TRANSFORMER HEALTH MONITORING USING ARDUINO AND GSM

A Main project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

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R G M C E T

(ESTD-1995)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

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(AUTONOMOUS)

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BONAFIDE CERTIFICATE

This is to certify that the thesis entitled "TRANSFORMER HEALTH MONITORING USING ARDUINO AND GSM" that is being submitted by Mr.M.ARAVIND (17091A0204) , Mr.G.k . SABARIMALLESH (17091A0253),Mr. S.md.SHAREEF (18095A0221), have carried out the main project for the fulfillment of the award of Bachelor of Technology in Electrical and Electronics Engineering in Rajeev Gandhi Memorial college of Engineering & technology(Autonomous)and this is record of the work done by them during the year 2017-21.

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ABSTRACT

This project is about design and implementation of a mobile embedded system to monitor and record key parameters of a distribution transformer like load currents, oil level and ambient temperature. The idea of on-line monitoring system integrates a Global Service Mobile (GSM) Modem, with a standalone Arduino and different sensors. The obtained parameters are processed and recorded in the system memory. If any abnormality or an emergency situation occurs the system sends SMS (short message service) messages to the mobile phones containing information about the abnormality according to some predefined instructions programmed in the Arduino. This mobile system will help the transformers to operate smoothly and identify problems before any catastrophic failure. A powerful GSM networking is designed to send data from a network to other network for proper corrective action at the earliest. Any change in parameters of transmission is sensed to protect the entire transmission and distribution. The performance of prototype model developed is tested at laboratory for monitoring various parameters like transformer Over voltage and Under Voltage, Over current and Under current, Over temperature etc.

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CHAPTER-1

1.1 INTRODUCTION

Electricity plays an important role in our life. Every moment of our life depends upon electricity. Electricity has several components and equipment helping human to transfer and regulate the distribution according to usage. The most crucial equipment of transmission and distribution of electric power is transformer. In power systems, an electrical equipment distribution transformer directly distributes power to the low-voltage users and its operation condition is an important criterion of the entire network operation. The majority of these devices have been in service for many years in different (electrical, mechanical and environmental) conditions. They are the main components and constitute a large portion of capital investment. Operation of distribution transformer under rated condition (as per specification in their nameplate) guarantees their long service life. However, their life is significantly reduced if they are subjected to overloading, heating, low or high

voltage/current resulting to unexpected failures and loss of supply to a large number of customers thus effecting system reliability. Abnormality in distribution transformer is accomplished with variation in different parameters like

o Load current

o Load voltage

o Winding temperature

Overloading, load current and ineffective cooling of transformer are the major cause of failure in distribution transformer. When a transformer fails, an adverse effect occurs in the continuity of transmission and distribution system resulting in increase of power system cost and decrease of reliability in electric delivery. As transformer is a combination of many parts, this all parts must be checked regularly to maintain the transformer in perfect operating conditions. The monitoring devices or systems which are presently used for monitoring distribution transformer have some problems and deficiencies. According to the above requirements, we need a distribution transformer real time monitoring system to monitor all essential parameters operation, and send to the monitoring center in time. It leads to online monitoring of main functional parameters of distribution transformers which will provide necessary information about the health of transformers. This will help and guide the utilities to optimally use the transformers and keep this equipment in operation for a longer period. Transformer Health Monitoring System will help to identify or recognize unexpected situations before any serious failure which leads to greater reliability and significant cost savings. Widespread use of mobile networks and GSM modems, have made the man attractive option both for voice media and wide area network applications.

1.2. Literature Survey

In most power companies, for online monitoring of power transformers, use supervisory control and data acquisition (SCADA) system, but for online monitoring of power transformer, the extending the SCADA system is an expensive proposition. Power transformers are currently monitored manually, where a person visits a transformer site, for maintenance and taking records. But main drawbacks of these systems are, it cannot provide information about overloads (Voltage & Current) and overheating of transformer oil & windings. Due to these , the transformer life is reduced.

Monika Agarwal et al. [1] This paper represents that they are designing a system where there exists communication between system and operator. For this we are using Transformer, micro controller, logic level converter and GSM i.e. global system for mobile communication modem. This GSM modem helps to monitor transformer health by sending message to the system.

Hongyan Mao, et al. [2] This paper represents a large number of power distribution transformer stations and they are far away from city, wireless GPRS transmission provides a good communication solution to supervise power distribution transformer stations. The scheme of remote wireless monitoring system for power distribution transformer station based on GPRS wireless network was designed in this paper. A control terminal system implement was mainly given, which adopted LPC2132 as main processor, GR47 as the date communication module. The monitor terminal software and flow chart were also designed. At last, the way of configuring the GPRS module to connect network is analyzed.

Pathak A.K, et al. [3] This paper represents a design and implementation of a mobile embedded system to monitor and record key parameters of a distribution transformer like load currents, oil level and ambient Modem, withstand alone single chip microcontroller 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 abnormality or an emergency situation occurs the system sends SMS (short message service) messages to the mobile phones containing information about the abnormality according to some predefined instructions programmed in the microcontroller. This mobile system will help the transformers to operate smoothly and identify problems before any catastrophic failure.

Disadvantage of Existing System

1. Firing of transformer can easily occurs.

2. Not accurate.

3. Frequency interference in system.

4. Noise problem in network.

CHAPTER – 2

CHAPTER – 2

DESCRIPTION OF THE COMPONENTS

1. Arduino UNO:

The Arduino Uno is an open-source microcontroller board based on the Micro chip 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 IDE (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 board comes pre-programmed with a boot loader that allows uploading new code to it without the use of an external hardware programmer.

