A Project Report On

WIFI BASED SUBSTATION MONITORING, CONTROLLING AND PROTECTION USING THINGSPEAKAND BLYNK APP ON MATLAB

A dissertation submitted to CBIT (A) affiliated to Osmania University in partial fulfilment of the requirements for the award of the degree of

Bachelor of Engineering in

Electrical and Electronics Engineering by

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This is to certify that the project seminar report entitled "**WIFI BASED SUBSTATION MONITORING, CONTROLLING AND PROTECTION USING THINGSPEAK AND BLYNK APP ON MATLAB**" submitted to Chaitanya Bharathi Institute of Technology, in partial fulfilment of the requirements for the award of the degree of B.E (ELECTRICAL AND ELECTRONICS ENGINEERING) during the academic year 2021-22 is a record of original work carried out by

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DECLARATION

This is to certify that the work reported in the present project titled "**WIFI BASED SUBSTATION MONITORING, CONTROLLING AND PROTECTION USING THINGSPEAK AND BLYNK APP ON MATLAB**" is a record of work done by us at **Chaitanya Bharathi Institute of Technology**, Hyderabad under the guidance of Dr.M.Deepthi, Asst. Professor, Dept. of EEE for the award of B.E Degree (E.E.E), this project work has not been submitted to any other university/ institution.

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ABSTRACT

The substation is a particularly important part of the power system network. Monitoring, Protection and Controlling of a substation plays a key role for supplying quality power to the consumer. To remotely operate a substation, we designed a Wi-Fi based communication network using ESP8266 microcontroller and Blynk application. For Monitoring of Load currents in a substation we use direct interface of thingspeak with MATLAB; For Controlling of Switches connected to the Load and for Over current Protection ESP8266 microcontroller is used. Blynk application is used to connect and disconnect loads according to user requirement. The above proposed work is implemented using MATLAB Simulink, to decrease the implementation cost and provide real time experience of substation monitoring, controlling and protection effectively.

Keywords:

Monitoring, Controlling, Protecting, ESP8266 micro controller, Blynk,thingspeak.

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1. INTRODUCTION

1.1 Introduction

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1.2 Objectives

1. To monitor the substation parameters
2. To control the relay
3. To protect the system Equipment from abnormalities
4. To improve the power quality
5. To maintain power supply continuity
6. To experience a real time monitoring
7. Collect data for future analysis

1.3 Literature survey

As of [1]The purpose is to acquire the remote electrical parameters like voltage, current, and frequency and send these real-time values over the gsm network using the gsm modem/phone along with temperature at the power station. This project is also designed to protect the electrical circuitry by operating a spdt relay. This relay gets activated whenever the electrical parameters exceed the predefined values. The relay can be used to switch off the main electrical supply. Users can send commands in the form of SMS (Short Message Service) messages to read the remote electrical parameters. This system also can automatically send the real-time electrical parameters periodically (based on time settings) in the form of SMS. This system can be designed to send SMS alerts whenever the relay trips or whenever the voltage or current exceeds the predefined limits. This project makes use of a microcontroller. The controller can efficiently communicate with the different sensors being used. The controller is provided with some internal memory to hold the code. This memory is used to dump some set of assembly instructions into the controller. And the functioning of the controller is dependent on these assembly instructions. The controller is programmed using embedded c language.

As of [2] The purpose of this project is to acquire the remote electrical parameters like Voltage, Current, and Frequency and send these real-time values over the GSM network using GSM Modem/phone along with temperature at the power station. This project is also designed to protect the electrical circuitry by operating an Electromagnetic Relay. This Relay gets activated whenever the electrical parameters exceed the predefined values. The Relay can be used to operate a Circuit Breaker to switch off the main electrical supply. Users can send commands in the form of SMS messages to read the remote electrical parameters. This system also can automatically send the real-time electrical parameters periodically (based on time settings) in the form of SMS. This system can be designed to send SMS alerts whenever the Circuit Breaker trips or whenever the Voltage or Current exceeds the predefined limits. This project makes use of an onboard computer which is commonly termed a microcontroller. This onboard computer can efficiently communicate with the different sensors being used. The controller is provided with some internal memory to hold the code. This memory is used to dump some set of assembly instructions into the controller. And the functioning of the controller is dependent on these assembly instructions. The controller is programmed using Embedded C language

As of [3] paper introduces the structure configuration and realization method of the upper monitoring system of a medium and small substation and mainly completes selection and control of communication settings and real-time refreshing and display of field data collected, etc. Due to the requirement for real-time performance of monitoring system, how to ensure stable serial communication has become the core problem of the whole software, and meanwhile considering that a lot of real-time data needs to be collected and a mass of historical data needs to be kept in power system, and therefore the local database is also an important component of this monitoring system.

As of [4] monitoring and control software is one of the most important parts of the substation automation system. With the rapid development of substation automation systems, a main tendency of the monitoring and control software is to be supportive of the network architecture and to have powerful functions of configuration and real-time performance. The gross structure of the SCADA system in the substation is introduced in this paper, the entire design of the configuration monitor software is also discussed, and the key technologies of the configuration software for substation monitoring and control are described. The reliability of this software is very good, and this software can also offer a human-computer interaction interface, so this software has a better monitoring effect.

2. SUBSTATION

2.1 Introduction

A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions. Between the generating station and consumer, electric power may flow through several substations at different voltage levels. A substation may include transformers to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages.
Substations may be owned and operated by an electrical utility, or may be owned by a large industrial or commercial customer. Generally substations are unattended, relying on SCADA for remote supervision and control.
The word substation comes from the days before the distribution system became a grid. As central generation stations became larger, smaller generating plants were converted to distribution stations, receiving their energy supply from a larger plant instead of using their own generators. The first substations were connected to only one power station, where the generators were housed, and were subsidiaries of that power station.

2.2 Substation equipment's

Fig 1: Substation

The general substation consists of the following Equipment:

1. Incoming line
2. Lightning Arresters
3. Air-break switch
4. Circuit Breakers
5. Step-down Transformer

6. Bus
7. Outgoing line

There are different types of Substations are there, depending on the voltage rating, and they use extra Equipment like wave traps, Reactors, etc.

2.3 Types

Substations may be described by their voltage class, their applications within the power system, the method used to insulate most connections, and by the style and materials of the structures used. These categories are not disjointed; for example, to solve a particular problem, a transmission substation may include significant distribution functions.

2.3.1 Transmission substation

A transmission substation connects two or more transmission lines.[2] The simplest case is where all transmission lines have the same voltage. In such cases, substation contains high-voltage switches that allow lines to be connected or isolated for fault clearance or maintenance. A transmission station may have transformers to convert between two transmission voltages, voltage control/power factor correction devices such as capacitors, reactors or static VAR compensators and equipment such as phase shifting transformers to control power flow between two adjacent power systems.

Transmission substations can range from simple to complex. A small "switching station" may be little more than a bus plus some circuit breakers. The largest transmission substations can cover a large area (several acres/hectares) with multiple voltage levels, many circuit breakers, and a large amount of protection and control equipment (voltage and current transformers, relays and SCADA systems). Modern substations may be implemented using international standards such as IEC Standard 61850.

2.3.2 Distribution Substation

A distribution substation transfers power from the transmission system to the distribution system of an area.[2] It is uneconomical to directly connect electricity consumers to the main transmission network, unless they use large amounts of power, so the distribution station reduces voltage to a level suitable for local distribution.

The input for a distribution substation is typically at least two transmission or sub-transmission lines. Input voltage may be, for example, 115 kV, or whatever is common in the area. The output is a number of feeders. Distribution voltages are typically medium voltage, between 2.4 kV and 33 kV, depending on the size of the area served and the practices of the local utility. The feeders run along streets overhead (or underground, in some cases) and power the distribution transformers at or near the customer premises.

In addition to transforming voltage, distribution substations also isolate faults in either the transmission or distribution systems. Distribution substations are typically the points of voltage regulation, although on long distribution circuits (of several miles/kilometers), voltage regulation equipment may also be installed along the line.

The downtown areas of large cities feature complicated distribution substations, with high-voltage switching, and switching and backup systems on the low-voltage side. More typical distribution substations have a switch, one transformer, and minimal facilities on the low-voltage side.

2.3.3 Collector substation

In distributed generation projects such as a wind farm or photovoltaic power station, a collector substation may be required. It resembles a distribution substation although power flow is in the opposite direction, from many wind turbines or inverters up into the transmission grid. Usually for economy of construction the collector system operates around 35 kV, although some collector systems are 12 kV, and the collector substation steps up voltage to a transmission voltage for the grid. The collector substation can also provide power factor correction if it is needed, metering, and control of the wind farm. In some special cases a collector substation can also contain an HVDC converter station.

Collector substations also exist where multiple thermal or hydroelectric power plants of comparable output power are in proximity. Examples for such substations are Brauweiler in Germany and Hradec in the Czech Republic, where power is collected from nearby lignite-fired power plants. If no transformers are required for increasing the voltage to transmission level, the substation is a switching station

2.3.4 Converter Substation

Converter substations may be associated with HVDC converter plants, traction current, or interconnected non-synchronous networks. These stations contain power electronic devices to change the frequency of current, or else convert from alternating to direct current or the reverse. Formerly rotary converters changed frequency to interconnect two systems; nowadays such substations are rare.

