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GSM Based Substation Monitoring And Control System

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Abstract: *The project named 'Substation Monitoring System' proposes an innovative design to develop a system based on a Arduino microcontroller. It is used for monitoring the voltage, current, frequency, and temperature of a distribution transformer in a substation and to protect the system from the rise in mentioned parameters. The objective is to monitor the electrical parameters continuously and hence to guard the burning of the distribution transformer due to the constraints such as overload, over-temperature, and input high voltage. If any of these values increase beyond the limit then the entire unit is shut down by operating an Electromagnetic Relay. This relay is activated as soon as the parameters exceed the predefined threshold values. The relay also works as a circuit breaker to switch off the main power supply. GSM communication is used to continuously send the instantaneous values to the intermediate station. The GSM modem is used to send the real-time electrical parameters in the form of SMS. The system is designed to send SMS alerts to the authorized person whenever the parameters (Voltage, Current, frequency and Temperature) exceed the predefined limits.*

Keywords: Substation Monitoring System

I. INTRODUCTION

Electricity is an extremely handy and useful form of energy. It plays an ever-growing role in our modern industrialized society. The electrical power systems are highly non-linear, extremely huge and complex networks. Such electric power systems are
unified for economic benefits, increased reliability And operational advantages. They are one of the most significant elements of both national and global infrastructure, and when these systems collapse it leads to major direct and indirect impacts on the economy and national security. A power system
consists of components such as generators, lines,
transformers, loads, switches and compensators. However, a widely dispersed power sources and loads are the general configuration of modern power systems. Today electricity still suffers from power outages and blackouts due to the lack of automated analysis and poor visibility of the utility over the grid.
WSN will give the utility provide the needed view by collecting information from the different sub-systems of the grid. A sensor node will decide information or
to slightly delay this notification (whether to immediately notify the sink about this information.). As complexity of distribution network has grown, automation of substation has become a need of every utility company to increase its efficiency and to improve quality of power being delivered. Supplying electricity to consumers necessitates power generation, transmission, and distribution [4]. Initially electric power is generated by using electric generators such as: nuclear power generators, thermal power generators and hydraulic power generators and then transmitted through transmission systems using high voltage. Power departs from the generator and enters into a transmission substation, where huge transformers convert the generator's voltage to extremely high voltages (155kV to 765 kV) for long-distance (up to about 300 miles) transmission [4]. Then, the voltage level is reduced using transformers and power is transferred to customers through electric power distribution systems. Power starts from the transmission grid at distribution substations where the voltage is stepped-down (typically to less than 10kV) and carried by smaller distribution lines to supply commercial, residential, and industrial users [4]. Monitoring and controlling of substations is an important task for supplying healthy power to the consumers in this automated era. But due to the aging

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infrastructure of the distribution grids (substations) and lack of automation systems that monitors the critical conditions at the substations, the risk of blackouts, brownouts and fire are rapidly increasing. Substations consist different electronic components like transformers, circuit breakers, relays etc.

1.1 Problem Statement

Mostly substation consists of Transformers, Protective relays, Lightening arrestors, wave trap, bus bars, Isolators etc.

- Generally Transformers used in the substation will damage due to the raise in the oil temperature i.e., whenever there is a huge amount of current flows through the winding then that leads to blackouts in the substations.
- Instead of such blackouts that occurred in microseconds of time that may leads to collapse the entire substation.
- So to we have to protect the entire substation & that is done by using AVR microcontrollers which acts as the heart in controlling the entire system .
- By sensing the parameters we can shut down the transformers if any value is crossing it's limit.

1.2 Objectives

To improve reliability and compatibility. This is one of the main objectives of our project to improve the reliability of the power being delivered by speedy detection and isolation of the fault and maintaining a constant voltage level, which will make the project utmost reliable and compatible. Real time monitoring, As complexity of distribution network has grown, automation of substation has become a need of every utility company to increase its efficiency and to improve quality of service. One of the main objectives of this project of ours is to ensure real time monitoring. Remote sensing of observant parameters although this project is meant for all the substation equipment but we developed this prototype keeping in mind the transformers which are usually deployed in dispersed locations. Through this project we want to ensure remote sensing all the observant parameters. To Maintain Continuity of supply by keeping track on the real time parameters, we want to maintain the continuity of the supply. To reduce labour cost One of
the main objectives of our project is to reduce the labour cost to some extent which will make the facility more economical.