While the Uno communicates using the original STK500 protocol, it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

BACKGROUND

The Arduino project started at the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. At that time, the students used a BASIC Stamp microcontroller at a cost of $100, a considerable expense for many students. In 2003 Hernando Barragán created the development platform Wiring as a Master's thesis project at IDII, under the supervision of Massimo Banzi and Casey Reas, who are known for work on the Processing language. The project goal was to create simple, low-cost tools for creating digital projects by non-engineers. The Wiring platform consisted of a printed circuit board (PCB) with an ATmega168 microcontroller, an IDE based on Processing and library functions to easily program the microcontroller.[8] In 2003, Massimo Banzi, with David Mellis, another IDII student, and David Cuartielles, added support for the cheaper ATmega8 microcontroller to Wiring. But instead of continuing the work on Wiring, they forked the project and renamed it Arduino. Early arduino boards used the FTDI USB-to-serial driver chip and an ATmega168.[8] The Uno differed from all preceding boards by featuring the ATmega328P microcontroller and an ATmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

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: 20mA
- DC Current for 3.3V Pin: 50mA
- Flash Memory: 32 KB of which 0.5 KB used by boot loader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g

Fig 2.1

PINS:

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 50mA.
- **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.

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, labelled 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.

Automatic (software) reset

Rather than requiring a physical press of the reset button before an upload, the Arduino/Genuino Uno board is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip.

This setup has other implications. When the Uno is connected to a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened.

2. LIQUID CRYSTAL DISPLAY (LCD)

LCD DISPLAY

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 segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

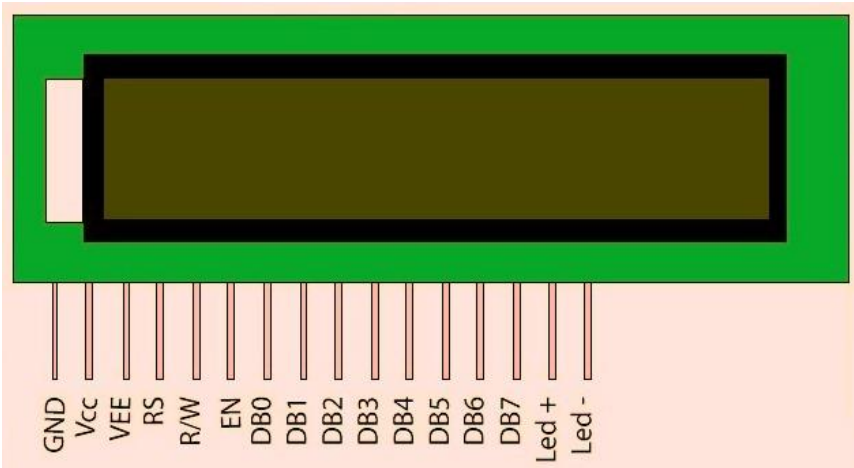


Fig 2.2

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-

ALL LCD HAVE

- Eight(8) Data pins
- VCC (Apply 5v here)
- GND (Ground this pin)
- RS (Register select)
- RW (read - write)
- EN (Enable)
- V0 (Set Lcd contrast)

8-Data pins carries 8-bit data or command from an external unit such as microcontroller.

Set ICD contrast here. Best way is to use variable resistor such as potentiometer. Output of the potentiometer is connected to this pin. Rotate the potentiometer knob forward and backward to adjust the lcd contrast.

RS(Register select)
There are two registers in every lcd
1.Command Register
2.Data Register
Command Register
When we send commands to lcd these commands go to Command register and are processed their.
Commands with their full description are given in the picture below.
When RS=0 Command Registers Selected.
Data Register
When we send Data to lcd it goes to data register and is processed their.
When RS=1 Data Register is selected.
RW(Read Write)
When RW=1 We want to read data from lcd.
When RW=0 We want to write to lcd.

EN(Enable signal)
When you select the register(Command and Data) and set RW(read - write) now its time to execute the instruction. By instruction i mean the 8-bit data or

8-bit command present on Datelines of lcd.
This requires an extra voltage push to execute the instruction and EN(enable) signal is used for this purpose. Usually we make it en=0 and when we want to execute the instruction we make it. high en=1 for some milli seconds. After this we again make it ground en=0.high en=1 for some milli seconds. After this we again make it ground en=0

Interfacing LCD

VEE pin is meant for adjusting the contrast of the LCD display and the contrast can be adjusted by varying the voltage at this pin. This is done by connecting one end of a POT to the Vcc (5V), other end to the Ground and connecting the center terminal (wiper) of the POT to the VEE pin. See the circuit diagram for better understanding.

The JHD162A has two built in registers namely data register and command register. Data register is for placing the data to be displayed , and the command register is to place the commands. The 16×2 LCD module has a set of commands each meant for doing a particular job with the display. We will discuss in detail about the commands later. High logic at the RS pin will select the data register and Low logic at the RS pin will select the command register. If we make the RS pin high and the put a data in the 8 bit data line (DB0 to DB7) , the LCD module will recognize it as a data to be displayed . If we make RS pin low and put a data on the data line, the module will recognize it as a command.

R/W pin is meant for selecting between read and write modes. High level at this pin enables read mode and low level at this pin enables write mode.

E pin is for enabling the module. A high to low transition at this pin will enable the module.

DB0 to DB7 are the data pins. The data to be displayed and the command instructions are placed on these pins.

LED+ is the anode of the back light LED and this pin must be connected to Vcc through a suitable series current limiting resistor. LED- is the cathode of the back light LED and this pin must be connected to ground.

LCD initialization.

The steps that has to be done for initializing the LCD display is given below and these steps are common for almost all applications.

- Send 38H to the 8 bit data line for initialization
- Send 0FH for making LCD ON, cursor ON and cursor blinking ON.
- Send 06H for incrementing cursor position.
- Send 01H for clearing the display and return the cursor.

16×2 LCD module commands.

16×2 LCD module has a set of preset command instructions. Each command will make the module to do a particular task. The commonly used commands and their function are given in the table below.

