IoT LOAD FORECAST FOR DISTRIBUTION TRANSFORMER USING MQTT

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Abstract *:*
The strong coupling of Information and Communication (ICT) technologies – especially via the usage of networked embedded devices – with the energy domain, is leading to a sophisticated dynamic ecosystem referred to as the Internet of Energy. In the last mile of the Smart distribution transformer i.e. the future consumer, heterogeneous devices will be able to measure and share their energy consumption, and actively participate in house-wide or building wide energy management systems. The emerging Smart distribution will heavily depend on cooperation that will emerge at various layers (horizontally and vertically), and on the interaction with networked embedded systems that will be realizing its sensing and actuation functionality. We focus here on the enabling aspects of cooperation between the real world such as the Internet of Things and its interactions in the and Smart distribution.

I.INTRODUCTION

In existing electricity infrastructure we are witnessing a typical centralized approach where few powerful central stations broadcast energy to the different consumers. However in order to tackle the ever rising need for energy and comply with social and economic demands of our times, we move towards increasing the usage of alternative energy resources which are smaller and decentralized. This leads to a very dynamic future energy network, where electricity will be produced in a distributed way, where customers will be not only consumers but also producers (hence they are called prosumers), and where bidirectional interaction between producers, consumers and other entities will be possible. The emerging Internet of Energy and more specifically its core entity i.e. the Smart distribution, is a highly dynamic complex ecosystem of energy production and consumption parties that heavily uses Information and Communication Technologies (ICT) in order to be more efficient compared to its current traditional operation. Additionally the Smart distribution enables the creation of new innovative services based on bidirectional interaction of its stakeholders. In order to realize the promise of Smart distribution, a key element would be to have timely monitoring and control.

The functionality offered by the the networked embedded devices that would realize the monitoring and control part is crucial for the success of the Smart distribution. For instance smart meters is are the key for monitoring energy consumption. However in parallel the bidirectional interaction is pursued i.e. that there is an adaptation on the behavior of the prosumer device based on the information that it receives e.g. electricity price Due to developments in the embedded systems, the energy consuming/producing devices will be no more considered as black-boxes but will also get interconnected, which will provide fine-grained info e.g. energy optimization per device. It is also expected that they will provide their functionality as a service and be able to consume on-line services (Internet of Services). As such they will be able to collaborate with other entities

What Is Internet of Things (IoT)

The Internet of Things (IoT) refers to the fast growing network of physical objects that feature an internet protocol (IP) address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices.
The Internet of Things will:
Connect both inanimate and living things.
Use sensors for data collection.
Change what types of item communicate over an IP Network.

Fig 1.1: IoT Definition

Fig 1.2: Internet of Things schematic showing the end users and application areas based on dat

II. LITERATURE SURVEY

[1] Mrs.s.sivaranjani,m.e describes about the IoT based distribution transformer monitoring system, Distribution transformers are one of the most important equipment in power network. Because of, the large amount of transformers distributed over a wide area in power electric systems, the data acquisition and condition monitoring is important issue. The main aim of this system is distribution transformer monitoring and controlling through IOT. Also, it sends SMS to a central database via the GSM modem for further processing. The idea of on-line monitoring system mixes a global service mobile (GSM) Modem, with chip micro controller and different sensors. It is installed at the distribution transformer site and the above parameters are recorded using the analog to digital converter (ADC) of the embedded system. The obtained parameters are processed and recorded in the system memory. If any deviation or an emergency situation occurs the system sends SMS (short message service) messages to the mobile phones containing information about the deviation according to some predefined instructions programmed in the micro controller.

[2] Rahul describes about the Internet of Things Based Real Time Transformer Health Monitoring System, Transformer is one of the important electrical equipment that is used in power system. Monitoring transformer for the problem before they occur can prevent faults that are costly to repair and result in a loss of electricity. The main aim of the paper is to acquire real-time data of transformer remotely over the internet falling under the category of Internet of Things (IOT). For this real-time aspect, we take one temperature sensor, one potential transformer and one current transformer for monitoring T, V, I data of the transformer and then send them to a remote location.