2.3.5 Switching Substation

A switching station is a substation without transformers and operating only at a single voltage level. Switching stations are sometimes used as collector and distribution stations.

Sometimes they are used for switching the current to back-up lines or for parallelizing circuits in case of failure. An example is the switching stations for the HVDC Inga–Shaba transmission line.

A switching station may also be known as a switchyard, and these are commonly located directly adjacent to or nearby a power station. In this case the generators from the power station supply their power into the yard onto the generator bus on one side of the yard, and the transmission lines take their power from a Feeder Bus on the other side of the yard.

An important function performed by a substation is switching, which is the connecting and disconnecting of transmission lines or other components to and from the system. Switching events may be planned or unplanned. A transmission line or other component may need to be de-energized for maintenance or for new construction, for example, adding or removing a transmission line or a transformer. To maintain reliability of supply, companies aim at keeping the system up and running while performing maintenance. All work to be performed, from routine testing to adding entirely new substations, should be done while keeping the whole system running.

Unplanned switching events are caused by a fault in a transmission line or any other component, for example:

a line is hit by lightning and develops an arc,

a tower is blown down by high wind.

The function of the switching station is to isolate the faulty portion of the system in the shortest possible time. De-energizing faulty equipment protects it from further damage, and isolating a fault helps keep the rest of the electrical grid operating with stability

2.3.6 Railway

Electrified railways also use substations, often distribution substations. In some cases a conversion of the current type takes place, commonly with rectifiers for direct current (DC) trains, or rotary converters for trains using alternating current (AC) at frequencies other than that of the public grid. Sometimes they are also transmission substations or collector substations if the railway network also operates its own grid and generators to supply the other stations

2.3.7 Mobile Substation

A mobile substation is a substation on wheels, containing a transformer, breakers and buswork mounted on a self-contained semi-trailer, meant to be pulled by a truck. They are designed to be compact for travel on public roads, and are used for temporary backup in times of natural disaster or war. Mobile substations are usually rated much lower than permanent installations, and may be built in several units to meet road travel limitations

2.4 Design

2.4.1 Elements of Substation

Substations generally have switching, protection and control equipment, and transformers. In a large substation, circuit breakers are used to interrupt any short circuits or overload currents that may occur on the network. Smaller distribution stations may use recloser circuit breakers or fuses for protection of distribution circuits. Substations themselves do not usually have generators, although a power plant may have a substation nearby. Other devices such as capacitors, voltage regulators, and reactors may also be located at a substation.

Substations may be on the surface in fenced enclosures, underground, or located in special-purpose buildings. High-rise buildings may have several indoor substations. Indoor substations are usually found in urban areas to reduce the noise from the transformers, for reasons of appearance, or to protect switchgear from extreme climate or pollution conditions.

A grounding (earthing) system must be designed. The total ground potential rise, and the gradients in potential during a fault (called touch and step potentials), must be calculated to protect passers-by during a short circuit in the transmission system. Earth faults at a substation can cause a ground potential rise. Currents flowing in the Earth's surface during a fault can cause metal objects to have a significantly different voltage than the ground under a person's feet; this touch potential presents a hazard of electrocution. Where a substation has a metallic fence, it must be properly grounded to protect people from this hazard.

The main issues facing a power engineer are reliability and cost. A good design attempts to strike a balance between these two, to achieve reliability without excessive cost. The design should also allow expansion of the station, when required

2.4.2 Location Selection

Selection of the location of a substation must consider many factors. Sufficient land area is required for installation of equipment with necessary clearances for electrical safety, and for access to maintain large apparatus such as transformers.

Where land is costly, such as in urban areas, gas insulated switchgear may save money overall. Substations located in coastal areas affected by flooding and tropical storms may often require an elevated structure to keep equipment sensitive to surges hardened against these elements. The site must have room for expansion due to load growth or planned transmission additions. Environmental effects of the substation must be considered, such as drainage, noise and road traffic effects.

The substation site must be reasonably central to the distribution area to be served. The site must be secure from intrusion by passers-by, both to protect people from injury by electric shock or arcs, and to protect the electrical system from misoperation due to vandalism.

2.4.3 Design Diagrams

The first step in planning a substation layout is the preparation of a one-line diagram, which shows in simplified form the switching and protection arrangement required, as well as the incoming supply lines and outgoing feeders or transmission lines. It is a usual practice by many electrical utilities to prepare one-line diagrams with principal elements (lines, switches, circuit breakers, transformers) arranged on the page similarly to the way the apparatus would be laid out in the actual station.

In a common design, incoming lines have a disconnect switch and a circuit breaker. In some cases, the lines will not have both, with either a switch or a circuit breaker being all that is considered necessary. A disconnect switch is used to provide isolation, since it cannot interrupt load current. A circuit breaker is used as a protection device to interrupt fault currents automatically, and may be used to switch loads on and off, or to cut off a line when power is flowing in the 'wrong' direction. When a large fault current flows through the circuit breaker, this is detected through the use of current transformers. The magnitude of the current transformer outputs may be used to trip the circuit breaker resulting in a disconnection of the load supplied by the circuit break from the feeding point. This seeks to isolate the fault point from the rest of the system, and allow the rest of the system to continue operating with minimal impact. Both switches and circuit breakers may be operated locally (within the substation) or remotely from a supervisory control center.

With overhead transmission lines, the propagation of lightning and switching surges can cause insulation failures into substation equipment. Line entrance surge arrestors are used to protect substation equipment accordingly. Insulation Coordination studies are carried out extensively to ensure equipment failure (and associated outages) is minimal.

Once past the switching components, the lines of a given voltage connect to one or more buses. These are sets of busbars, usually in multiples of three, since three-phase electrical power distribution is largely universal around the world.The arrangement of switches, circuit breakers, and buses used affects the cost and reliability of the substation. For important substations a ring bus, double bus, or so-called "breaker and a half" setup can be used, so that the failure of any one circuit breaker does not interrupt power to other circuits, and so that parts of the substation may be de-energized for maintenance and repairs. Substations feeding only a single industrial load may have minimal switching provisions, especially for small installations.

This single-line diagram illustrates the breaker-and-a-half configuration often used in switchyards of small utilities. In large utilities the double-bus-double-breaker configuration is often preferred.

Once having established buses for the various voltage levels, transformers may be connected between the voltage levels. These will again have a circuit breaker, much like transmission lines, in case a transformer has a fault (commonly called a "short circuit").

Along with this, a substation always has control circuitry needed to command the various circuit breakers to open in case of the failure of some component.

2.4.4 Automation

Early electrical substations required manual switching or adjustment of equipment, and manual collection of data for load, energy consumption, and abnormal events. As the complexity of distribution networks grew, it became economically necessary to automate supervision and control of substations from a centrally attended point, to allow overall coordination in case of emergencies and to reduce operating costs. Early efforts to remote control substations used dedicated communication wires, often run alongside power circuits. Power-line carrier, microwave radio, fiber optic cables as well as dedicated wired remote control circuits have all been applied to Supervisory Control and Data Acquisition (SCADA) for substations. The development of the microprocessor made for an exponential increase in the number of points that could be economically controlled and monitored. Today, standardized communication protocols such as DNP3, IEC 61850 and Modbus, to list a few, are used to allow multiple intelligent electronic devices to communicate with each other and supervisory control centers. Distributed automatic control at substations is one element of the so-called smart grid.

2.4.5 Insulation

Switches, circuit breakers, transformers and other apparatus may be interconnected by air-insulated bare conductors strung on support structures. The air space required increases with system voltage and with the lightning surge voltage rating. For medium-voltage distribution substations, metal-enclosed switch gear may be used and no live conductors exposed at all. For higher voltages, gas-insulated switch gear reduces the space required around live bus. Instead of bare conductors, bus and apparatus are built into pressurized tubular containers filled with sulfur hexafluoride (SF_6) gas. This gas has a higher insulating value than air, allowing the dimensions of the apparatus to be reduced. In addition to air or SF_6 gas, apparatus will use other insulation materials such as transformer oil, paper, porcelain, and polymer insulators.

2.4.6 Structure

Outdoor, above-ground substation structures include wood pole, lattice metal tower, and tubular metal structures, although other variants are available. Where space is plentiful and appearance of the station is not a factor, steel lattice towers provide low-cost supports for transmission lines and apparatus. Low-profile substations may be specified in suburban areas where appearance is more critical. Indoor substations may be gas-insulated switchgear (at high voltages), or metal-enclosed or metal-clad switchgear at lower voltages. Urban and suburban indoor substations may be finished on the outside so as to blend in with other buildings in the area.

A compact substation is generally an outdoor substation built in a metal enclosure, in which each item of the electrical equipment is located very near to each other to create a relatively smaller footprint size of the substation.

2.5 Parameters

1. voltage

Voltage is measured using PT (potential transformer) and voltmeter. Primary of PT connected across the line and then voltmeter is connected to the secondary of the PT. PT will step down the voltage to a value that can be measured by low range voltmeter and the proportionality constant (i.e. transformation ratio) is multiplied with the measured value from the voltmeter. As we are connecting it to the microcontroller an Analog to digital converter is used after the voltmeter (which converts the continuous analog signal into a digital signal).

