltage, under voltage, voltage swell, voltage sag, noise and harmonics caused by the disturbances in power supply could be harmful. If just a single tap changer is required it can be operated manually, tapping points are usually made on the high voltage or on the lower current winding side of the transformer to handle the current requirements of the contacts.

However, a transformer may consist of a tap changer on each of its windings, even if there are some disadvantages in it. For example, consider that in a distribution network of a power system, the higher rating step down transformer can have an off load tap changer on one of the windings let us consider it as primary and can have an on load automatic tap changer on the other. There is no requirement to change the tappings on the high voltage side since it has already been designed to meet the future need. But coming to the low voltage side, the tappings have to be varied to various positions for a greater number of times every day, uninterrupting the power supply to the consumer, according to the loading conditions on the low-voltage (secondary winding) network.

Tap changers mainly fail to operate due to these reasons:

1. If there is improper contact pressure at the tap contacts it can cause hot spots and may also cause thermal damage of the switch.

2. Sometimes there is a possibility of overvoltage due to switching or lightning impulses, this will create voltage stresses on the tap connections. This may cause insulation breakdown at the contacts. Such tap changers would have been created for tap changing under no load condition and these are ones which are used widely.

3. Using these kinds of tap changers to vary taps under load for which they are not created produces excessive wear at the contacts owing to arcing, leading to premature failure. But, the study shows that the tap changers may also get damaged apart from these reasons even when it is operated correctly.

At present the tap changing is done using mechanical tap changers which has the disadvantages of arcing, regular maintenance requirement, cost, etc. In order to overcome this, solid state devices or relays are incorporated along with microcontrollers. Thus the system automatically varies its tappings according to the load variation by continuously monitoring the variation in current and voltage. One of the drawbacks is that monitoring the variation in load on a daily basis is difficult which could be rectified using Internet of Things (IOT) and tappings could be controlled remotely using a cloud server.

The Internet of Things has the ability to interconnect the world in an unimaginable way and it is considered by many people to be the next step in the evolution of the internet. It is a big technological advancement; where a human interacts with the machines and performs work more accurately and swiftly. In this paper, an effective solution is proposed for better control of the tappings of the transformer using Internet Of Things. IOT connects the system to the wider application of the Internet. Internet associated things like the physical items or things are allowed to connect, collaborate and communicate with one another.

The paper focuses on accurately changing the tappings by monitoring the load variations provided. Selected advantages of this project are like, controlling the tappings of the transformer through IOT from anywhere and additionally we provide the history of data i.e voltage and current on the webpage.

2. Circuit Configuration of Existing Work

Various methods have been proposed and applied to overcome the problems such as over voltage, under voltage etc of the power system. One amongst the ways which can be done is by using an on load tap changing power transformer. The load tap changing method is the method which is mostly preferred it is used because it ensures good regulation of output voltage even in the presence of large variations of the input voltage. At present the tap changing of the transformer is done either manually or using solid state drives.

Various selector switches are available to make new connections of tap changers even before releasing from the old one. It overcomes the problems of open and short circuit during the tap changing process. The current and potential transformer provides the values of the current and voltage respectively to the central control unit. The motor driver circuit is provided so that the tap changing mechanism can be implemented with ease. The disadvantage of the system is that it is a step by step process. That is it cannot switch from highest to lowest position instantaneously.

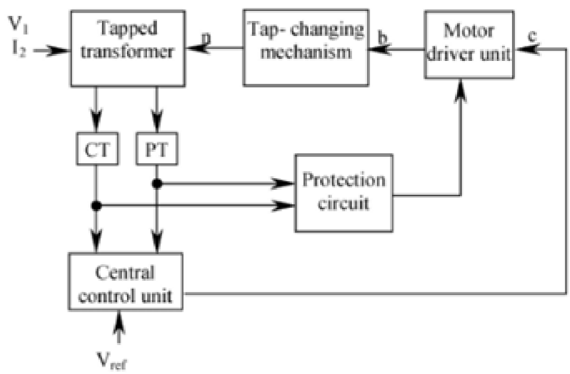

Fig 1: Mechanical tap changer - Block diagram.

The existing mechanical tap changer also has a disadvantage of producing arcing, requires regular maintenance, slow reaction times etc. These factors can be overcome by using electronic tap changers. In the electronic tap changing mechanism either relays or solid state drives and microcontrollers are used to change the tappings of the transformer.