1.3 Components Used

1. Arduino UNO
2. GSM Modem
3. Relay
4. Voltage Transformer
5. Current Transformer
6. Buzzer
7. LCD display
8. IC555
9. DTH sensor
10. LED
11. Rectifier

II. WORKING

The project named 'Substation Monitoring System' proposes an innovative design to develop a system based on microcontroller. It is used for monitoring the voltage, current and temperature of a distribution transformer in a substation and to protect the system from the rise in mentioned parameters. The objective is to monitor the electrical parameters continuously and hence to guard the burning of distribution transformer due to the constraints such as overload, over temperature and input high voltage. If any of these values increase beyond the limit then the entire unit is shut down by operating an Electromagnetic Relay. This relay is activated as soon as the parameters exceed the

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predefined threshold values. The relay also works as a circuit breaker to switch off the main power supply. RF communication is used to continuously send the instantaneous values to the intermediate station. The GSM modem is used to send the real time electricalparameters in the form of SMS. The system is designed to send a SMSalerts to the authorized person whenever the parameters (Voltage, Current and Temperature) exceeds the predefined limits. Supplying electricity to consumers necessitates power generation, transmission, and distribution [4]. Initially electric power is generated by using electric generators such as: nuclear power generators, thermal power generators and hydraulic power generators and then transmitted through transmission systems using high voltage. Power departs from the generator and enters into a transmission substation, where huge transformers convert the generator's voltage to extremely high voltages (155kV to 765 kV) for long-distance (up to about 300 miles) transmission [4]. Then, the voltage level is reduced using transformers and power is transferred to customers through electric power distribution systems. Power starts from the transmission grid at distribution substations where the voltage is stepped-down (typically to less than 10kV) and carried by smaller distribution lines to supply commercial, residential, and industrial users [4]. Monitoring and controlling of substations is an important task for supplying healthy power to the consumers in this automated era. But due to the aging infrastructure of the distribution grids (substations) and lack of automation systems that monitors the critical conditions at the substations, the risk of blackouts, brownouts and fire of rapidly Substations consist of different electronic components like transformers, circuit breakers, relays etc. The transformer fluid leaks or internal insulation breakdown cause overheating that leads to failures. The traditional method includes periodic manual checking of the system which is time consuming and with very low accuracy. Also the substations in the rural areas are even more difficult to monitor manually and hence requires more time to take respective actions. The solution to all these problems is automation of the substations. The various parameters like current, temperature and voltage are continuously sensed with the help of different sensors. The outputs of these sensors is given to the aurdiuno. Aurdiuno is preprogramed in such a way that if the parameters exceed predefined threshold value then it will inform the intermediate or main station with the help of wireless communication technologies like GSM .230 v ac power given to the transformer . transformer convert ac to ac voltage it converts 23v ac to 12-14v ac then that voltage is given to the rectifier circuit that convert ac voltage to dc voltae then rectifier output will be 12v dc .we have required 12v constant for the relay and buzzer and 5v dc constant for the arduino so that's why we are using voltage regualator IC 7812 and 7805 it gives constant 12 vdc and 5v dc .and filter circuit is used for the removing ripples from the output.In this project DTH sensor is used for the temperature purpose it gives temperature value if your temperature is increase above certain level then it send sms to authorized person using GSM. and also all the data like temperature, voltage, current, frequency displayed on the lcd. for voltage sensing we are using potentiometer by using we can incrase or decrease the voltage level. if your voltage is increase above certain level then it send sms to authorized person using GSM current sensor is used for current measurement if load is 60w then current is small but if load will be increase then send sms .for frequency purpose we are using lm358 and 555IC.555 IC it generate square wave it gives constant frequency so we are using pot for changing the frequency and also lm358 is used for giving constant 50 HZ frequency. lm358 using we are making one zero crossing circuit that gives constant 50 HZ frequency.If any of the data increase certain level then buzzer will be on and relay will be off. and all the data send through SMS using GSM and that time If RELAY on sms sending to GSM then relay will be on and GSM send command to the arduino then arduino send command to GSM and GSM send SMS to particular person that sms is relay on.If Load on sms sending to gsm then relay will be on and gsm send command to the arduino then arduino send command to gsm and gsm send sms to particular person that sms is substation on.