2. Current

Current is measured using CT (Current Transformer) and Ammeter. The primary of the CT is connected in series with the line, Ammeter is connected to the secondary of CT. CT will step down the current to the value that can be measured by the low range Ammeter.

The transformation ratio will be multiplied with the measured value by Ammeter. Same a voltage measurement we use ADC here.

3. Frequency

A frequency counter is the most used method to measure the frequency of the circuit. This is an electronic instrument that measures the frequency of an applied repetitive electronic signal and displays the result in hertz on a digital display, or we can send the output to the microcontroller for further operations.

4. Power

We have three powers, one which is consumed by the consumers and one which circulates in the line to operate the Equipment in the network, and the other is the rating of the line. Powers are measured by the wattmeter, the input to the wattmeter are CT and PT secondaries and the output is given to ADC which is then given to the microcontroller.

5. Temperature

The temperature of the different equipment can be measured by the temperature sensor and the measured data will be sent to the microcontroller for further operations.

2.6 Importance of substation in Power system Network

A power system network is used to transmit the power from generating station to the load(consumers). The power is transmitted at high voltages to reduce the losses and weight of the conductor. But as we can't use that high voltage for our loads, we are using substations in the middle of generation and consumption. Mostly all substations are step-down substations or Isolation substations. So, without using the substation Equipment we can’t supply the generated power to the consumer. And as the line is exceedingly long, the environmental effects will affect the Quality of the power, which can be controlled in the substation. The importance of substation is to control the voltage range and maintain the Quality power through the line.

3. IoT (INTERNET OF THINGS)

3.1 Introduction to IoT

The Internet of things (IoT) describes physical objects (or groups of such objects) that are embedded with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.

Things are the individual devices, which are used to measure the physical parameters and send them to other devices or the cloud, it may be a sensor or other device but it is a node of the complex network.

Communication between the devices or with the cloud can follow different protocols depending upon the application we use one or many in the same network for extra protection.

Internet is a global computer network providing a variety of information and communication facilities, consisting of interconnected networks using standardized communication protocols.

3.2 Network Communications

The Internet of things (IoT) refers to using the Internet to facilitate communication with “things”. IoT is the connection of highly distributed physical objects, which have embedded electronics, computers, software, sensors, or actuators, to the internet to collect and exchange data for monitoring and control. The Industrial Internet of Things (IIoT) is a subset of IoT addressing industrial applications and processes. IIoT is sometimes called industrial internet or Industry 4.0 and incorporates machine learning and big data to harness sensor and machine data to enhance efficiency and productivity. IoT Communication defines the infrastructure, technologies, and protocols used to connect IoT devices, gateways, and cloud platforms.

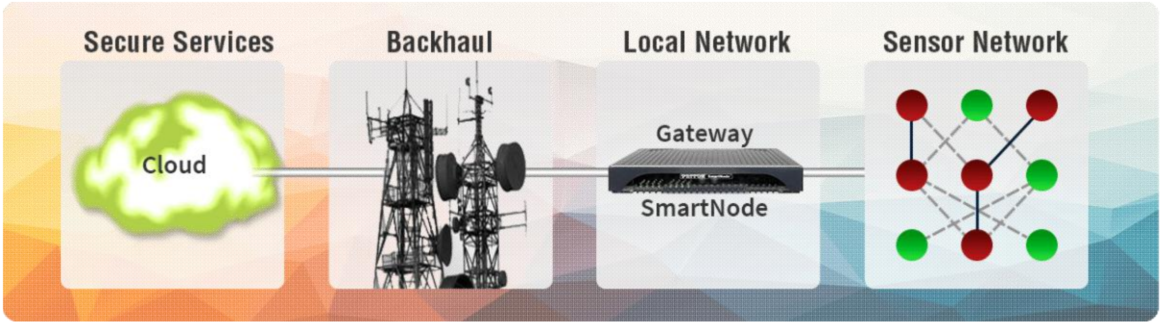

Fig 2: IoT Network Communication

Different communications:

1. Copper Link Ethernet Extenders deliver Ethernet-connected IoT devices over the low-voltage wire at long distances far beyond the limits of Ethernet.
2. The Fiber Plex products offer fibre transport solutions for IoT devices presenting RF, Ethernet/IP, SCADA, Serial Data, Contact Closure/Actuation, Video, and other interfaces.
3. Smart Nodes products provide IoT Gateway services supporting the MQTT and other IoT messaging protocols with seamless connectivity over any access network, including Copper and Fiber Ethernet, xDSL, Private and Public Wireless broadband, or legacy dial-up modems.
4. Smart Nodes support the IPsec VPN Tunnel for SCADA and Management Traffic and Remote Management as well as multi-WAN redundancy and out-of-band management access to IoT devices.
5. The Copper link, Fiber Plex, and Smart Node products are all offered in industrial-grade ruggedized enclosures for use in harsh environments.

3.3 Need for IoT in Modern Life

The Internet of Things (IoT) is creating much buzz while it goes about transforming our lives. IoT is everywhere, even though we don't always see it or know that a device is part of the IoT. The IoT is turning physical objects into an ecosystem of information shared between devices that are wearable, portable, even implantable, making our lives technology and data-rich. IoT business applications are numerous. Smart machines are changing when, where and how work is done in virtually every industry. IoT is an unprecedented network connecting machines, individuals, data, and processes and is now filtering down to real-life, shaping how we go about our daily lives.

Some real-world examples of IoT are wearable fitness and trackers (like Fitbits) and IoT healthcare applications, voice assistants (Siri and Alexa), smart cars (Tesla), and smart appliances (iRobot). With IoT's rapid deployment coming into contact with multiple IoT devices every day will be unavoidable soon.

4. ESP8266

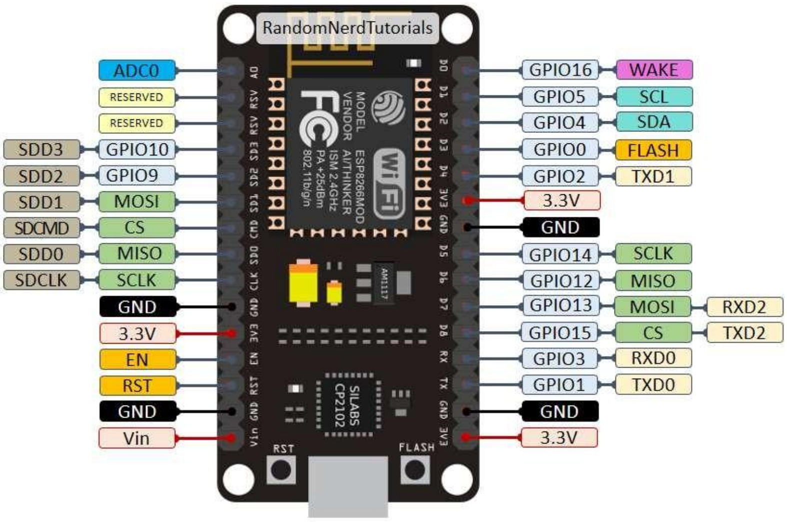

Fig 3 Pin diagram

4.1 Introduction

Espressif's ESP8266EX delivers highly integrated Wi-Fi SoC solution to meet users' continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry. With the complete and self-contained Wi-Fi networking capabilities, ESP8266EX can perform either as a standalone application or as the slave to a host MCU. When ESP8266EX hosts the application, it promptly boots up from the flash. The integrated high speed cache helps to increase the system performance and optimize the system memory. Also, ESP8266EX can be applied to any micro controller design as a Wi-Fi adaptor through SPI/SDIO or UART interfaces. ESP8266EX integrates antenna switches, RF balun, power amplifier, low noise receives amplifier, filters and power management modules. The compact design minimizes the PCB size and requires minimal external circuitries. Besides the Wi-Fi functionalities, ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs. Software Development Kit (SDK) provides sample codes for various applications.

Espressif Systems' Smart Connectivity Platform (ESCP) enables sophisticated features including:

- Fast switch between sleep and wakeup mode for energy-efficient purpose;

- Adaptive radio biasing for low-power operation
- Advance signal processing
- Spur cancellation and RF co-existence mechanisms for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation.