The block diagram of microcontroller based tap changer is given below. The transformer with tappings is connected to a relay circuit which in turn is attached with the load. The microcontroller gives commands to the relay circuit to operate. The sensing unit is used to sense the voltage and current values of load then it passes the values to the microcontroller. The microcontroller is programmed according to which it generates a signal and passes the same to the relay circuit. Then the relay circuit is operated and the respective relay of tapping of the transformer changes.

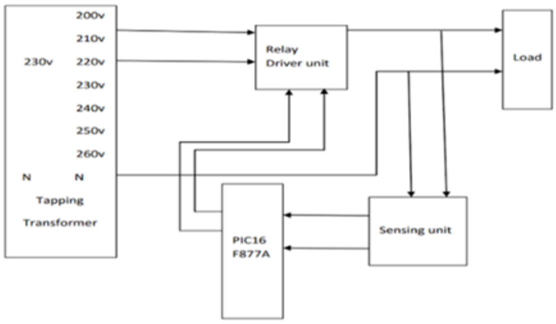

Fig 2: Block diagram of Microcontroller based tap changer.

The working principle of solid state tap changer is similar to that of microcontroller based tap changer; the only difference is that instead of relays, semiconductor devices like triac, IGBTs, and thyristors are used. This system automatically changes its tappings according to the load variation but it does not provide any information about the load variation at a particular instant. And if the user wants to set the tappings of the transformer to higher or lower value regardless of the load it's not possible in this system. These disadvantages are overcome in the proposed system.

3. Construction of Autotransformer using Iot for Proposed System

Our proposed system comprises the following components as follows.

A. Auto Transformer:

An Auto Transformer is a device which has a laminated core wound with a winding. An auto transformer is very much similar in way to the double winding transformer. But the only difference is that, in the way in which the first and the second coil are interconnected. It is seen that a section of the winding is shared by both the windings that are primary and secondary sides. The important aim of the transformer is to regulate the voltage according to the demand.

B. Stepper Motor:

A stepper motor is a mechanical apparatus aimed at converting the electrical power into mechanical power. The stator of the device has eight poles, and the rotor has six poles since the rotor must have a number of poles less than stator. The rotor requires 24 pulses of electric power to maneuver the 24 steps, complete one entire revolution. Another way to mention this is simply is that the rotor moves exactly 15 degrees for each pulse of given power input that the motor receives.

Input 1	Input 2	Enable1,2	Outcome
0	0	1	Terminate
0	1	1	Counter-clockwise rotation
1	0	1	Clockwise rotation
1	1	1	Terminate
0	1	50% of duty cycle	Counter-clockwise rotation with half speed
1	1	50% of duty cycle	Clockwise rotation with half speed

C. Stepper Motor Driver:

For a smooth operation, the stepper motor being a driver or a circuit, provides the necessary voltage values and current values to the stepper motor. A DC motor which rotates in steps can also be called a stepper motor. The motor driver receives the signal from the microprocessor and transmits it to the motors. It has two voltage pins, one which is utilized to get current for the working of the driver circuit and the another to provide voltage to the motors. Finally, The motor driver circuit controls its output in response to the input signal generated from the microprocessor or microcontroller.

The motor driver IC deals with heavy currents. Because of such tons, movement of electrons in the circuit gets heated. So, we had a kind of a conductor to scale back the heating. As a result, the driver circuit is provided with 4 ground pins. Once the pins are soldered on PCB, we get an enormous metallic space between the grounds where the thermal heat is often liberated. A best example of an inductive load is a DC motor. Basically, the motor generates a back EMF when it is connected to a voltage supply. It may be noticed that it has repeated voltage fluctuations while using the motor. At now the fluctuation in voltage is quite high and this might damage the IC. Thus four capacitors are put into operation which will help to reduce the severe current variation.

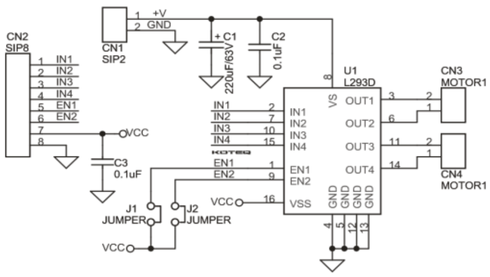

Fig 3: Stepper motor driver circuit

D. Voltage Sensor:

A voltage sensor is a sensor which is used to measure the quantity of voltage across two terminals. Either AC or DC voltage is found out by the use of voltage sensors. The voltage sensor's input will be a voltage, whereas the voltage sensor's output could be a analog voltage signal or may be an audible signal or may be switches or may be a current signal.