Command	Function
OF	LCD ON, Cursor ON, Cursor blinking ON
01	Clear screen
02	Return home
04	Decrement cursor
06	Increment cursor
0E	Display ON ,Cursor blinking OFF
80	Force cursor to the beginning of 1^{st} line
C0	Force cursor to the beginning of 2^{nd} line
38	Use 2 lines and 5×7 matrix
83	Cursor line 1 position 3
3C	Activate second line
08	Display OFF, Cursor OFF
C1	Jump to second line, position1

OC	Display ON, Cursor OFF
C1	Jump to second line, position1
C2	Jump to second line, position2

Sending data to the LCD.

The steps for sending data to the LCD module is given below. I have already said that the LCD module has pins namely RS, R/W and E. It is the logic state of these pins that make the module to determine whether a given data input is a command or data to be displayed.

- Make R/W low.
- Make RS=0 if data byte is a command and make RS=1 if the data byte is a data to be displayed.
- Place data byte on the data register.
- Pulse E from high to low.
- Repeat above steps for sending another data.

The circuit diagram given above shows how to interface a 16×2 LCD module with AT89S1 microcontroller. Capacitor C3, resistor R3 and push button switch S1 forms the reset circuitry. Ceramic capacitors C1,C2 and crystal X1 is related to the clock circuitry which produces the system clock frequency. P1.0 to P1.7 pins of the microcontroller is connected to the DB0 to DB7 pins of the module respectively and through this route the data goes to the LCD module. P3.3, P3.4 and P3.5 are connected to the E, R/W, RS pins of the microcontroller and through this route the control signals are transffered to the LCD module. Resistor R1 limits the current through the back light LED and so do the back light intensity. POT R2 is used for adjusting the contrast of the display. Program for interfacing LCD to 8051 microcontroller is shown below.

GSM

GSM (**Global System for Mobile Communications**, originally **Group especial Mobile**), is a standard developed by the European 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 band.

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 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.

Block Diagram

The type of interface used in GSM is digital air interface. The analogue voice signals are converted to digital signals before transmission. Up to 8 MS subscribers can be handled by the GSM RF carrier at a time. The rate of transmission is 270 Kbps.

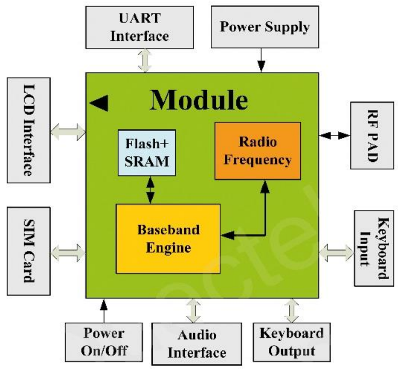


Fig 2.3

The Gaussian minimum shift keying (GMSK) is used for transmitting the digital signals. In GMSK , a phase change represents the change from a digital “1 ” or a “0 “,occurs over a period of time. The addition of high frequency components to the spectrum is reduced. In GSMK ,the phase change is not constant and it is spread- out.

GSM MODULE

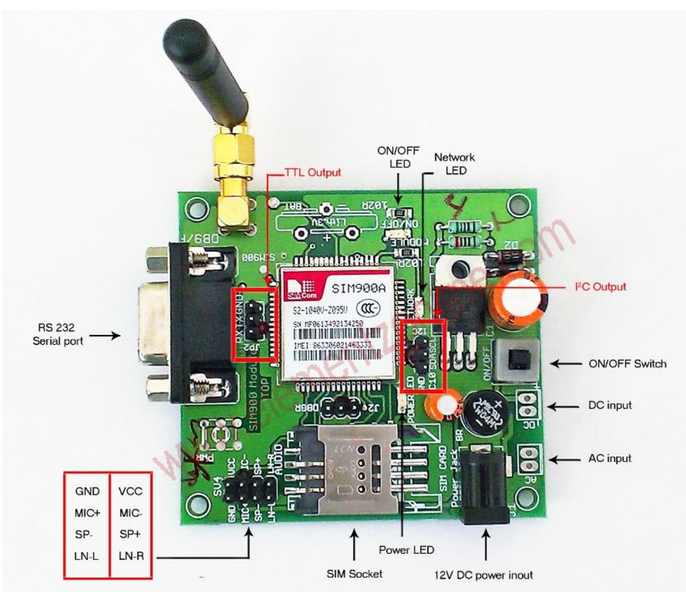


Fig 2.4

Allows you to create data connections on the GSM network through a standard USB interface.

The cellular modems, particularly USB-stick ones, are now at very affordable prices, however they are 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 circuit is made simple by the adoption of a mobile phone module of Simcom SIM908 andSIM900 of the SIMCom. The USB connection is implemented with the aid of a converter TTL / USBtype FT782M. Our modem is ideal to perform data links without access to the GPRS network or in any case to the Internet and allows, for example, the use in point-to-point mode, locators GPS / GSM or GSM only so as to obtain instantly data positioning and follow moves on live. In short, it allows direct data connection with another modem or mobile phone , but without going through the web: connections are made directly to the GSM data channel.

Full Type Approved Quad Band Embedded GSM Module (GSM 850/900 1800/1900) with AT command set and RS232 interface on CMOS level. This GSM wireless data module is the ready a solution for remote wireless applications, machine to machine or user to machine and remote data communications in all vertical market applications.

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
- Full RS232 on CMOS level with flow control (RX, TX, CTS, RTS, CTS, DTR, DSR, DCD, RI)
- Embedded TCP/IP Stack UDP/IP Stack , Embedded FTP and SMTP Client
- High performance on low price

Smallest size designed for tiny applications

Tracking (people, animals, people), container tracking, PDA, POS terminal, PCMCIA cards, AMR

Pin to Pin upgrade policy to save your developing investments High level technical support to help you in the integration of your solution

- Exhaustive product documentation
- 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
- 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

Audio

- Telephony and emergency calls (Half Rate (HR), Full Rate (FR), Enhanced Full Rate (EFR))
- Echo cancellation and noise reduction
- DTMF
- Handset operations and basic hands free operation

SMS

- SMS Mobile Originated (MO), Mobile Terminated (MT) and Cell Broadcast (CB - DRX)

GPRS, data and Fax

- 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

Other Features

- SIM Phonebook management
- Fixed Dialing Number (FDN)

- SIM Toolkit class 2
- Real time clock
- Alarm management

BUZZER

A buzzer takes some sort of input and emits a sound in response to it. They may use various means to produce the sound; everything from metal clappers to electromechanical devices.