4.2 Wi-Fi Key Features

- 802.11 b/g/n support
- 802.11 n support (2.4 GHz), up to 72.2 Mbps
- Defragmentation
- 2 x virtual Wi-Fi interface
- Automatic beacon monitoring (hardware TSF)
- Support Infrastructure BSS Station mode/SoftAP mode/Promiscuous mode

4.3 Applications

- Home appliances
- Home automation
- Smart plugs and lights
- Industrial wireless control
- Baby monitors
- IP cameras
- Sensor networks
- Wearable electronics
- Wi-Fi location-aware devices
- Security ID tags
- Wi-Fi position system beacons

4.4 Specification

Wi-Fi	Certification	Wi-Fi Alliance
	Protocols	802.11 b/g/n (HT20)
	Frequency Range	2.4 GHz ~ 2.5 GHz (2400 MHz ~ 2483.5 MHz)
	TX Power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: –91 dbm (11 Mbps)
		802.11 g: –75 dbm (54 Mbps)
		802.11 n: –72 dbm (MCS7)
	Antenna	PCB Trace, External, IPEX Connector, Ceramic Chip
Hardware	CPU	Tensilica L106 32-bit processor
	Peripheral Interface	UART/SDIO/SPI/I2C/I2S/IR Remote Control
		GPIO/ADC/PWM/LED Light & Button
	Operating Voltage	2.5 V ~ 3.6 V
	Operating Current	Average value: 80 mA
	Operating Temperature Range	–40 °C ~ 125 °C
	Package Size	QFN32-pin (5 mm x 5 mm)
	External Interface	-
Software	Wi-Fi Mode	Station/SoftAP/SoftAP+Station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network)
	Software Development	Supports Cloud Server Development / Firmware and SDK for fast on-chip programming
	Network Protocols	IPv4, TCP/UDP/HTTP
	User Configuration	AT Instruction Set, Cloud Server, Android/iOS App

Table1:Specification

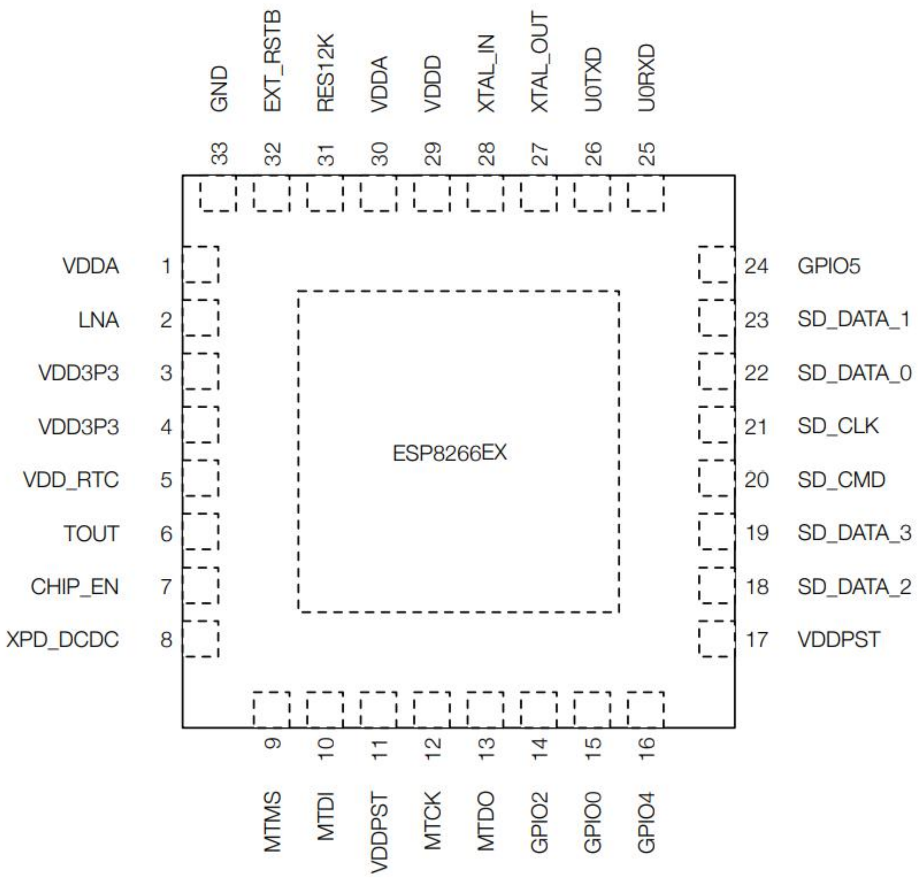

Fig 4: Pin layout for 32-pin QFN package

Pin	Name	Type	Function
1	VDDA	P	Analog Power 2.5 V ~ 3.6 V
2	LNO	I/O	RF antenna interface Chip output impedance = 39 + j6 Ω. It is suggested to the π-type matching network to match the antenna.
3	VDD3P3	p	Amplifier Power 2.5 V ~ 3.6 V
4	VDD3P3	P	Amplifier Power 2.5 V ~ 3.6 V
5	VDD_RTC	P	NC (1.1 V)
6	TOUT	I	ADC pin. It can be used to test the power-supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin 6). However, these two functions cannot be used simultaneously.
7	CHIP_EN	I	Chip Enable High: On, chip works properly Low: Off, small current consumed
8	XPD_DCDC	I/O	Deep-sleep wakeup (need to be connected to EXT_RSTB); GPIO16

9	MTMS	I/O	GPIO 14; HSPI_CLK
10	MTDI	I/O	GPIO 12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8 V ~ 3.6 V)
12	MTCK	I/O	GPIO 13; HSPI_MOSI; UART0_CTS
13	MTDO	I/O	GPIO 15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART TX during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8 V ~ 3.6 V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 20 Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200 Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200 Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200 Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200 Ω); SPI_MISO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200 Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART TX during flash programming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 2.5 V ~ 3.6 V
30	VDDA	P	Analog Power 2.5 V ~ 3.6 V

Table 2: ESP8266EX Pin Definitions

4.5 Functional Description

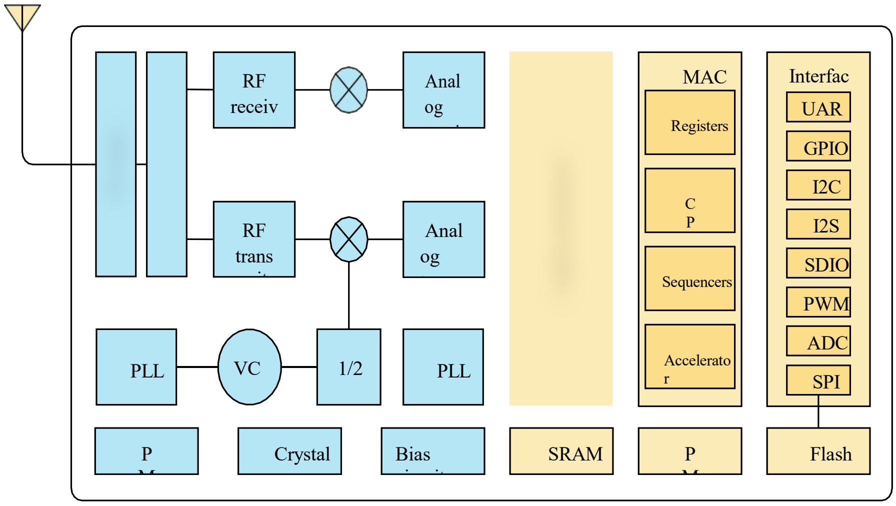

Fig 5: Functional Block Diagram

4.5.1 CPU

The ESP8266EX integrates a Tensilica L106 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160 MHz. The Real-Time Operating System (RTOS) and Wi-Fi stack allow 80% of the processing power to be available for user application programming and development. The CPU includes the interfaces as below:

- Programmable RAM/ROM interfaces (iBus), which can be connected with memory controller, and can also be used to visit flash.
- Data RAM interface (dBus), which can connected with memory controller.
- AHB interface which can be used to visit the register.

4.5.2 Memory

ESP8266EX Wi-Fi SoC integrates memory controller and memory units including SRAM and ROM. MCU can access the memory units through iBus, dBus, and AHB interfaces. All memory units can be accessed upon request, while a memory arbiter will decide the running sequence according to the time when these requests are received by the processor.

According to our current version of SDK, SRAM space available to users is assigned as below.

- RAM size < 50 kB, that is, when ESP8266EX is working under the Station mode and connects to the router, the maximum programmable space accessible in Heap + Data section is around 50 kB.
- There is no programmable ROM in the SoC. Therefore, user program must be stored in an external SPI flash.

4.5.3 External Flash

ESP8266EX uses external SPI flash to store user programs, and supports up to 16 MB memory capacity theoretically.

The minimum flash memory of ESP8266EX is shown below:

- OTA disabled: 512 kB at least
- OTA enabled: 1 MB at least

5. BLYNK

5.1 Introduction to Blynk

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it, and do many other cool things.

There are three major components in the platform:

- Blynk App - allows to you create amazing interfaces for your projects using various widgets we provide.
- Blynk Server - responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynk server locally. It’s open-source, could easily handle thousands of devices, and can even be launched on a Raspberry Pi.
- Blynk Libraries - for all the popular hardware platforms - enable communication with the server and process all the incoming and outcoming commands

Every time you press a Button in the Blynk app, the message travels to the Blynk Cloud, where it magically finds its way to your hardware. It works the same in the opposite direction and everything happens in a blynk of an eye.