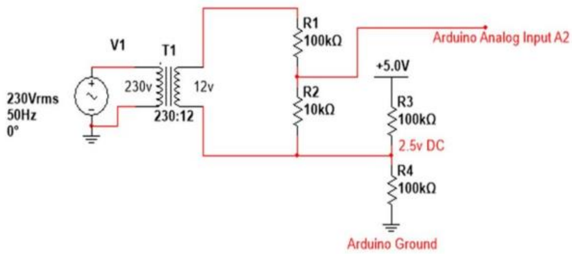

Fig 4: Voltage sensor circuit

E. Current Sensor:

A current sensor is fully integrated. It is a Hall-effect based, linear sensor IC. Identification of current through either conductor or a wire is done by a current sensor. As a result it generates a signal when compared to initial current which can be an analog or digital voltage depending upon it. The Vcc pin of the sensor is connected to the power supply and GND is given a negative 0V. When the supply is given Vout produces the output denoting the current flowing through the sensor.When there is no load it produces an output proportional to Vcc/2.Current sensor is able to provide bilateral current measurement, i.e. voltage bigger than 2.5V (Vcc/2) indicates one direction, otherwise indicates the another direction.

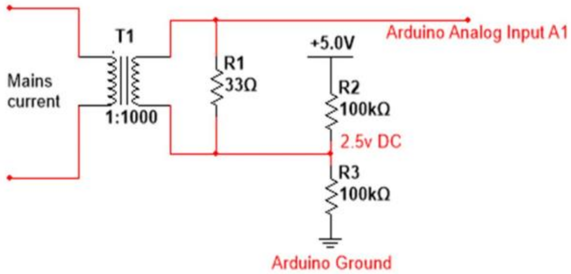

Fig 5: Current sensor circuit

F. NodeMCU:

NodeMCU is a low cost and open source Lua based IoT platform. It comprises firmware that runs on the ESP8266 Wi-Fi SoC and hardware supported by the ESP-12 module. There are four power pins viz. one VIN pin & three 3.3V pins. The VIN is employed to provide external and regulated power supply to the ESP8266 and its peripherals. The on-board transformer output starts from 3.3V. These pins are often used to supply power to external components.

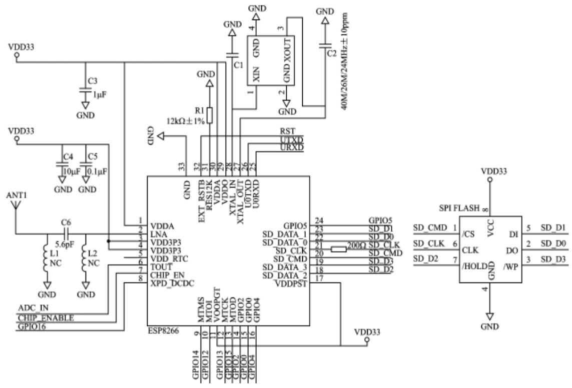

Fig 6: NodeMCU circuit

G. Arduino UNO:

The Arduino Uno is a Microchip ATmega328P based microcontroller and it is an open source one. Arduino has 6 analog input pins, 14 digital input/output pins, a 16 MHz quartz crystal oscillator. It also has a type B USB connection, power jack, a button and an ICSP header. The board comprises various input/output pins both digital and analog which are interfaced to several expansion boards and other circuits.

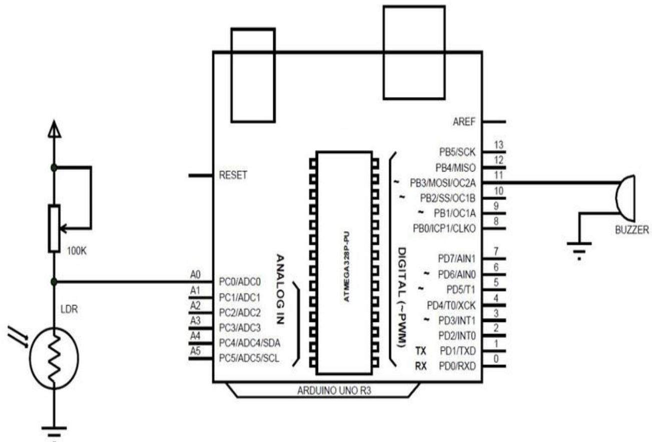

Fig 7: Arduino UNO circuit

H. Internet of Things:

IoT Platform being a fundamental factor in the rising technology and services which can merge the virtual and real time object and other people. IoT can also be a highly advanced automation and analytics system which utilizes networking, sensing, big data, and AI technology to deliver complete systems for a product or service.