A buzzer needs to have some way of taking 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. In other cases, however, 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 knows that they are running on backup power and not on mains power.

Piezo buzzer is an electronic device commonly used to produce sound. Light weight, simple construction and low price make it suitable in various applications like car/truck reversing indicator, computers, call bells etc. Piezo buzzer is based on the inverse principle of piezo electricity discovered in 1880 by Jacques and Pierre Curie. It is the phenomena of generating electricity when mechanical pressure is applied to certain materials and the vice versa is also true. Such materials are called piezo electric materials. Piezo electric materials are either naturally available or manmade. Piezoceramic is class of manmade material, which poses piezo electric effect and is widely used to make disc, the heart of piezo buzzer. When subjected to an alternating electric field they stretch or compress, in accordance with the frequency of the signal thereby producing sound.

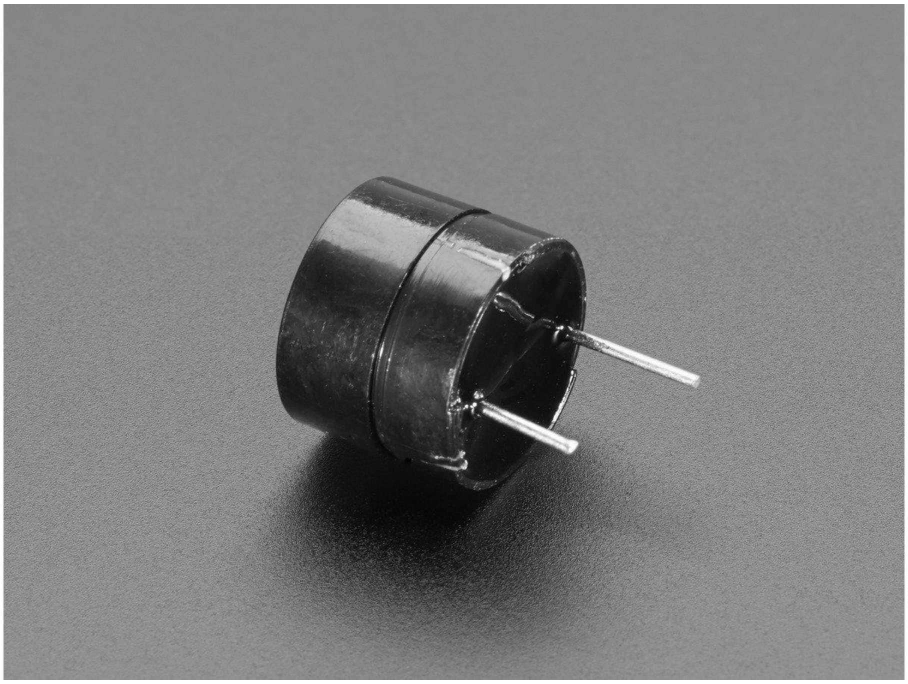


Fig 2.5

The above image shows a very commonly used piezo buzzer also called **piezo transducer** operating at DC voltage. Encapsulated in a cylindrical plastic coating, it has a hole on the top face for sound to propagate. A yellow metallic disc which plays an important role in the producing sound can be seen through the hole.

10. 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, it emits photons as a byproduct. Normal light bulbs produce light by heating a metal filament until its white hot. Because LEDs produce photons directly and not via heat, they are far more efficient than incandescent bulbs. Not long ago LEDs were only bright enough to be used as indicators on dashboards or electronic equipment. But recent advances have made LEDs bright enough to rival traditional lighting technologies. Modern LEDs can replace incandescent bulbs in almost any application.

LEDs are based on the semiconductor diode. When the diode is forward biased (switched on), electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence and the color of the light is determined by the energy gap of the semiconductor. The LED is usually small in area (less than 1 mm2) with integrated optical components to shape its radiation pattern and assist in reflection.

Fig 2.6

LEDs present many advantages over traditional light sources including lower energy consumption, longer lifetime, improved robustness, smaller size and faster switching. However, they are relatively expensive and require more precise current and heat management than traditional light sources.

Applications of LEDs are diverse. They are used as low-energy and also for replacements for traditional light sources in well-established applications such as indicators and automotive lighting. The compact size of LEDs has allowed new text and video displays and sensors to be developed, while their high switching rates are useful in communications technology. So here the role of LED is to indicate the status of the components like relays and power circuit etc…

LED Circuits

To build LED circuits, it helps to be familiar with Ohm's law, and the concepts of voltage, resistance, and current. LEDs do not have resistance like a resistor does. LEDs have a dynamic resistance, that is their resistance changes depending on how much current passes through them. But it's easiest to think of them as having NO resistance. This means that if you just connect an LED to a battery, you'll have a short circuit. That's bad. You would probably ruin your led.