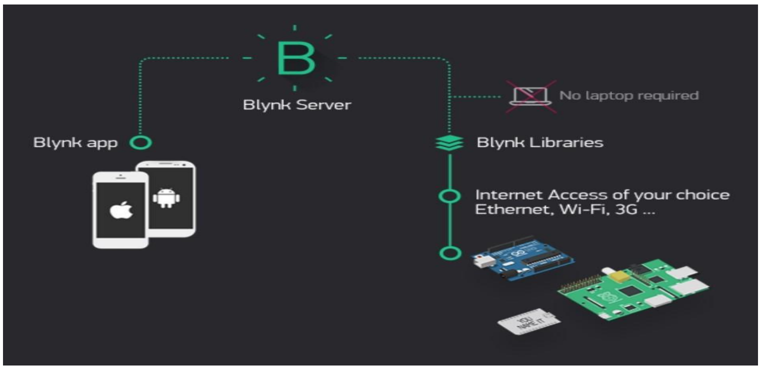

Fig 6: Blynk Network

5.2 Features

- Similar API & UI for all supported hardware & devices
- Connection to the cloud using:
  - Wi-Fi

    - Bluetooth and BLE
    - Ethernet
    - USB (Serial)
    - GSM
    - …
- Set of easy-to-use Widgets
- Direct pin manipulation with no code writing
- Easy to integrate and add new functionality using virtual pins
- History data monitoring via Super Chart widget
- Device-to-Device communication using Bridge Widget
- Sending emails, tweets, push notifications, etc.
- new features are constantly added!

5.3 Connecting to Blynk

1. Hardware.

An Arduino, Raspberry Pi, or a similar development kit.

Blynk works over the Internet. This means that the hardware you choose should be able to connect to the internet. Some of the boards, like Arduino Uno, will need an Ethernet or Wi-Fi Shield to communicate, others are already Internet-enabled: like the ESP8266, Raspberry Pi with Wi-Fi dongle, Particle Photon, or Spark Fun Blynk Board. But even if you don't have a shield, you can connect it over USB to your laptop or desktop (it is a bit more complicated for newbies, but we got you covered). What is cool, is that the list of hardware that works with Blynk is huge and will keep on growing.

2. A Smartphone.

The Blynk App is a well-designed interface builder. It works on both iOS and Android, Procedure:

1. create a Blynk account (use your mail to log in because it is needed after)

2. Create a NEW project

3. Choose your hardware

4. Auth Token

Auth Token is a unique identifier that is needed to connect your hardware to your smartphone. Every new project you create will have its own Auth Token. You'll get Auth Token automatically on your email after project creation. You can also copy it manually. Click on the devices section and select the required device.

5. Select Email (for receiving Auth Token)

6. click on Create

7. Add widget (select required blocks and mention the PINs)

8. Run the project

6.Simulink

6.1 Introduction

Simulink is a MATLAB-based graphical programming environment for modeling, simulating and analyzing multidomain dynamical systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in automatic control and digital signal processing for multidomain simulation and model-based design.

6.2 Simulink is for model based Design

From Concept to Operation

To transform development of complex systems, market-leading companies adopt Model-Based Design by systematically using models throughout the entire process.

- Use a virtual model to simulate and test your system early and often
- Validate your design with physical models, Hardware-in-the-Loop testing, and rapid prototyping
- Generate production-quality C, C++ , CUDA, PLC, Verilog, and VHDL code and deploy directly to your embedded system
- Maintain a digital thread with traceability through requirements, system architecture, component design, code and tests
- Extend models to systems in operation to perform predictive maintenance and fault analysis

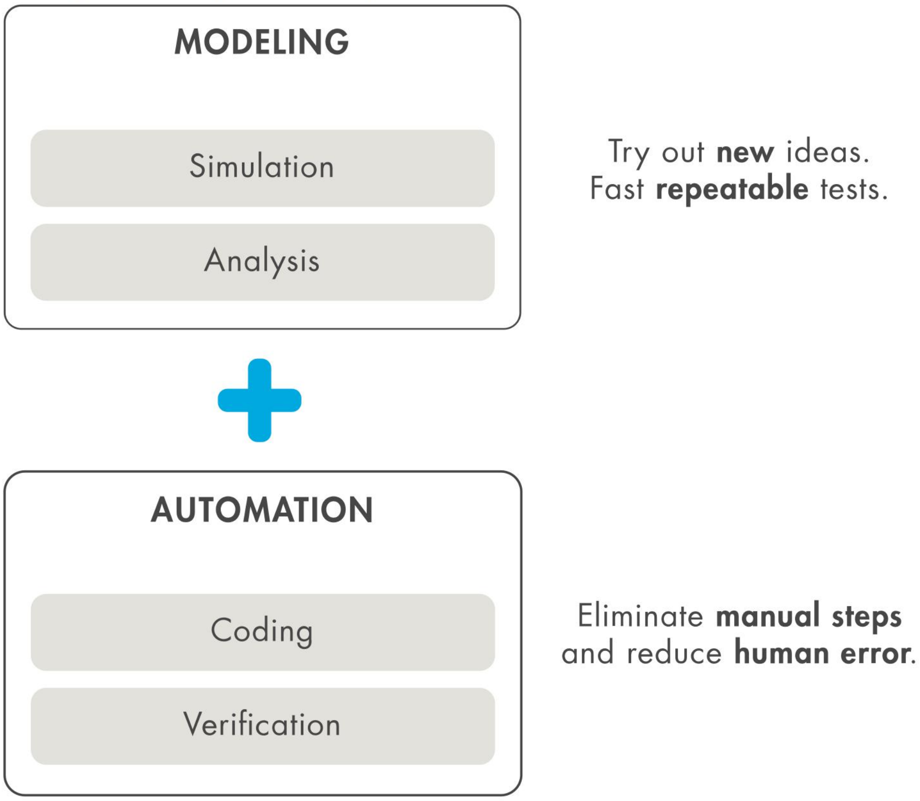

Fig 7: Model based design

6.3 Simulink for simulation

Design and simulate your system before moving to hardware

Explore a wide design space and test your systems early with multidomain modeling and simulation.

- Quickly evaluate multiple design ideas in one multidomain simulation environment
- Simulate large-scale system models with reusable components and libraries including specialized, third-party modeling tools
- Deploy simulation models for desktop, real-time, and Hardware-in-the-Loop testing
- Run large simulations on multicore desktops, clusters, and the cloud

6.4 Simulink is for Model-Based Systems Engineering

Design, analyze, and test system and software architectures

Model-based systems engineering (MBSE) is the application of models to support the full system lifecycle. Simulink bridges development from requirements and system architecture to detailed component design, implementation, and testing.

- Capture and decompose requirements
- Define and elaborate specifications for components, compositions, and architectures
- Establish a single-source for architecture and component-level interfaces
- Perform analysis and trade studies using MATLAB
- Validate requirements and verify system architectures using simulation-based test

6.5 Simulink is for Agile Software Development

Agile software development helps teams deliver value to their customers faster using short iteration cycles with an emphasis on continuous integration and team collaboration. Simulation, automated testing, and code generation shorten the development cycle, enabling you to become a successful Agile team.

- Develop and run simulation tests in an automation server to continuously verify new design iterations
- Perform more analysis and testing on the desktop before going to hardware
- Deliver working software through simulations that customers can evaluate
- Respond to changing requirements quicky through model updates and simulation
- Make progress visible to key stakeholders with automated reports and dashboards

7. IMPLEMENTATION

7.1 Block Diagram

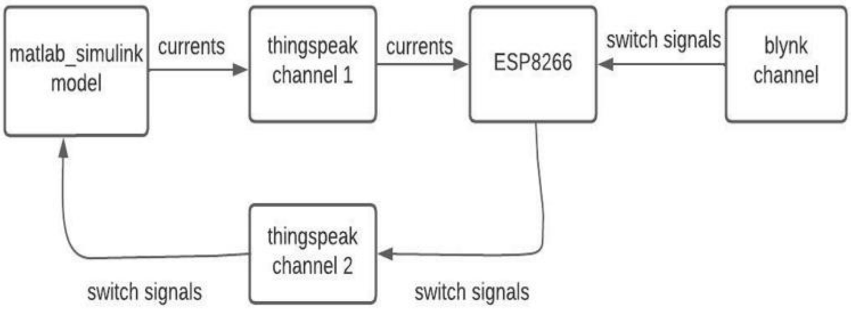

Fig 8: Block Diagram for Data Flow

Uses of each block:

ESP8266 is the main interface device between all the modules.

Sensors will feed the data to ESP8266

ESP8266 will perform logic for protecting the line from any abnormalities.

If there is any abnormalities Esp8266 will send triggering signal to relays (in Matlab)

Relay is used to switch the circuit breaker.

Working of each block:

Sensors will measure the line parameters by using different techniques and feed the data to ESP8266. ESP8266 is programmed to operate the relay based on data its value and the signal sent by Blynk application. Blynk application is used to control the relay using the switch in its UI widget.

7.2 Algorithm:

1. Read load current in Matlab Simulink model

2. Connect to WIFI

2. Read the command coming from BLYNK, and send it to Matlab Simulink model

3. IF command=1 then turn ON the relay

4. Else Turn OFF

5. Initialize the limits (max and min current)

6. If any of (load currents) violets the limits then activate the corresponding Relay.

7. Else continue.

The above algorithm will continue in a loop infinitely.