If Load off sms sending to gsm then relay will be off and gsm send command to the arduino then arduino send command to gsm and gsm send sms to particular person that sms is substation off. If STATE sms sending to gsm and send command to the arduino then arduino send command to gsm and gsm send all the status off the temperature voltage current and frequency.

2.1 Hardware Requirement

- Arduino Uno
- Current transformer

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- Voltage transformer
- 555 IC
- frequency sensing circuit
- relay
- Weight :25g

2.2 Software Requirement

- Arduino IDE
- Eagle
- Proteus

2.3. Arduino UNO

TheArduinoUno isan opensource microcontrollerboard basedonthe Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The

board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. The word "uno" means "one" in Italian and was chosen to mark the initial release of the Arduino Software. The Uno board is the first in a series of USB-based Arduino boards, and it and version 1.0 of the Arduino IDE were the reference versions of Arduino, now evolved to newer releases. The ATmega328 on the Arduino IDE were the reference versions of Arduino, now evolved to newer releases.

2.4.TECHNICAL SPECIFICATIONS

- Microcontroller: Microchip ATmega328P
- Operating Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm

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2.5. General Pin Functions

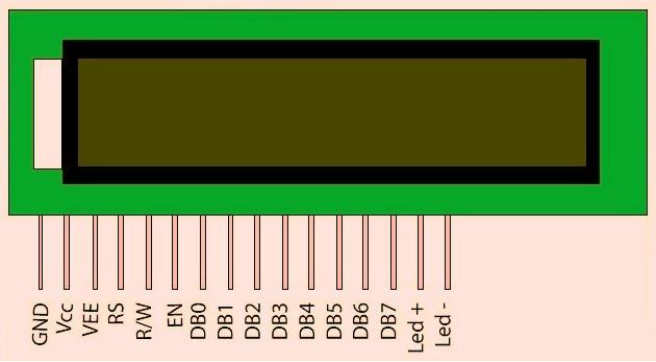
- LED: There is a built-in LED driven by digital pin 13. When the pin is high value, the LED is on, when the pin is low, it's off.
- VIN: The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 20V),the USB connector (5V), or the VIN pin of the board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.
- 3V3: A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND: Ground pins.
- IOREF: This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.
- Reset: Typically used to add a reset button to shields which block the one on the board.

2.6.Special Pin Functions

Each of the 14 digital pins and 6 analog pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function.In addition, some pins have specialized functions:

- Serial / UART: pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL serial chip.
- External interrupts: pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- PWM (pulse-width modulation): 3, 5, 6, 9, 10, and 11. Can provide 8-bit PWM output with the analogWrite() function.
- SPI (Serial Peripheral Interface): 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- TWI (two-wire interface) / I²C: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- AREF (analog reference): Reference voltage for the analog inputs.

2.7 LCD Display



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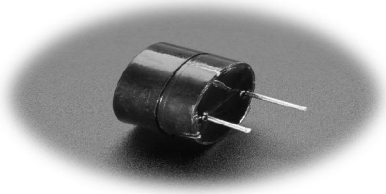
LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segment of other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters , animations and so on.

Pin Description:

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

2.8. Buzzer

A buzzer needs to have some way of taking in energy and converting it to acoustic energy. Many buzzers are part of a larger circuit and take their power directly from the device's power source. the buzzer may be battery powered so that it will go off in the event of a mains outage. Some devices that provide emergency power have buzzers on them so that the user



2.9.GSM

GSM(Global System for Mobile Communications, originally Groupe Spécial Mobile), is Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in July 1991.