So an LED circuit needs some resistance in it, so that it isn't a short circuit. Actually we need a very specific amount of resistance. Among the specifications for LEDs, a "maximum forward current" rating is usually given. This is the most current that can pass through the LED without damaging it, and also the current at which the LED will produce the most light. A specific value of resistor is

needed to obtain this exact current. There is one more complication. LEDs consume a certain voltage. This is known as the "forward voltage drop", and is usually given with the specs for that LED. This must be taken into account when calculating the correct value of resistor to use. So to drive an LED using a voltage source and a resistor in series with the LED, use the following equation to determine the needed resistance:

Ohm's = (Source Voltage - LED Voltage Drop) / Amps

For example, to drive an LED from your car's 12v system, use the following values:

Source Voltage	=	13.4 volts (12v car systems aren't really 12v in most cases)
Voltage Drop	=	3.6 volts (Typical for a blue or white LED)
Desired Current	=	30 milliamps (again, a typical value)

So the resistor we need is:

(13.4 - 3.6) / (30 / 1000) = 327 ohms

11. POWER SUPPLY

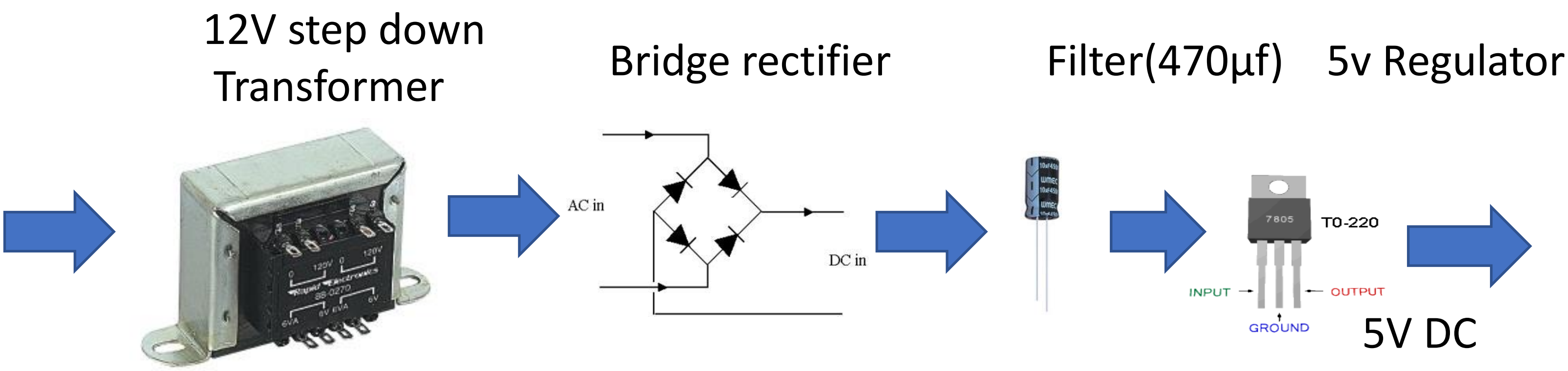
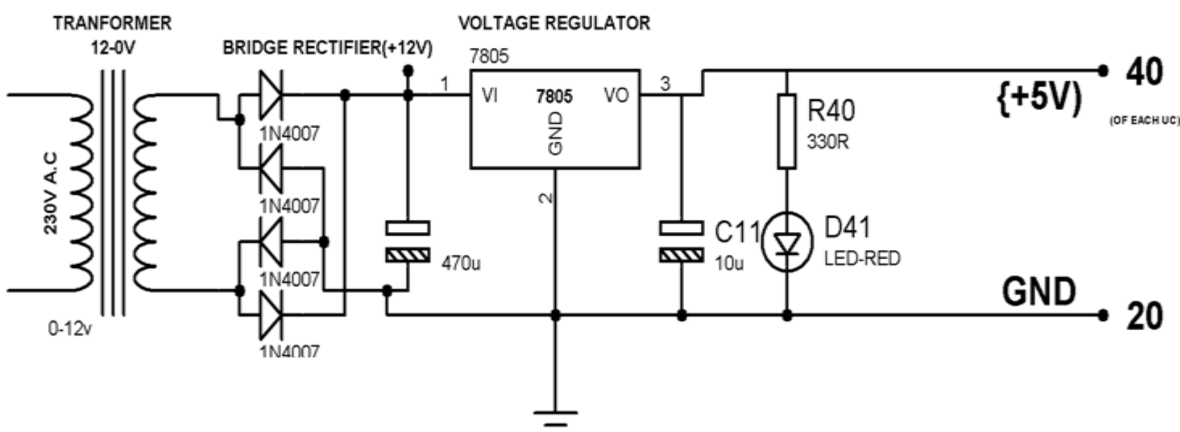


Fig 2.7



- The circuit uses standard power supply comprising of a step-down transformer from 230v to 12v and 4 diodes forming a Bridge Rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470microf to 100microF.
- The filtered dc being unregulated IC LM7805 is used to get 5v constant at its pin no 3 irrespective of input dc varying from 9v to 14v.
- The regulated 5volts dc is further filtered by a small electrolytic capacitor of 10 micro farads for any noise so generated by the circuit.

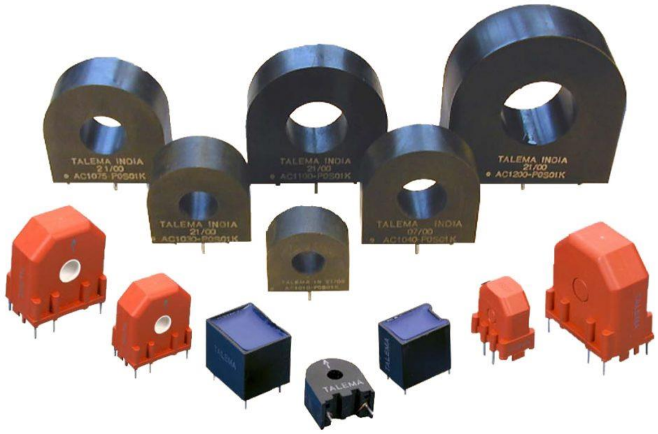
- One LED is connected of this 5v point in series with a resistor of 330 ohms to the ground i.e. negative voltage to indicate 5v power supply availability.