III. HARDWARE REQUIREMENTS:

STM32F103C8PROCESSOR

The STM32F103xx medium-density performance line family incorporates the high-performance ARMCortex-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 128 Kbytes and SRAM up to 20 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, three general purpose 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I2Cs and SPIs, three USARTs, an USB and a CAN.

These features make the STM32F103xx medium-density performance line microcontroller family suitable for a wide range of applications such as motor drives, application control, medical and handheld equipment, PC and gaming peripherals, GPS platforms, industrial applications, PLCs, inverters, printers, scanners, alarm systems, video intercoms, and HVACs.

LCD 16x2 modules

A 16x2 is a display of fundamental module for providing visible information. Here it is used to display frequency and proximity warning. A 16x2 LCD can display 20 characters in each line and has 4 such lines. Figure 5.5 shows physical appearance of LCD. In LCD, each character will be of size 5x7 matrix. This has two specific registers for data and command.

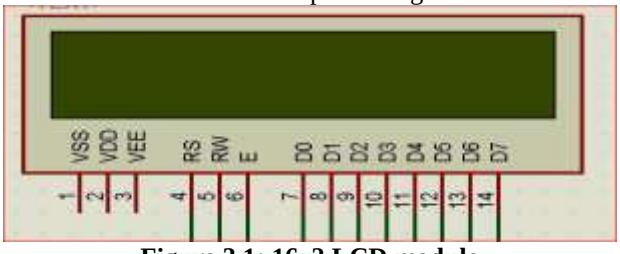

Figure 3.1: 16x2 LCD module

Voltage Regulator(7805):

7805 is a voltage regulator integrated circuit. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator ICmaintains the output voltage at a constant value. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

FEATURES:
Output Current up to 1A.
Thermal Overload Protection.
Short Circuit Protection.
Output Transistor Safe Operating Area Protection.

Fig3. 2: Pin Diagram of 7805

Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

Table : Pin Description

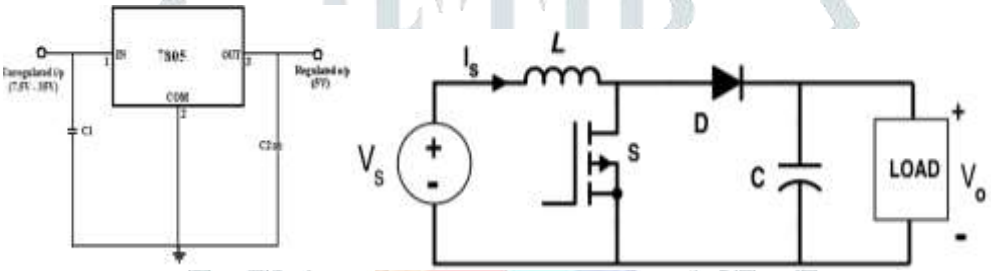

Fig3.3:Regulator Circuit

Overview on DC/DC converter

The basic DC/DC converter comprises a switch, a filter circuit and load. The DC/DC converter may classify by various methods, one of the basic methods is isolation, according to that it is classified into two types.
Isolated DC/DC converter.
Non-Isolated DC/DC converter.

In isolated DC/DC converter type the output and input are electrically isolated by the use of a transformer. It is bulky, requires more space and costly while comparing with the non-isolated type DC/DC converter.

The non-isolated DC/DC converters can be further differentiated by element connections like Buck converter, Boost converter, Buck-Boost converter, Cuk converter and Sepic converter.

DC/DC converter is widely used for the purpose of converting unregulated DC input into a regulated DC output. A DC-DC converter is a hart of MPPT hardware implementation. MPPT uses the one of the above converter for regulating the solar input voltage to the MPP and providing impedance
matching for the maximum power transfer to the load.