7.3 Program:

Program uploaded in ESP8266 through Arduino IDE.

```
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPLDjhQW241"
#define BLYNK_DEVICE_NAME "cooler"
#define BLYNK_AUTH_TOKEN "DLQNJH4Xk9NRMoa7L1sE1jbiYh8FaYm-"
#include<BlynkSimpleEsp8266.h>;
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <WiFiClientSecure.h>
#include <WiFiServer.h>
#include "ThingSpeak.h"
char auth[]=BLYNK_AUTH_TOKEN;

char ssid[] = "Mm"; // your network SSID (name)
```

```
char pass[] = "sailusai1"; // your network password

WiFiClient  client;
unsigned long counterChannelNumber =1561089;
unsigned long ccn2=1611357;// Channel ID
const char * myCounterReadAPIKey ="4AAIUU0IHWEK5AID"; // Read API Key
const char *mywr="W1UCA77LJ18VU3XN";
int a,b,c,d;
void setup () {
  Serial.begin(115200);
  initWiFi();
  ThingSpeak.begin(client);
  Blynk.begin(auth,ssid,pass);
} BLYNK_WRITE(V0)
{
  int pin0=param.asInt();
  a=pin0;
  ThingSpeak.writeField(ccn2,1, a,mywr);

} BLYNK_WRITE(V1)
{
  int p1=param.asInt();
  b=p1;
  ThingSpeak.writeField(ccn2,2, b,mywr);
}
BLYNK_WRITE(V2)
{
  int p2=param.asInt();
```

```
  c=p2;
  ThingSpeak.writeField(ccn2,3, c,mywr);
}
BLYNK_WRITE(V3)
{
  int p3=param.asInt();
  d=p3;
  ThingSpeak.writeField(ccn2,4, d,mywr);
}
void loop () {


   Blynk.run();
  delay (15000);
long temp =ThingSpeak.readLongField(counterChannelNumber,1,
myCounterReadAPIKey);
long temp1 = ThingSpeak.readLongField(counterChannelNumber,2,
myCounterReadAPIKey);
long temp2 = ThingSpeak.readLongField(counterChannelNumber,3,
myCounterReadAPIKey);
long temp3 = ThingSpeak.readLongField(counterChannelNumber,4,
myCounterReadAPIKey);
long statusCode = ThingSpeak.getLastReadStatus();
if (statusCode == 200)
  {
    if(temp>1)
    {
      ThingSpeak.writeField(ccn2,1,1,mywr);
    }
    if(temp1>16)
    {
```

```
    ThingSpeak.writeField(ccn2,2,1,mywr);
   }
   if(temp2>16)
   {
    ThingSpeak.writeField(ccn2,3,1,mywr);
   }
   if(temp3>1006)
   {
    ThingSpeak.writeField(ccn2,4,1, mywr);
   }

   Serial.println(temp);
   Serial.println(temp1);
   Serial.println(temp2);
   Serial.println(temp3);
  }

else
  {
   Serial.println("Unable to read channel / No internet connection");
  }
  Serial.println(a);
  Serial.println(b);
  Serial.println(c);
  Serial.println(d);
}
void initWiFi()
  { WiFi.mode(WIFI_STA);
  WiFi.begin(ssid,pass);
  Serial.print("Connecting to WiFi ..");
```

```
while (WiFi.status()!= WL_CONNECTED)
  { Serial.print('.');
  delay (1000);
 }
 Serial.println(WiFi.localIP());
}
```

7.4 Matlab Substation model:

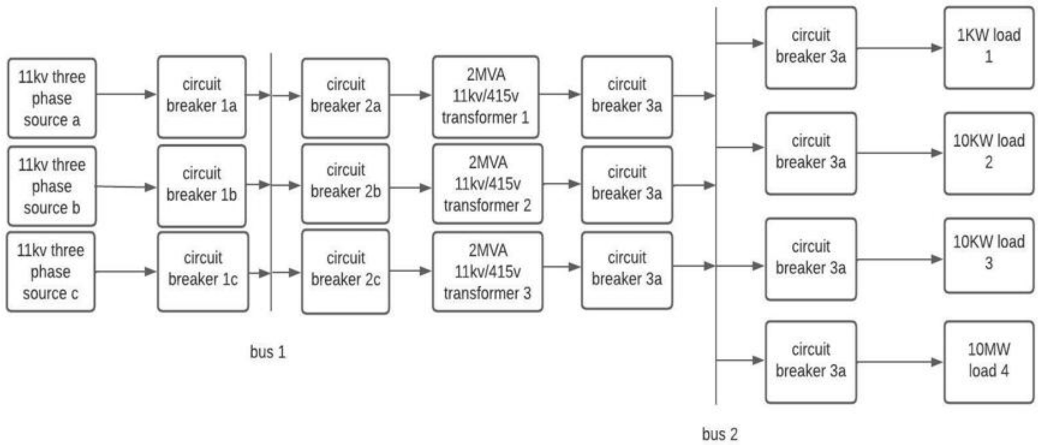

Fig 9 :Substation Model

7.5 Mathematical model:

- Three input lines: 11kv and 50HZ
- Output loads:
  - 415v,1000w,50hz
  - 415v,10000w,50hz
  - 415v,10000w,50hz
  - 415v,10000000w,50hz
- Transformer: 2MVA,11kv/415v, 50hz (three connected in parallel)

7.6 Matlab simulation:

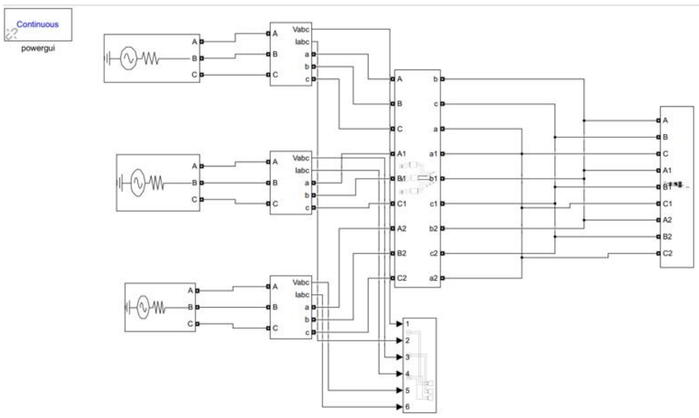

Fig 10: design 1

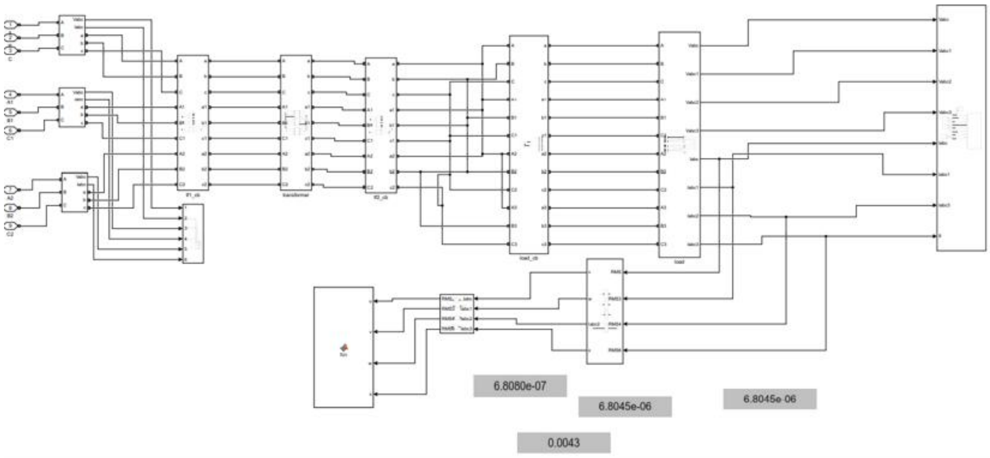

Fig 11: design 2

Program to send data to Thingspeak:

```
function fcn(u, v, w, x)

    coder.extrinsic("thingSpeakWrite");
    thingSpeakWrite(1561089,"Fields",[1,2,3,4],'Values',[u,v,w,x],'WriteKey','0MT5WK8TP2E0F3ZT');
```

Program to Receive data From Thingspeak:

```
function [b,c,d,e] = fcn
coder.extrinsic("thingSpeakRead");
a=thingSpeakRead(1611357,'Fields',[1,2,3,4],'NumPoints',1,'ReadKey','W1UCA77LJ18VU3XN');
b=0;
c=0;
d=0;
e=0;
b=a(1);
c=a(2);
d=a(3);
e=a(4);
```

Program to alter the received data to circuit breaker matching input:

```
function [b,c,d,e] = fcn(r,s,t,u)
persistent l;
persistent m;
persistent n;
persistent o;
persistent g;

if(isempty(g))
    l=1;
    m=1;
    n=1;
    o=1;
    g=1;
end


if(isnan(r))

    b=l;
else
    l=r;
    b=r;
end
 if(isnan(s))
     c=m;
 else
     m=s;
     c=s;
 end
 if(isnan(t))
     d=n;
 else
     n=t;
     d=t;
 end
 if(isnan(u))
     e=o;
 else
     o=u;
     e=u;
 end
end
```