AC Input 12 Volt Power Supply Specifications

- **Dimensions**: 7.96" x 3.92" x 1.96"
- Complies with RoHS Directive.
- **AC** Input **Voltage** Range: 85-132/ 170-264VAC Selected by Switch.
- Input Frequency: 47-63Hz.
- Inrush Current: Cold Start, 20A/115V, 40A/230V.
- Input Leakage Current: <0.7mA/230V.
- Line Regulation (Full Load): <± 0.5%

CURRENT TRANSFORMER

A **current transformer** is an instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current and differs in phase from it by an angle which is approximately zero.

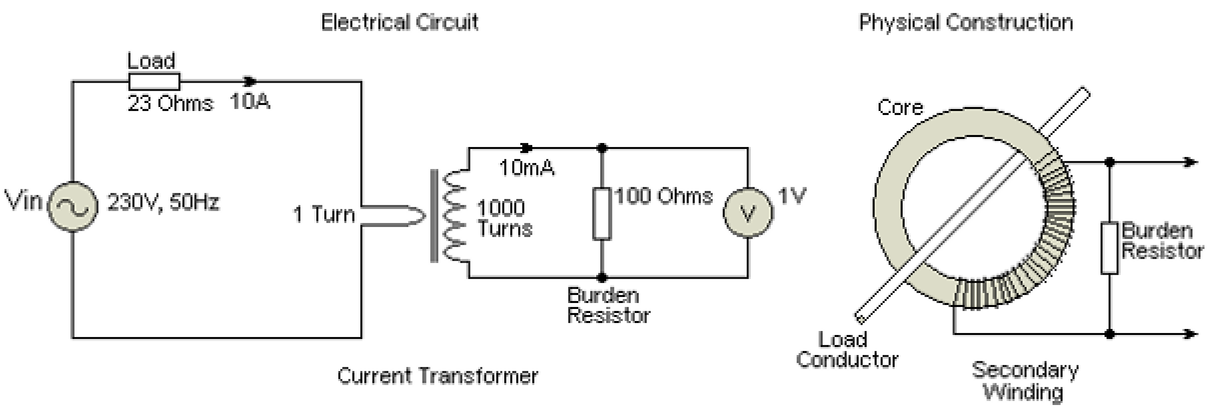


The design and testing of current transformers are governed by standard IEC 61869-2:2012 (replaces IEC 60044-1:1996)

The principle of operation of a current transformer is the same as that of the power transformer. The current transformer has a primary and a secondary winding. An alternating current flowing in the primary winding induces an alternating current in the secondary winding.

The primary winding may be a single turn or a small number of turns, the secondary winding will have many more turns depending on transformation ratio. The rated transformation is the ratio of the rated primary current to the rated secondary current.

Below is a simple circuit showing single turn ,10 A primary winding and 1000 T CT with 10 mVA burden and R = 100 Ω.



Simple CT Circuit

I_p = 10
I_s = 10/1000 = 10 mA
V_b = 10 mA × 100 = 1 V

The secondary winding is terminated on the rated burden resistor, the value on which the accuracy requirements of the current transformer is based.

In an ideal current transformer, the current in the secondary winding will reflect the actual primary current without current ratio error or phase displacement. However, under normal conditions, there will be current ratio error and phase displacement between primary and secondary currents.

Accuracy Class

Accuracy Class is a designation assigned to a current transformer where the errors remain within specified limits under prescribed conditions .

For example, if the accuracy class of a current transformer is 1, then the ratio error will be ±1% at the rated primary value.

In the case of metering CTs, accuracy class is typically 0.1, 0.2, 0.5, and 1

Table 201 – Limits of ratio error and phase displacement for measuring current transformers (classes 0,1 to 1)

Accuracy class	Ratio error ± % at current (% of rated)				Phase displacement ± Minutes at current (% of rated)				Phase displacement ± Centiradians at current (% of rated)			
	5	20	100	120	5	20	100	120	5	20	100	120
0,1	0,4	0,2	0,1	0,1	15	8	5	5	0,45	0,24	0,15	0,15
0,2	0,75	0,35	0,2	0,2	30	15	10	10	0,9	0,45	0,3	0,3
0,5	1,5	0,75	0,5	0,5	90	45	30	30	2,7	1,35	0,9	0,9
1	3,0	1,5	1,0	1,0	180	90	60	60	5,4	2,7	1,8	1,8

For classes 0.1, 0.2, 0.5, and 1, the current error and phase displacement shall not exceed the values given in table 201 when the secondary burden is any value from 25% to 100% of the rated burden.

Power Transformer:

One of the main reasons that we use alternating AC voltages and currents in our homes and workplace's is that AC supplies can be easily generated at a convenient voltage, transformed (hence the name transformer) into much higher voltages and then distributed

The reason for transforming the voltage to a much higher level is that higher distribution voltages implies lower currents for the same power and therefore lower I^2R losses along the networked grid of cables. These higher AC transmission voltages and currents can then be reduced to a much lower, safer and usable voltage level where it can be used to supply electrical equipment in our homes and workplaces, and all this is possible thanks to the basic **Power Transformer or Voltage Transformer**.

fig 2.9

The **Voltage Transformer** can be thought of as an electrical component rather than an electronic component. A transformer basically is very simple static (or stationary) electro-magnetic passive electrical device that works on the principle of Faraday's law of induction by converting electrical energy from one value to another.

The transformer does this by linking together two or more electrical circuits using a common oscillating magnetic circuit which is produced by the transformer itself. A transformer operates on the principals of "electromagnetic induction", in the form of Mutual Induction.

Mutual induction is the process by which a coil of wire magnetically induces a voltage into another coil located in close proximity to it. Then we can say that transformers work in the "magnetic domain", and transformers get their name from the fact that they "transform" one voltage or current level into another.

Transformers are capable of either increasing or decreasing the voltage and current levels of their supply, without modifying its frequency, or the amount of Electrical Power being transferred from one winding to another via the magnetic circuit.