Need of DC/DC converter

A dc/dc converter is an integral part of any MPPT circuit system. Without dc/dc converter no any MPPT circuit can be designed. When a direct connection is carried out between the source and the load, the output of the PV module is irregularly shifted away from the maximum power point. It is necessary to overcome this problem by adding an adaptation circuit between the source and the load. A MPPT controller circuit with a DC-DC converter circuit is used as an adaptive circuit.

For maximum power transfer from source to load an extra circuit is required to support the load to match the impedance with source impedance.

BOOST CONVERTER

In a boost converter or regulator output voltage of the converter is greater than input voltage of the converter circuit that means it boosting the input voltage that' s way its name is " BOOST" regulator. The boost circuit consist a energy storing element inductor, a capacitor, a diode, a load and a switching device like MOSFET, BJT etc. Circuit diagram of boost converter is shown in figure 3.1 below

The control strategy is based on manipulation the duty cycle of the MOSFET causes the voltage change in Boost converter.

Boost Converter Operating Modes

Boost converter have two operating modes based on "ON" and "OFF" condition of switching device (MOSFET)
Mode 1 when MOSFET is "ON"
Mode 2 when MOSFET is "OFF"
Mode 1

This mode is also known as charging mode. In this mode when MOSFET is on inductor is energized and start storing the energy from source during on time (t_1) of MOSFET. This time period diode restricts the current flow through it from the source to the load and capacitor is discharging by the load R.

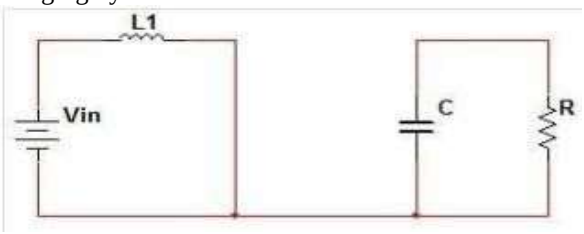

Fig. 3.4 Equivalent Circuit for Mode 1

Assuming the inductor current is linearly rises between to then i_1 to i_2

$$V_{in} = L\frac{i_2-i_1}{t_1} V_{in} = L\frac{i_2-i_1}{t_1} \quad (3.1)$$

$$t_1 = L\frac{i_2-i_1}{V_{in}} t_1 = L\frac{i_2-i_1}{V_{in}} \quad (3.2)$$

Mode 2

This mode is known as discharging mode. In this mode MOSFET is " OFF" and diode is forward bias due to nature of inductor opposing its causing in this mode inductor support source voltage. So the circuit becomes

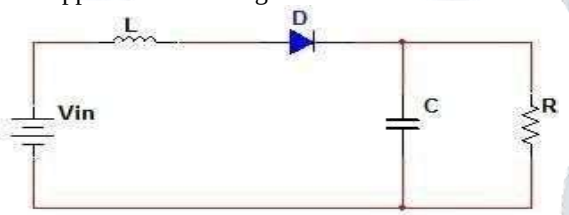

Fig. 3.5Equivalent circuit mode 2

$$V_L = V_{IN} - V_o V_L = V_{IN} - V_o \quad (3.3)$$

$$L\frac{i_2-i_1}{t_2} = V_{in} - V_o L\frac{i_2-i_1}{t_2} = V_{in} - V_o \quad (3.4)$$

$$t_2 = L\frac{i_2-i_1}{V_{in}-V_o} t_2 = L\frac{i_2-i_1}{V_{in}-V_o} \quad (3.5)$$

(3.5)

From equation 3.5 and 3.2

$$L(i_2 - i_1) = (V_{in} - V_o)t_2 = V_{in}t_1 L(i_2 - i_1) = (V_{in} - V_o)t_2 = V_{in}t_1 \quad (3.6)$$

$$T = t_1 + t_2 T = t_1 + t_2$$

(3.7)

From equation 3.6 and 3.7

$$V_o = \frac{1}{1-D} V_{in} V_o = \frac{1}{1-D} V_{in} \quad (3.8)$$

Where, $D = t_1/T_D D = t_1/T_D$

BUCK CONVERTER:

The fundamental operation of the buck converter has the current being controlled in inductor controlled by switches, two in number. The ideal converter, the segments are taken to be ideal. Particularly, the switch and the diode deal with zero voltage dropping when in on state and no current stream when in off and the inductor has no series resistance. Furthermore, it is accepted that data and yield voltages don't vary throughout the span of a cycle (this would infer the yield capacitance as being limitless).