The areas of improvement are easily made understandable using IOT. Recent analytics shows us an ostensible insight, but IoT provides real-world statistics resulting in simpler management of resources. Current information assortment experiences its constraints and its plan for detached use. IoT comes out of these barriers, and places it exactly where humans actually need to travel to research and explore our world. It provides an accurate and better picture of everything.

4. Block Diagram

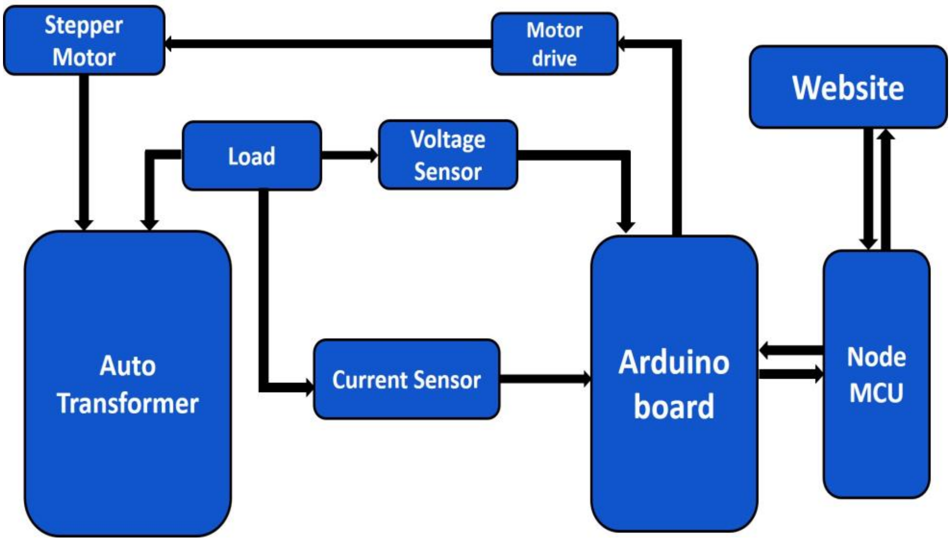

Fig 8: Block diagram of Proposed System

The main idea of the paper is to change the tappings of the auto transformer according to load variations. For this we are obtaining the current and voltage values of the load by using the current and voltage sensors respectively. Then these data are sent to the arduino board. The data are updated on the website provided by us. The history of those data measurements are maintained and updated regularly with the real time environment using Node MCU. The arduino is programmed in such a way that it calculates the stepper motor angle according to the load variations.

5. Circuit Diagram

The circuit diagram of our proposed system is shown in the figure 9. The auto transformer is interfaced with the load. The current sensor is interfaced in series with the load. The current sensor output is connected to the A0 pin of the arduino board. The voltage sensor is connected parallel by connecting both the positive and the negative terminal of the auto transformer.

The positive terminal and the negative terminal are connected to the A0 and ground pin of the arduino board respectively. Then the Rx pin and the digital pin D3 are connected with the digital pins D1 and D7 of the Node MCU respectively. The four digital pins such as D8, D9, D10, D11 of the arduino board are linked to the input pins like 1A, 2A, 3A, 4A of the motor driver circuit. The output pins namely 1Y, 2Y, 3Y, 4Y are interfaced with the stepper motor.