7.7 Blynk application

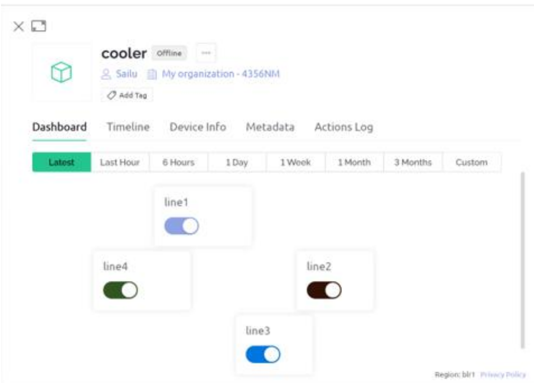

Fig 12: Web view

Fig 13: Mobile view

7.8 Thingspeak channels

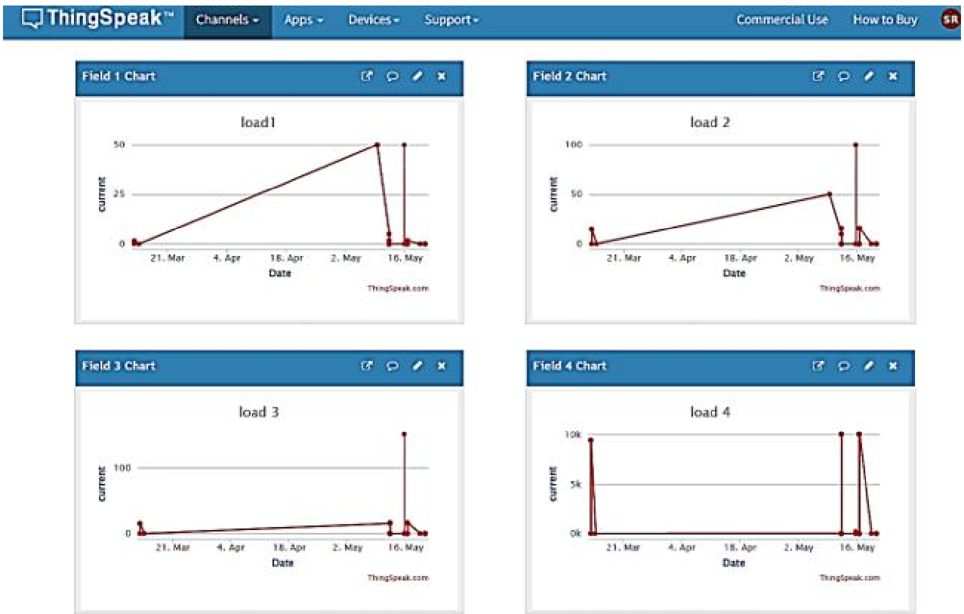

Fig 14: Channel 1

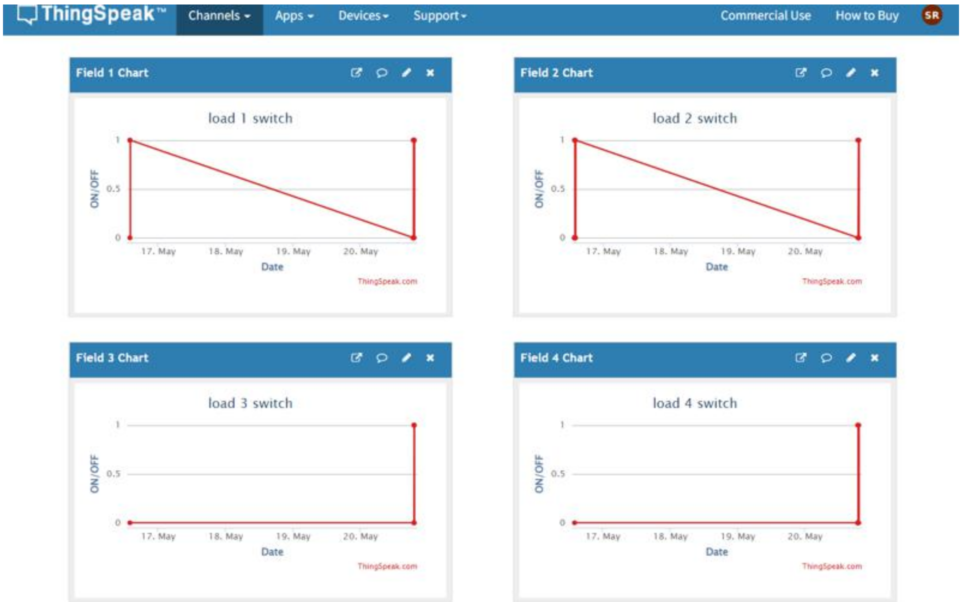

Fig 15: Channel 2

RESULT

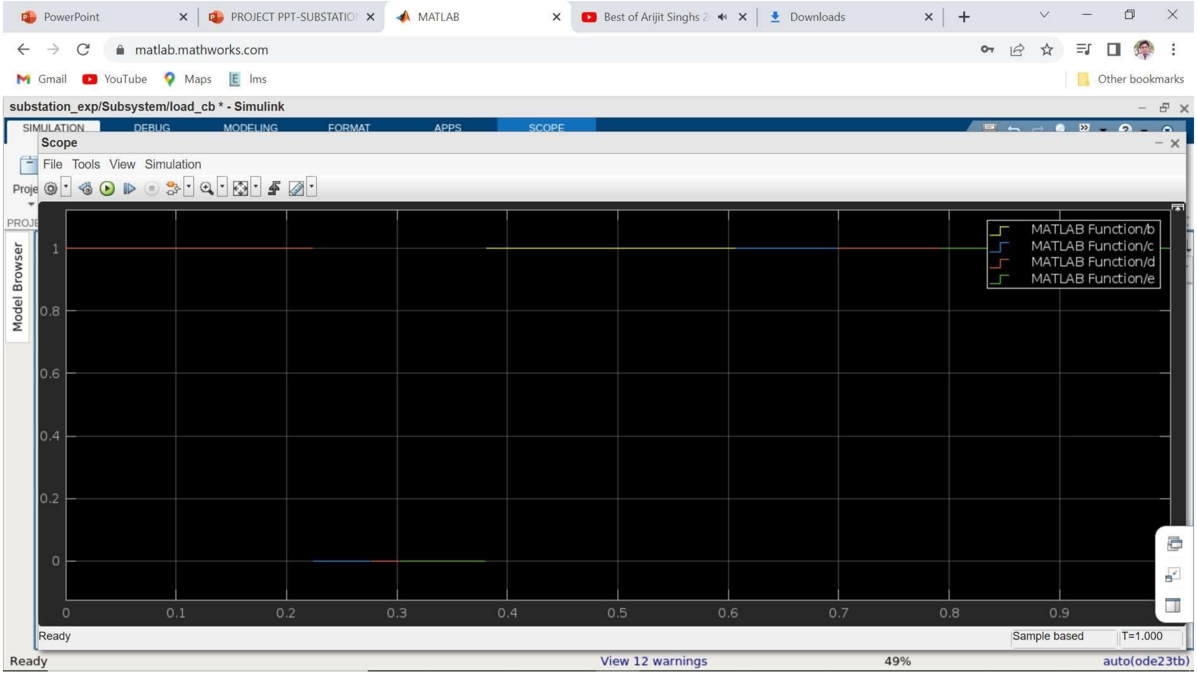

Fig 16: switch

b (load 1)

c (load 2)

d (load 3)

e (load 4)