Modes of Operation:

Continuous Mode:-

This converter works in non-stop mode if the current flowing from the inductor never tumbles to null throughout the commutation. At the point when the switch as shown above in previous page is shut. The current flowing from the inductor climbs straight. As the diode is converse predisposition by the source voltage V, no current courses from it. At the point when the switch is off, the diode is biased in forward direction.

Discontinuous Mode:-

In some circumstances, the measure of energy needed is excessively little. For this situation, the current flowing from the inductor tumbles to nothing throughout a piece of time period. The main distinction in the standard depicted is that inductor is totally released at the ending of commutation. This has, be that as it may, some impact on the past mathematical statements. If converter works in relentless state, the energy in the inductor is the same at the start and at ending of the cycle (on account of intermittent mode, it is zero). This implies that the normal estimation is zero for inductor voltage.

BUCK-BOOST CONVERTER

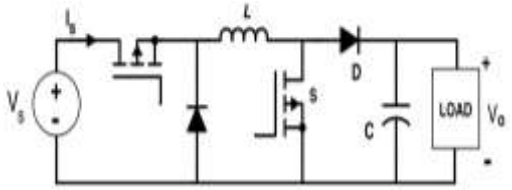

Fig.3.6: Schematic for Buck-Boost converter

With continuous conduction for the Buck-Boost converter Vx =Vin when the transistor is ON and Vx=Vo when the transistor is OFF. For zero net current change over a period the average voltage across the inductor is zero.

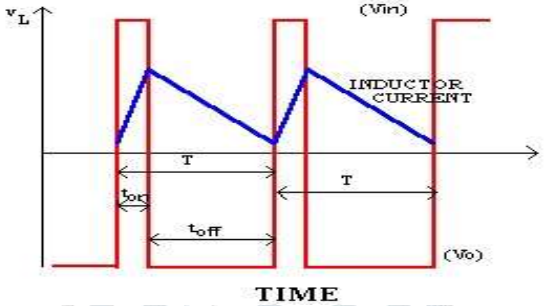

Fig. 3.7: Waveforms for Buck-Boost converter

$$V_{int_{ON}} + V_{ot_{OFF}} = 0 \quad (3.9)$$

Which gives the voltage ratio

$$\frac{V_o}{V_{in}} = -\frac{D}{(1-D)}\frac{V_o}{V_{in}} = -\frac{D}{(1-D)} \quad (3.10)$$

And the corresponding current i

$$\frac{I_o}{I_{in}} = -\frac{(1-D)I_o}{D\ I_{in}} = -\frac{(1-D)}{D} \quad (3.11)$$

Since the duty ratio "D" is between 0 and 1 the output voltage can vary between lower or higher than the input voltage in magnitude. The negative sign indicates a reversal of sense of the output voltage.

3.5 GSM sim 800 module

SIM800 is a complete Quad-band GSM/GPRS solution in a SMT type which can be embedded in the customer applications.SIM800 support Quad-band 850/900/1800/1900MHz, it can transmit Voice, SMS and data information with low power consumption. With tiny size of 24*24*3mm, it can fit into slim and compact demands of customer design. Featuring Bluetooth and Embedded AT, it allows total cost savings and fast time-to-market for customer applications.