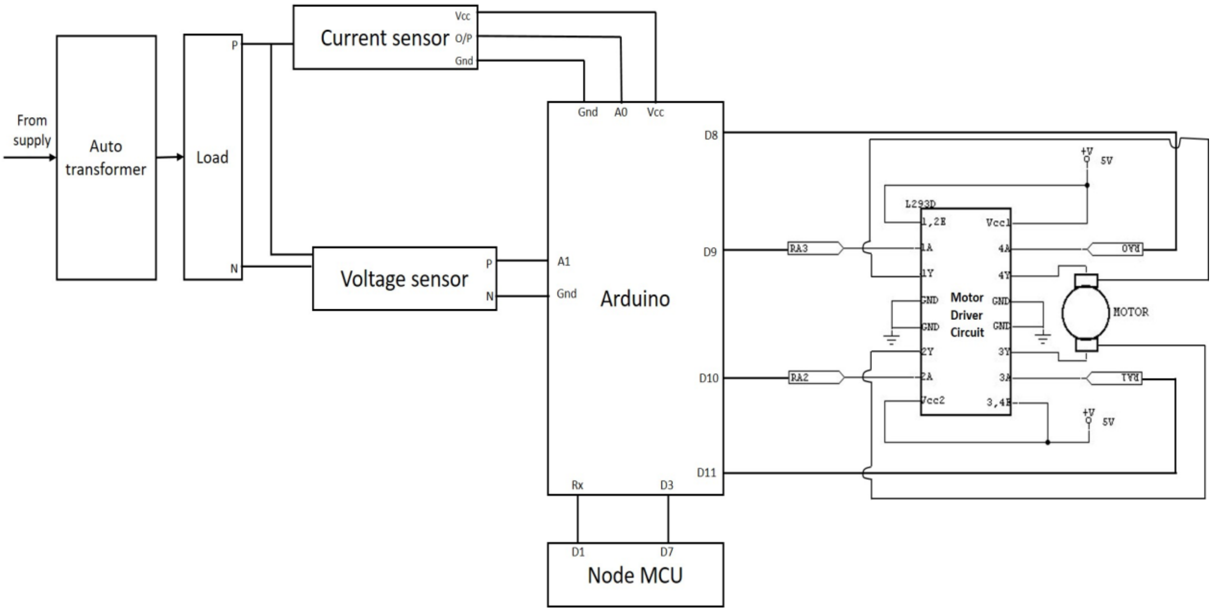

Fig 9: Circuit Diagram of Proposed System

6. Working of Proposed System

The sensing unit consists of a current sensor and a voltage sensor. The current sensor uses its conductance to calculate and measure the current in the circuit. When current flows through it, a magnetic field is generated.A voltage proportional to the field is produced and an analog current proportional to that is obtained as the output. The voltage sensor detects the ac voltage and produces a dc voltage proportional to it. These current and voltage values are given to the analog pins A0 and A1 of the Arduino UNO board.

The Arduino continuously monitors the data and any change in the data will automatically update the information to the stepper motor drive. The Arduino in turn sends them to the nodeMCU over serial communication. The Arduino sends a JSON message over softserial to nodeMCU. Since Arduino UNO works on 5V and nodeMCU works on 3V3 level hence a level shifter is connected between them. On receiving the information, nodeMCU will send it to the cloud without processing the data.

A website is created in which two modes of operation is possible. The former is that the current and voltage values are continuously updated and history of readings are provided. The latter is that a command is provided to the stepper motor through which the tappings of the transformer is adjusted.

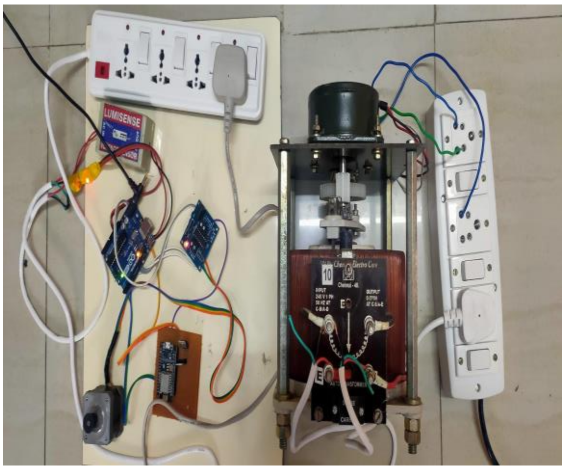

Fig 10: Hardware Setup

The ESP8266 in the nodeMCU is connected to the WiFi router and creates a Web Server which can be accessed by the user using a smartphone or a laptop connected to the WiFi router. After the connection is established, an IP address will be established on the serial monitor. The user should put the same IP address on the Web Browser of their device to obtain a web page.