A single phase voltage transformer basically consists of two electrical coils of wire, one called the "Primary Winding" and another called the "Secondary Winding". For this tutorial we will define the "primary" side of the transformer as the side that usually takes power, and the "secondary" as the side that usually delivers power. In a single-phase voltage transformer the primary is usually the side with the higher voltage.

These two coils are not in electrical contact with each other but are instead wrapped together around a common closed magnetic iron circuit called the "core". This soft iron core is not solid but made up of individual laminations connected together to help reduce the core's losses.

The two coil windings are electrically isolated from each other but are magnetically linked through the common core allowing electrical power to be transferred from one coil to the other. When an electric current passed through the primary winding, a magnetic field is developed which induces a voltage into the secondary winding as shown.

Single Phase Voltage Transformer

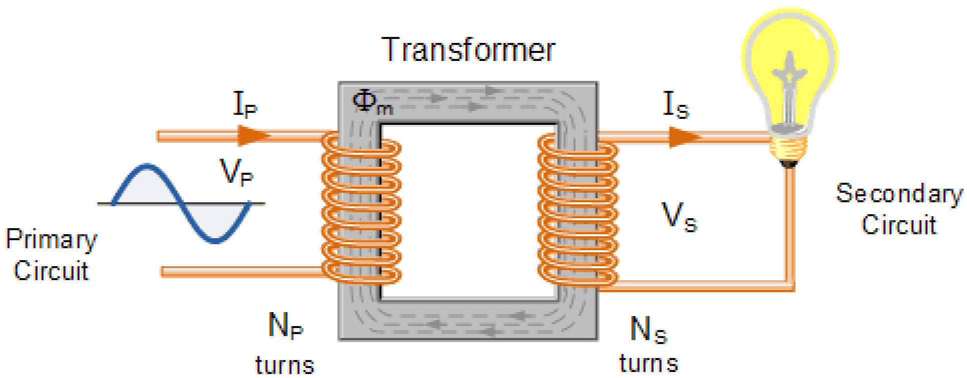


Fig 2.10

In other words, for a transformer there is no direct electrical connection between the two coil windings, thereby giving it the name also of an Isolation Transformer. Generally, the primary winding of a transformer is connected to the input voltage supply and converts or transforms the electrical power into a magnetic field. While the job of the secondary winding is to convert this alternating magnetic field into electrical power producing the required output voltage as shown.

Transformer Construction (single-phase)

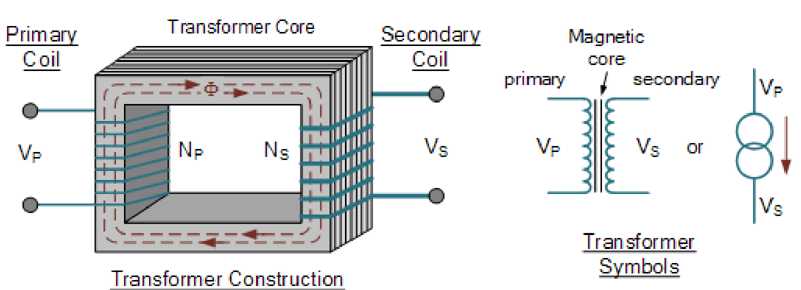


Fig 2.11

- V_P - is the Primary Voltage
- V_S - is the Secondary Voltage
- N_P - is the Number of Primary Winding turns
- N_S - is the Number of Secondary Winding turns
- Φ (phi) - is the Flux Linkage

Notice that the two coil windings are not electrically connected, but are only linked magnetically. A single-phase transformer can operate to either increase or decrease the voltage applied to the primary winding. When a transformer is used to “increase” the voltage on its secondary winding with respect to the primary, it is called a **Step-up transformer**. When it is used to “decrease” the voltage on the secondary winding with respect to the primary it is called a **Step-down transformer**.

However, a third condition exists in which a transformer produces the same voltage on its secondary as is applied to its primary winding. In other words, its output is identical with respect to voltage, current and power transferred. This type of transformer is called an “Impedance Transformer” and is mainly used for impedance matching or the isolation of adjoining electrical circuits.

The difference in voltage between the primary and the secondary windings is achieved by changing the number of coil turns in the primary winding (N_P) compared to the number of coil turns on the secondary winding (N_S).

As the transformer is basically a linear device, a ratio now exists between the number of turns of the primary coil divided by the number of turns of the secondary coil. This ratio, called the ratio of transformation, more commonly known as a transformers “turns ratio”, (TR). This turns ratio value dictates the operation of the transformer and the corresponding voltage available on the secondary winding.

It is necessary to know the ratio of the number of turns of wire on the primary winding compared to the secondary winding. The turns ratio, which has no units, compares the two windings in order and is written with a colon, such as 3:1 (3-to-1). This means in this example, that if there are 3 volts on the primary winding there will be 1 volt on the secondary winding, 3 volts-to-1 volt. Then we can see that if the ratio between the number of turns changes the resulting voltages must also change by the same ratio, and this is true.

Transformers are all about “ratios”. The ratio of the primary to the secondary, the ratio of the input to the output, and the turns ratio of any given transformer will be the same as its voltage ratio. In other words for a transformer: “turns ratio = voltage ratio”. The actual number of turns of wire on any winding is generally not important, just the turns ratio and this relationship is given as:

A Transformers Turns Ratio

$$\frac{N_P}{N_S} = \frac{V_P}{V_S} = n = \text{Turns Ratio}$$

Assuming an ideal transformer and the phase angles: $\Phi_P \equiv \Phi_S$

Note that the order of the numbers when expressing a transformers *turns ratio* value is very important as the turns ratio 3:1 expresses a very different transformer relationship and output voltage than one in which the turns ratio is given as: 1:3.