KEY FEATURES

- AT command interface
- Quad-band and Dual-band variants*
- Make and receive voice calls
- Send and receive SMS messages
- Send and receive GPRS data (TCP/IP, HTTP, etc.)
- Bluetooth: compliant with 3.0+EDR*
- USB Connector for Firmware Updating*
- Configurable Baud rate (9600-115200, factory default value: 9600)
- Connectors for external speaker and mic.
- Selectable interface between hardware serial port and software serial port
- Inbuilt Powerful TCP/IP protocol stack for Internet data transfer over GPRS.
- Level shifting circuitry to make it Arduino-safe
- SMA Connector with external antenna
- Indicator LEDs for Power and connectivity
- Standard Flap type SMA Socket
- ESD Protection over TVS Zener array
- Separate Reset switches for both Arduino and the shield
- Slide switch to swap the shield between Arduino and PC
- Provision to select between hardware and software serial ports.

LED INDICATIONS

The Network LED indicates the various status of GSM module eg. Power on, Network registration & GPRS connectivity. When the modem is powered up, this NETWORK LED will blink every second. After the Modem registers in the network (takes between 10-60 seconds), this LED will blink in step of 3 seconds. At this stage you can start using Modem for your application, showing that modem is registered with the network.

Current Sensors

Measuring a voltage in any system is a " passive" activity as it can be done easily at any point in the system without affecting the system performance. However, current measurement is " intrusive" as it demands insertion of some type of sensor which introduces a risk of affecting system performance.

Current measurement is of vital importance in many power and instrumentation systems. Traditionally, current sensing was primarily for circuit protection and control. However, with the advancement in technology, current sensing has emerged as a method to monitor and enhance performance.

Fig. 3.8:current sensor

Knowing the amount of current being delivered to the load can be useful for wide variety of applications. Current sensing is used in wide range of electronic systems, viz., Battery life indicators and chargers, 4-20 mA systems, over-current protection and supervising circuits, current and voltage regulators, DC/DC converters, ground fault detectors, programmable current sources, linear and switch-mode power supplies, communications devices , automotive power electronics, motor speed controls and overload protection, etc.

One Wire Digital Temperature Sensor - DS18B20

DS18x20 family members are relatively accurate digital temperature sensors. They use MAXIM' s 1-wire bus protocol, which requires only 1 wire for receiving and transmitting data (A ground line is also required). Moreover, DS18x20 support so-called parasite power mode, when they drain energy from data bus when it' s high – to charge sensor' s integrated capacitors that will be used as a power source.

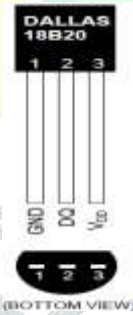

Fig: 3.9DS18B20 Temperature sensor

You can have up to 127 devices on 1-Wire line. To use one of them, a master device initiates a reset pulse, and them receives presence pulse from slave devices. Then it searches ROMs (each produced device has a unique 64-bit ROM code) serial number. Tiny first part of it defines a family of device, like 0x10 for DS18S20, 0x28 for DS18B20, 0x01 for iButton-DS1990A etc., and all remaining bits are a unique item number. Finally, master device selects the necessary slave device with MATCH ROM [55h] command. (Or transmits broadcast commands).

To get a temperature measurement, we need to issue CONVERT [44h] command. When our sensors receive it, they will initiate data conversion process - to produce 2 bytes with the measurement. This is relatively slow process, and it can take up to 750 milliseconds, so we have to wait for some time after issuing the command. All that measurements are stored in a so-called scratchpad – a piece of sensor' s RAM.

SCRATCHPAD (POWER-UP STATE)		
Byte 0	Temperature LSB (50h)	(85°C)
Byte 1	Temperature MSB (05h)	
Byte 2	T_H Register or User Byte 1*	
Byte 3	T_L Register or User Byte 2*	
Byte 4	Configuration Register*	
Byte 5	Reserved (FFh)	
Byte 6	Reserved	
Byte 7	Reserved (10h)	
Byte 8	CRC*	

Fig: 3.30 Scratchpad of DS18B20

To read a scratchpad, we issue a READ SCRATCHPAD [BEh] command. After that, we should receive 9 bytes of data. Then we can get a temperature according to the following formulae:

Temp = ((HighByte << 8) + LowByte) *0.0625

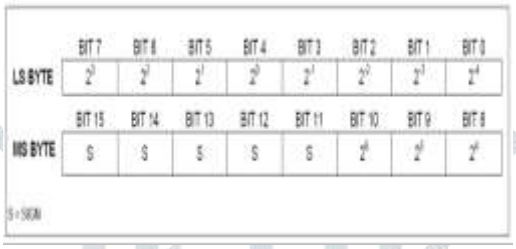

Fig: DS18B20 Temperature sensor register format.