GSM is a TDMA based wireless network technology developed GSM phones make use of a SIM card to identify the user's account. The use of the SIM card allows GSM network users to quickly move their phone number from one GSM phone to another by simply moving the SIM card. Currently GSM networks operate on the 850MHz, 900MHz, 1800MHz, and 1900MHz frequency bands. Devices that support all four bands are called quad-band, with those that support 3 or 2 bands called tri-band and dual-band, respectively. In the United States, Cingular operates on the 850 and 1900MHz bands, while T-Mobile operates only on the 1900MHz The module is managed by a microcontroller and has a TTL serial interface that allows it to communicate with the device that uses the cell phone (our circuit's PIC) as well

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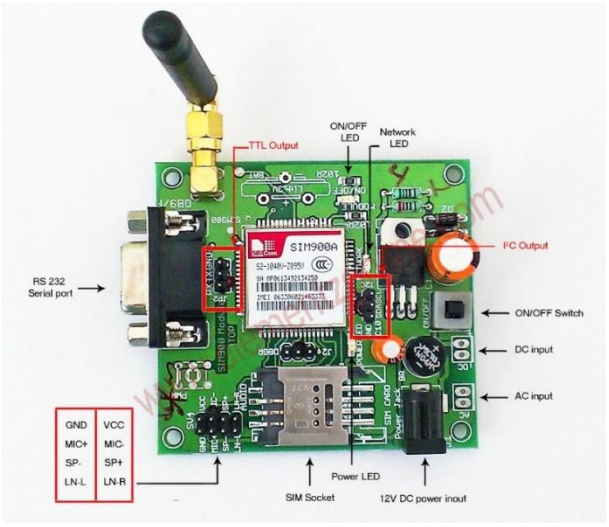
as to receive commands –standard AT commands, in the case of data phone connection. Aside from its own microphone, this module integrates a Flash and a SRAM, a UART, as well as interfaces needed for LCD display, audio, keyboard, and external SIM. The module is encapsulated in a package measuring just 1.14 inches x 1.14 inches x 0.14 inches, for SMD with 64 pins placed laterally, and reaching underneath the sides; it consumes 3,4÷4.5 V but, when idle, absorbs only 1,1 mA.

2.10 GSM Module

The cellular modems, particularly USB-stick ones, are now at very affordable prices, however they're limited: they are explicitly designed for Internet connections, so you cannot use it as a normal modem and so implement, for example, a point to point data communications with them. The GSM modems that allow this are quite rare, and so we create and offer you one: it is a device for PC with an USB interface with "voice" functions: there is a jack for a speaker and one for microphone

The GSM module offers the advantages as below

- Ultra small size (22x22x3 mm), lightweight (3.2 g) and easy to integrate
- Low power consumption
- R&TTE type approval plus CE, GCF, FCC, PTCRB, IC



Pin to Pin upgrade policy to save your developing investments High level technical support

- Evaluation kit and reference design
- Quick technical assistance by dedicated e-mail services and user forum
- Deep technical assistance by dedicated engineering support
- RD support and certification lab for all your needs

Product Features

- E-GSM 900/1800 MHz and GSM 1800/1900 with GSM Phase 2 / 2+
- Output Power Class 4 (2W) at GSM 850/900 MHz and Class 1 (1W) at GSM 1800/1900 MHz
- Control via AT commands (ITU, GSM, GPRS and manufacturer supplementary)
- Supply Voltage range: 3.22 V - 4.2 V, nominal: 3.8 V
- Power consumption: Idle mode: <1.8 mA, speech mode: 200 mA (average)
- Dimensions (mm): 3 x 20 x 20 and weight (g): 3.2 (including shielding)

Interfaces

- Power supply nominal 3,8 V
- 10 general purposes I/O ports and serial bi-directional bus on CMOS 2,8 V