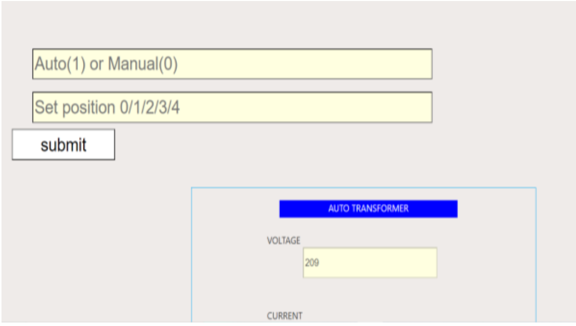

Fig 11: Mode Selection

On the webpage a toggle button is present where you can select either 0 or 1. Zero (0) implies manual rotation of the transformer where you can set the position through which the transformer should be rotated. In default, the system will be in automatic mode. In this mode the current and voltage values of the load are displayed. The history of certain parameters such as voltage, current and power are available in the website including its data and time.

HISTORY TO AUTOTRANSFORMER

BACK RESET

VOLTAGE	CURRENT	POWER	DATE & TIME
216	0.00	0	2021-03-24 12:46:45
21	0.00	0	2021-03-24 12:46:45
213	0.00	0	2021-03-24 12:46:45
214	0.00	0	2021-03-24 12:46:44
214	4.00	0	2021-03-24 12:46:44
216	0.00	0	2021-03-24 12:46:43
217	0.00	0	2021-03-24 12:46:43
217	3.00	0	2021-03-24 12:46:43
21	0.00	0	2021-03-24 12:46:42
216	0.00	0	2021-03-24 12:46:42
217	0.00	0	2021-03-24 12:46:42
216	0.00	0	2021-03-24 12:46:41
216	4.00	0	2021-03-24 12:46:41
216	0.00	0	2021-03-24 12:46:41
217	0.00	0	2021-03-24 12:46:40
217	0.00	0	2021-03-24 12:46:40

Fig 12: History Details

7. Result and Discussion

The stepper motor is coded in such a way that it has five stages of rotation. Each with 50 degree rotation. The default position of the stepper motor under no load condition is zero. According to the load variations, it automatically changes its stages. The figure 13 shows how command is given to the stepper motor manually via the website. The stages in the manual mode are depicted with the numerical values viz. 0, 1,2,3,4.

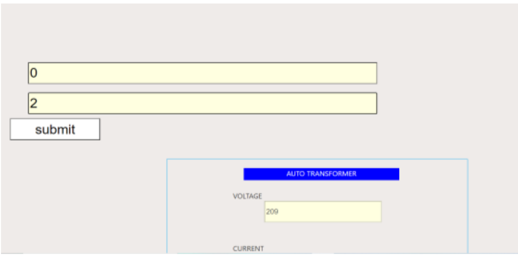

Fig 13: Manual mode instruction

Under the no load condition the website shows the voltage value and current values as zero. When the load is applied the values of current and power gets updated and if noticed the voltage value drops from previous the value.

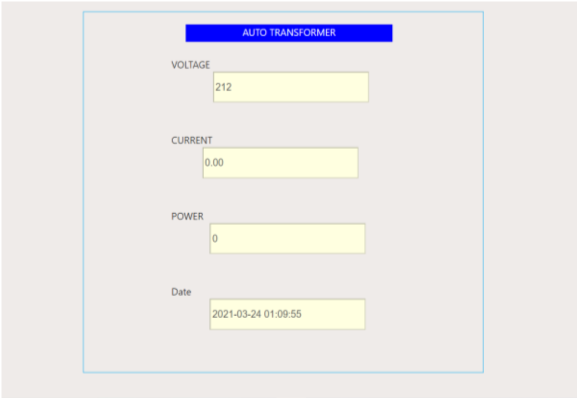

Fig 14: No load value

Fig 15: On Load value

8. Conclusion

This paper has proposed a system which has two different modes viz. manual mode and auto mode for automatic tap changing of the transformer according to the load variations. Changing the tappings of the transformer has been implemented using IOT. The system also provides a cloud based storage to store the historical backdrop of voltage and current readings through a web application. While comparing with the manual method the IOT based solution for monitoring and tap changing of autotransformer is quite easy and effective..

9. Future Scope

IOT(Internet of Things) makes the best use of the internet to direct the devices or to track the devices and supplementary physical things comprising it. The system can be used in industries where the monitoring and controlling of the transformer is required regularly. Updating of data in the website is random at several intervals of time. Current and Voltage values will not get intimated in the webpage during the Manual mode. These disadvantages can be nullified in future..

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