SOLID STATE RELAY

1. Traic Switch circuit for Load:

Triac switch circuit comprises of zero crossing detector MOC3031M IC (zero cross based optotriac isolator) which is used to turn on and off load and BTA12 triac which is connected in parallel to snubber circuit comprises of RC will avoid the inrush current.

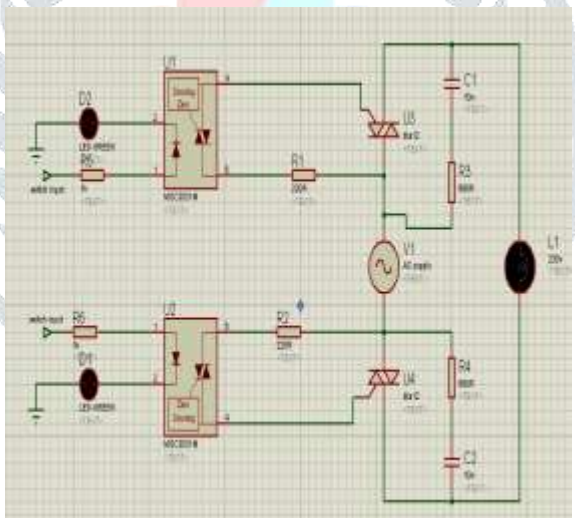

Fig3. 10: **Triac switch circuit for Load**

MOC3031

It's for on/off control only. After the opto-coupler sees the LED going on it waits for the next zero-crossing of the mains voltage, at which point it switches on. After switching off, like any triac it remains on until the current goes below a hold-value.

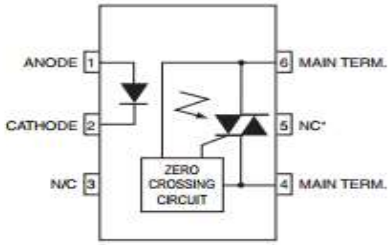

Fig3.11: **MOC3031 pin diagram**

BTA12 TRIAC:

BTA12 triac is suitable for general purpose AC switching. They can be used as an ON/OFF function in applications such as static relays, heating regulation, induction motor starting circuits... or for phase control operation in light dimmers, motor speed controllers.

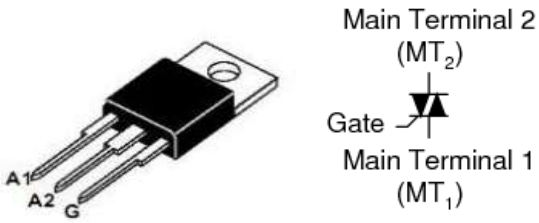

Fig3. 12: **BTA12 TRIAC**

IV.SOFTWARE REQUIREMENTS

1. Amazon Web Server

Amazon web administrations (AWS) utilized as a part of this for server operation with committed port as client can gets to the data from the application at whatever time and module associated with the peripherals are connected to Amazon server with devoted IP and port deliver which does the remote design of the framework.

2. MQTT Protocol

As we most likely know, the focal point of IOT is a correspondence itself. In the present day Internet there is an awesome number of traditions and structures used to complete correspondence channels. This arrangement is profoundly diminished in an IOT circumstance. A great part of the time, "things" that are talking with each other have compelled resources (processor, memory, battery, etcetera.). Fortunately, there are answers for those restricted necessities. One of them is MQTT a lightweight network convention.