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- External SIM
- Analogue audio for microphone, speaker and hands free set plus digital voice interface
- RS232 on CMOS 2,8 V (One RS232 (2,8V) with flow control (RX, TX, CTS, RTS, CTS, DTR, DSR, DCD, RI), baud rate 300 - 115.200 bps, auto bauding 1200 - 57.600 bps
- 50 Ohm antenna connector

SMS

- SMS Mobile Originated (MO), Mobile Terminated (MT) and Cell Broadcast (CB
- Circuit Switched Data (CSD) up to 14.4 kbps
- Fax Group 3
- Packed Data (GPRS class B, class 10) up to 115 kbps

GSM Supplementary Services

- Call Barring and Call Forwarding
- Advice of Charge
- Call Waiting and Call Hold
- Calling Line Identification Presentation (CLIP)
- Calling Line Identification Restriction (CLIR)
- Unstructured SS Mobile Originated Data (USSD)
- Closed User Group

2.11 Base Station Subsystem

GSM is a cellular network, which means that cell phones connect to it by searching for cells in the immediate vicinity. There are five different cell sizes in a GSM network macro, micro, pico, femto, and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average rooftop level. Micro cells are cells whose antenna height is under average rooftop level; they are typically used in urban areas. Today electricity still suffers from power outages and blackouts due to the lack of automated analysis and poor visibility of the utility over the grid. This relay is activated as soon as the parameters exceed the predefined threshold values. The relay also works as a circuit breaker to switch off the main power supply. RF communication is used to continuously send the instantaneous values to the intermediate station. This particular would be really helpful for monitoring of transformers as we know most of the time they are deployed in the dispersed locations. The greatest issue is to have all the transformers data at a single sink when the data is collected manually. The system is more efficiency and operating is easy.

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2.12.Basic Astable 555 Oscillator Circuit

An **Astable 555 Oscillator** is constructed using the following components, R1 = 1kΩ, R2 = 2kΩ and capacitor C = 10uF. Calculate the output frequency from the 555 oscillator and the duty cycle of the output waveform.

t_1 – capacitor charge "ON" time is calculated as:

$$t_1 = 0.693(R_1 + R_2).C$$
$$= 0.693(1000 + 2000) \times 10 \times 10^{-6}$$
$$= 0.021s = 21ms$$

t_2 – capacitor discharge "OFF" time is calculated as:

$$t_2 = 0.693\, R_2.C$$
$$= 0.693 \times 2000 \times 10 \times 10^{-6}$$
$$= 0.014s = 14ms$$

Total periodic time (T) is therefore calculated as:

$$T = t_1 + t_2 = 21ms + 14ms = 35ms$$

The output frequency, f is therefore given as:

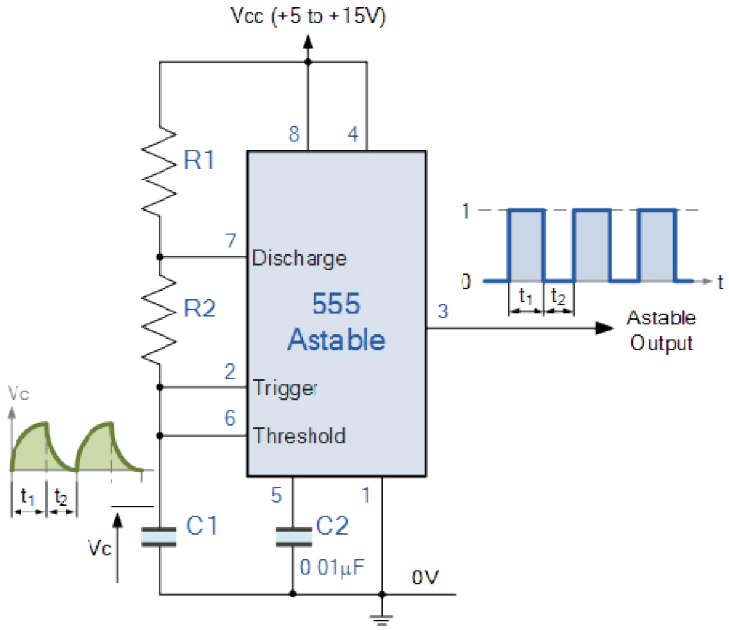
$$f = \frac{1}{T} = \frac{1}{35ms} = 28.6Hz$$

f= frequency

T=time period

t_1=capacitor charge "ON"

t_2=capacitor discharge "