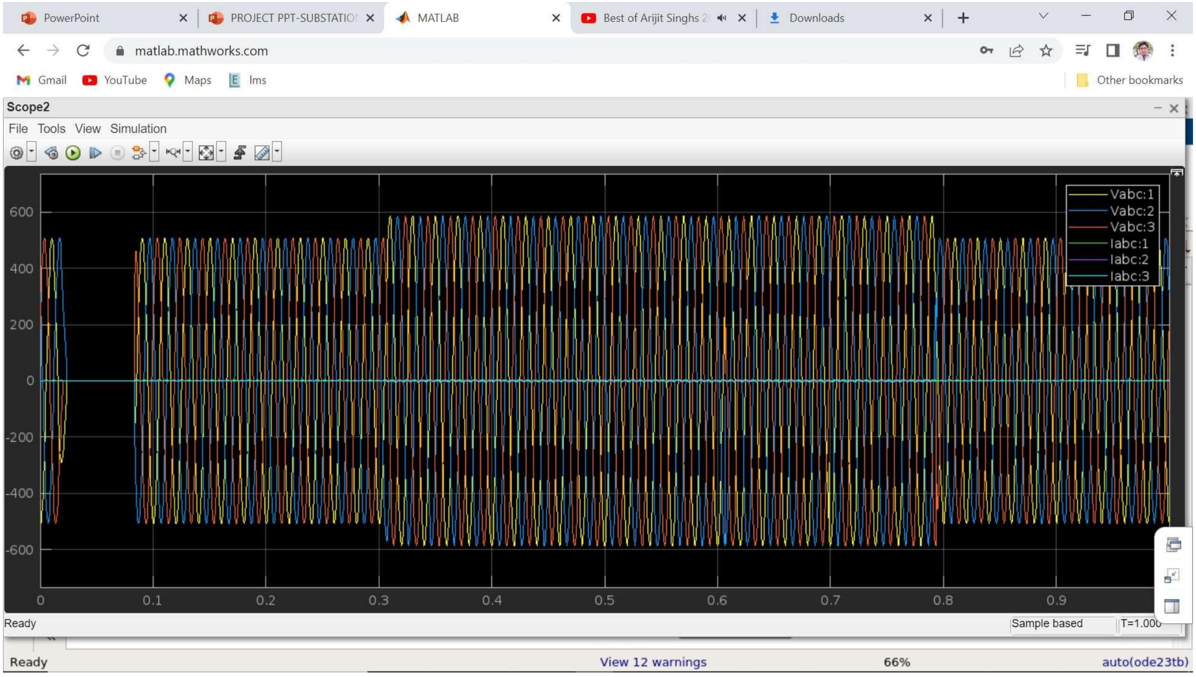

Fig 17 load 1

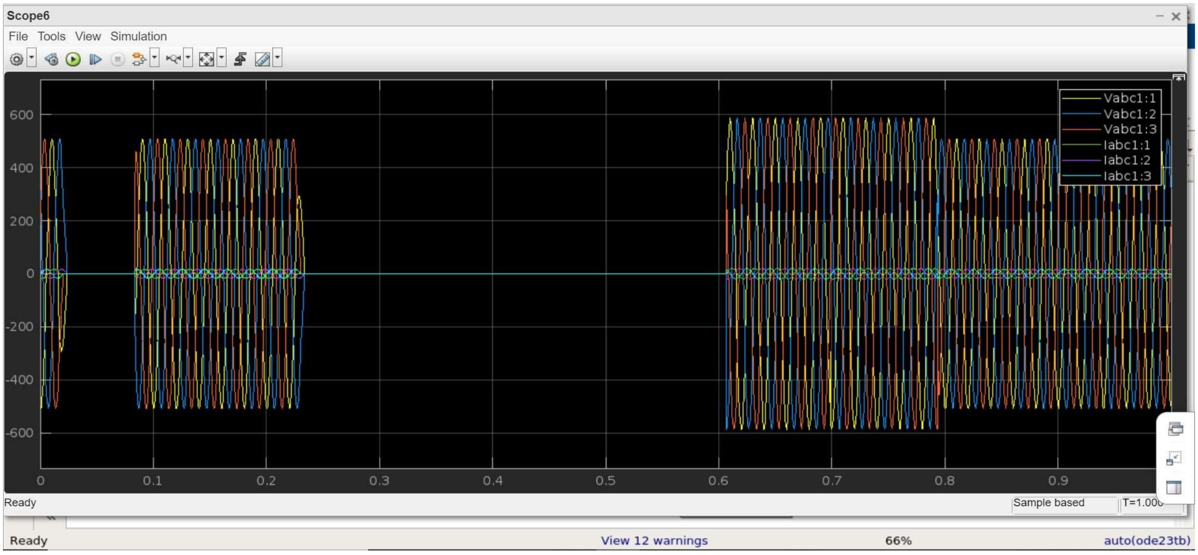

Fig 18: load 2

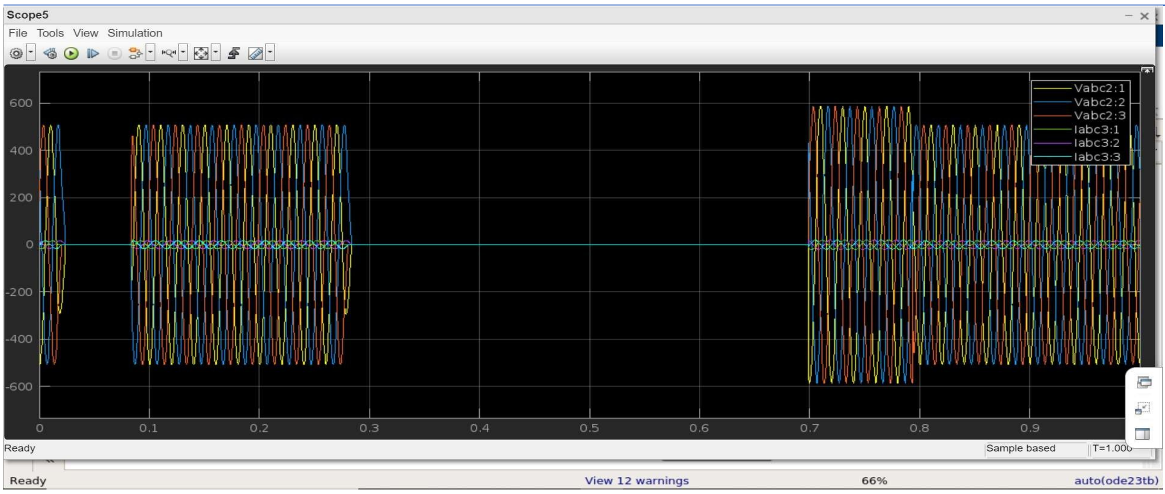

Fig 19: load 3

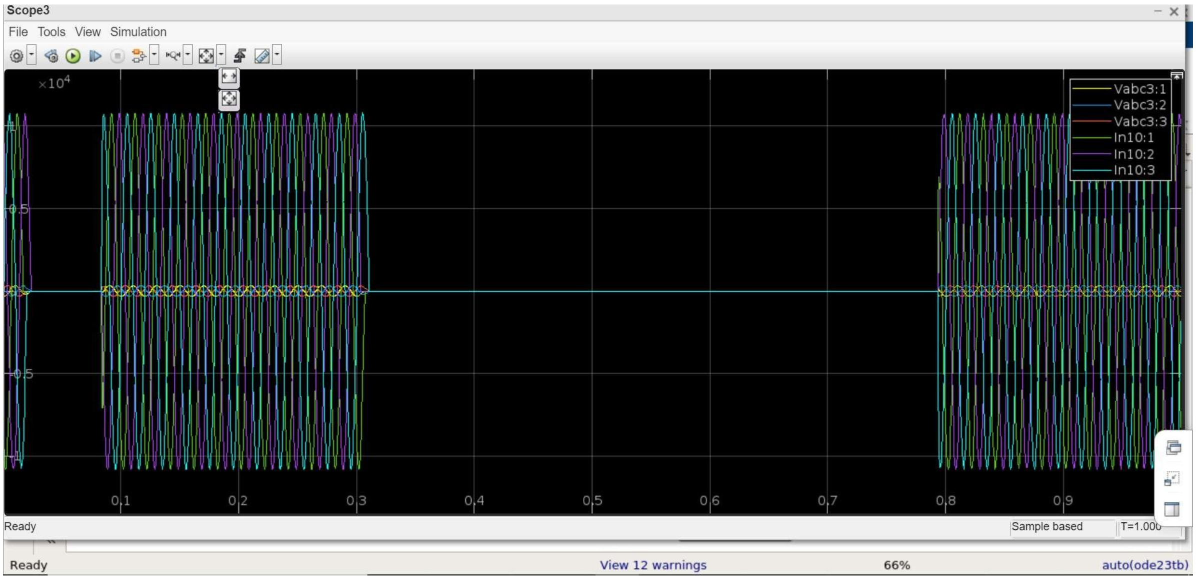

Fig 20: Load 4

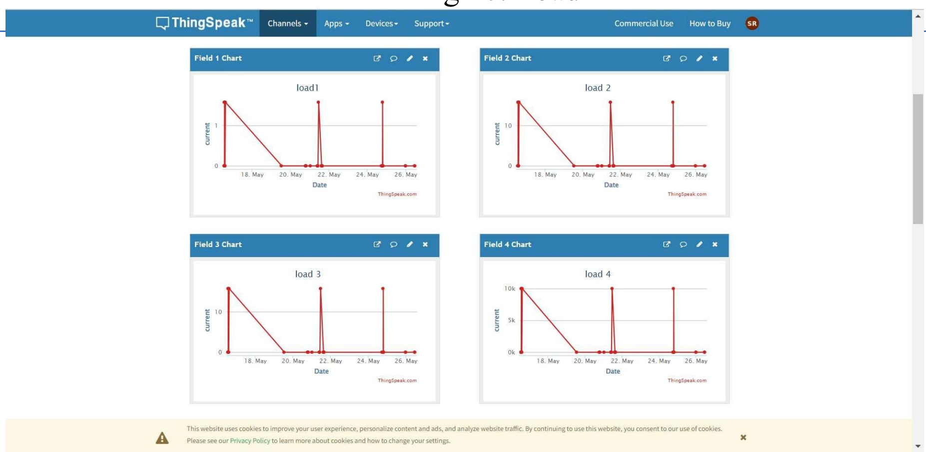

Fig 21: channel 2

Conclusion:

The proposed system will help us to monitor, Control and protect the substation in real time. And this makes the system Smart as the system will Autonomously Run. MATLAB makes the implementation of substation design economical. Through Blynk app, we can connect and disconnect the load from remote area.

Future Scope:

Designing, Testing a total power system in MATLAB for different conditions and do analysis.

Making the total power system autonomous and Remotely monitoring and controlling.

References:

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[3] Software design of a substation monitoring system by Kunming Yang Electric Information Engineering School, Xihua University, Chengdu, China Published in 2009 International Conference on Computer and Automation Engineering

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