MQTT remains for MQ Telemetry Transport. It is a distribute/subscribe, to a great degree basic and lightweight informing convention, intended for compelled gadgets and low-data transfer capacity, high-idleness or questionable systems. The plan standards are to minimize arrange data transfer capacity and gadget asset prerequisites while additionally endeavouring to guarantee unwavering quality and some level of affirmation of conveyance. These standards additionally end up making the convention perfect of the developing "machine-to-machine" (M2M) or "Web of Things" universe of associated gadgets, and for portable applications where transmission capacity and battery power are at a premium.

receives subscription from publishers
receives messages from publishers
receives subscription from clients
pushes messages to subscribers

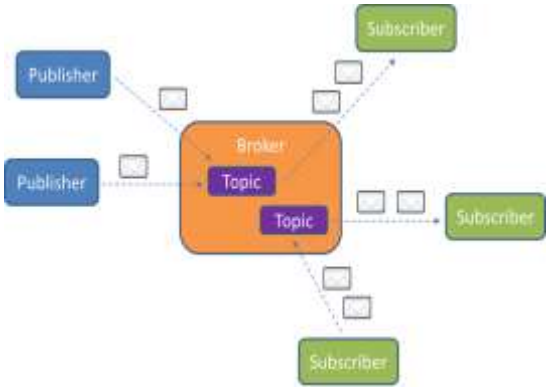

Figure 4.1: MQTT protocol

A MQTT session is partitioned into four phases: association, validation, correspondence and end. A customer begins by making a TCP/IP association with the merchant by either utilizing a standard port or a custom port characterized by the representative's administrators. While associating, perceive that the server may proceed with an old session if furnished with a re-utilized customer character.

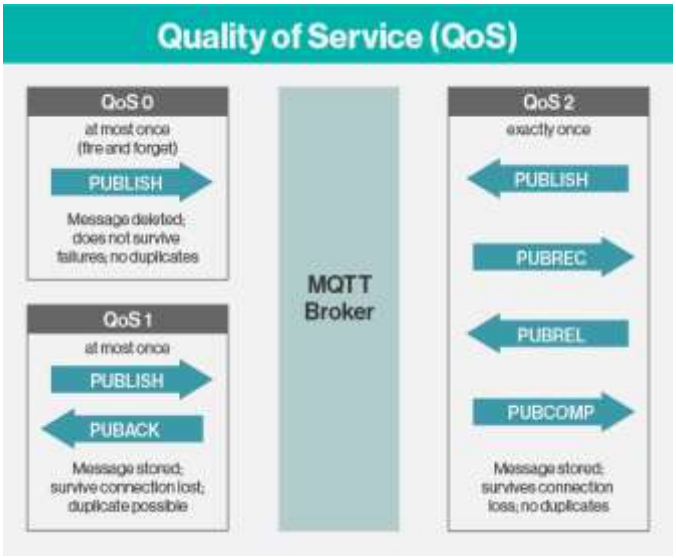

Fig4.2: MQTT QoS Levels

MQTT gives the run of the mill conveyance nature of administration (QoS) levels of message situated middleware. Despite the fact that TCP/IP gives ensured information conveyance, information misfortune can at present happen if a TCP association separates and messages in travel are lost. Along these lines MQTT includes three characteristics of administration stages which connect to transport control protocol layer.

V.ACKNOWLEDGEMENT

I would like to express my sincere thanks of gratitude to our beloved HoD Dr. P S Puttaswamy who gave the valuable guidance to do this project work.

VI. CONCLUSION

This project introduces the execution of a compact vitality meter which can screen the power utilization at gadget level as well as for industrial purpose.Counting voltage detection and current detection into the equipment and also preparing it to compute power can enhance the precision of the system.Readings can be securely provided by means of mqtt protocol.Hence an IoT based transformer monitoring system for power transformer is quite useful as compared to manual monitoring and it is also reliable as it is not possible to monitor always the oil level, oil temperature rise, ambient temperature rise, load current manually.

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