The output frequency of oscillations can be found by inverting the equation above for the total cycle time giving a final equation for the output frequency of an Astable 555 Oscillator Note that resistor R1 needs to be sufficiently high enough to ensure it does not interfere with the charging of the capacitor to produce the required 50% duty cycle. Also changing the value of the timing capacitor, C1 changes the oscillation frequency of the astable circuit. This system is more efficiency and it is operating is very simple and easy

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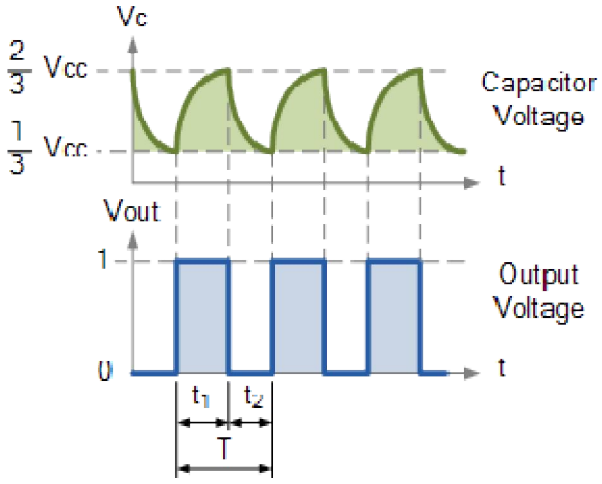
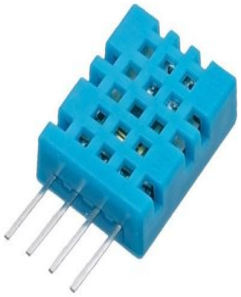


t_1=ON time
t_2=OFF time
V_c=Capacitor voltage
V_o=Output voltage
Total time(T)=t_1+t_2

Musical Definition	Rate	Beats per Minute	Cycle Time (T)	Frequency
Larghetto	Very Slow	60	1sec	1.0Hz
Andante	Slow	90	666ms	1.5Hz
Moderato	Medium	120	500ms	2.0Hz
Allegro	Fast	150	400ms	2.5Hz
Presto	Very Fast	180	333ms	3.0Hz

2.13.DHT Sensor

Humidity is the measure of water vapour present in the air. The level of humidity in air affects various physical, chemical and biological processes. In industrial applications, humidity can affect the business cost of the products, health and safety of the employees. So, in semiconductor industries and control system industries measurement of humidity is very important. Humidity measurement determines the amount of moisture present in the gas that can be a mixture of water vapour, nitrogen, argon or pure gas etc… Humidity sensors are of two types based on their measurement units. They are a relative humidity sensor and Absolute humidity sensor. DHT11 is a digital temperature and humidity sensor.



2.14. LED

LEDs are semiconductor devices. Like transistors, and other diodes, LEDs are made out of silicon. What makes an LED give off light are the small amounts of chemical impurities that are added to the silicon, such as gallium, arsenide, indium, and nitride. When current passes through the LED

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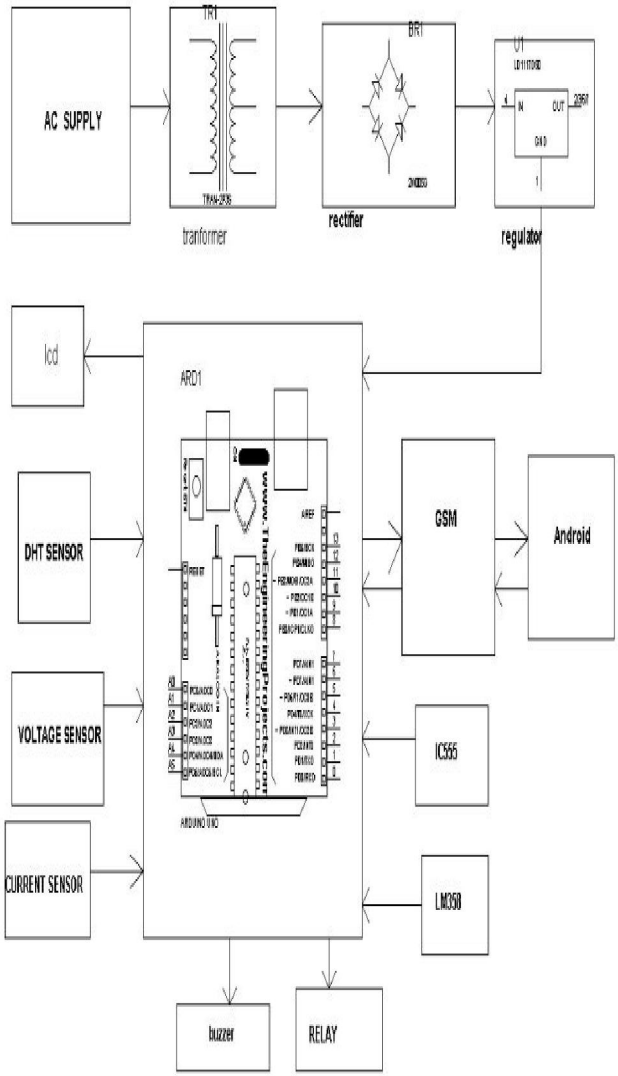
2.15 Advantages

1) Wireless Monitoring System.
2) Faster Control Action.
3) Automatic Control Action.
4) Accurate System.

2.16 Application

1) In industries to monitor different modules located at different places.
2) Distribution Points (DP) where the huge amount of power distribution takes place.
3) In the rural areas which are far away from the main stations.
4) Monitoring and controlling the home appliances

III. BLOCK DIAGRAM



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IV. FUTURE WORK

Addition of GSM Module By incorporating the GSM module, we will be able to send Personalised SMS to the authorities so that they can remain be updated about the plant while outside. And the microcontroller is programmed in such a way that a particular format of SMS is send which can be used as a input for the microcontroller for required operation. Addition of Wireless Camera We can install wireless cameras in the premises of substation switchyard; through we shall be able to visually monitor the substation in a better way. This particular would be really helpful for monitoring of transformers as we know most of the time they are deployed in the dispersed locations. Development of GUI The window display is developed using Graphical User Interface (GUI). The devices and their parameters such as frequency, voltage, load impedance, reluctance, oil level, temperature, cooling condition and power can be monitored integratedly3 in a displayer. This method helps the operator monitoring in real time the condition of each device easily. Furthermore, in the case of any failure, the operator will be acknowledged immediately that a specific device is experiencing some difficulty or failure. The blackout condition can be prevented and continuity power supply will be guaranteed. Coolant Management System We can add a coolant management system along with the temperature sensor module; which will be very helpful for the managing cooling flow and temperature management. It can be designed in such a way when the temperature of a module or a particular equipment will exceed a predefined limit the coolant flow will be rapid and continuous, and when temperature is well within range then the coolant flow will be slow and periodic.

V. CONCLUSION

Monitoring means acquiring significant parameters from the assets of interest. The acquired data is feasible to be used for analyses and diagnose the condition of the assets which is of great use for maintenance scheduling, failure management and controlling system and this method minimizes time contact between human and high voltage device. As it is known, most substation devices have high voltage and generate electromagnetic that can harm human health. This proposed system is specially designed for monitoring the condition of substation transformers which are deployed at dispersed locations There are many parameters to be quantified and monitored periodically It is quite costly and difficult to monitor the parameters by appointing a person at all locations and furthermore the data would also be error prone if the monitoring is manual. The greatest issue is to have all the transformers data at a single sink when the data is collected manually. Through our proposed system.

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