Transformer Basics

Example No1

A voltage transformer has 1500 turns of wire on its primary coil and 500 turns of wire for its secondary coil. What will be the turns ratio (TR) of the transformer.

$$T.R. = \frac{N_P}{N_S} = \frac{\#Pri.\ Coils}{\#Sec.\ Coils} = \frac{1500}{500} = \frac{3}{1} = 3:1$$

This ratio of 3:1 (3-to-1) simply means that there are three primary windings for every one secondary winding. As the ratio moves from a larger number on the left to a smaller number on the right, the primary voltage is therefore stepped down in value as shown.

Transformer Basics Example No2

If 240 volts rms is applied to the primary winding of the same transformer above, what will be the resulting secondary no load voltage.

$$T.R. = 3:1 \text{ or } \frac{3}{1} = \frac{V_P}{V_S} = \frac{\#Pri.\ Volts}{\#Sec.\ Volts} = \frac{240}{V_S}$$

$$\therefore \text{Sec. Volts, } V_S = \frac{V_P}{3} = \frac{240}{3} = 80 \text{ volts}$$

Again confirming that the transformer is a “step-down transformer as the primary voltage is 240 volts and the corresponding secondary voltage is lower at 80 volts.

Then the main purpose of a transformer is to transform voltages at preset ratios and we can see that the primary winding has a set amount or number of windings (coils of wire) on it to suit the input voltage. If the secondary output voltage is to be the same value as the input voltage on the primary winding, then the same number of coil turns must be wound onto the secondary core as there are on the primary core giving an even turns ratio of 1:1 (1-to-1). In other words, one coil turn on the secondary to one coil turn on the primary.

If the output secondary voltage is to be greater or higher than the input voltage, (step-up transformer) then there must be more turns on the secondary giving a turns ratio of 1:N (1-to-N), where N represents the turns ratio number. Likewise, if it is required that the secondary voltage is to be lower or less than the primary, (step-down transformer) then the number of secondary windings must be less giving a turns ratio of N:1 (N-to-1).

Transformer Action

We have seen that the number of coil turns on the secondary winding compared to the primary winding, the turns ratio, affects the amount of voltage available from the secondary coil.

We have said previously that a transformer basically consists of two coils wound around a common soft iron core. When an alternating voltage (V_P) is applied to the primary coil, current flows through the coil which in turn sets up a magnetic field around itself, called *mutual inductance*, by this current flow according to *Faraday's Law* of electromagnetic induction. The strength of the magnetic field builds up as the current flow rises from zero to its maximum value which is given as $d\Phi/dt$.

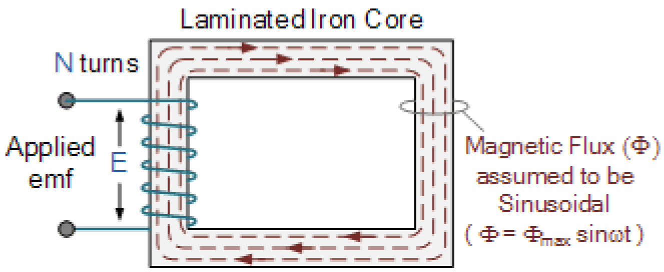


Fig 2.12

As the magnetic lines of force setup by this electromagnet expand outward from the coil the soft iron core forms a path for and concentrates the magnetic flux. This magnetic flux links the turns of both windings as it increases and decreases in opposite directions under the influence of the AC supply.

However, the strength of the magnetic field induced into the soft iron core depends upon the amount of current and the number of turns in the winding. When current is reduced, the magnetic field strength reduces.

When the magnetic lines of flux flow around the core, they pass through the turns of the secondary winding, causing a voltage to be induced into the secondary coil. The amount of voltage induced will be determined by: $N.d\Phi/dt$ (Faraday's Law), where N is the number of coil turns. Also this induced voltage has the same frequency as the primary winding voltage.

Then we can see that the same voltage is induced in each coil turn of both windings because the same magnetic flux links the turns of both the windings together. As a result, the total induced voltage in each winding is directly proportional to the number of turns in that winding. However, the peak amplitude of the output voltage available on the secondary winding will be reduced if the magnetic losses of the core are high.

If we want the primary coil to produce a stronger magnetic field to overcome the cores magnetic losses, we can either send a larger current through the coil, or keep the same current flowing, and instead increase the number of coil turns (N_P) of the winding. The product of amperes times turns is called the “ampere-turns”, which determines the magnetising force of the coil.

So assuming we have a transformer with a single turn in the primary, and only one turn in the secondary. If one volt is applied to the one turn of the primary coil, assuming no losses, enough current must flow and enough magnetic flux generated to induce one volt in the single turn of the secondary. That is, each winding supports the same number of volts per turn.

As the magnetic flux varies sinusoidally, $\Phi = \Phi_{max} \sin\omega t$, then the basic relationship between induced emf, (E) in a coil winding of N turns is given by:

emf = turns x rate of change of flux

$$E = N\frac{d\Phi}{dt}$$

$$E = N \times \omega \times \Phi_{max} \times \cos(\omega t)$$

$$E_{max} = N\omega\Phi_{max}$$

$$E_{rms} = \frac{N\omega}{\sqrt{2}} \times \Phi_{max} = \frac{2\pi}{\sqrt{2}} \times f \times N \times \Phi_{max}$$

$$\therefore E_{rms} = 4.44 f N \Phi_{max}$$

- Where:

- f - is the flux frequency in Hertz, $= \omega/2\pi$
- N - is the number of turns of coil windings.
- Φ - is the flux density in webers

This is known as the **Transformer EMF Equation**. For the primary winding emf, N will be the number of primary turns, (N_P) and for the secondary winding emf, N will be the number of secondary turns, (N_S).

Also please note that as transformers require an alternating magnetic flux to operate correctly, transformers cannot therefore be used to transform or supply DC voltages or currents, since the magnetic field must be changing to induce a voltage in the secondary winding. In other words ,**transformers DO NOT operate on steady state DC voltages**, only alternating or pulsating voltages.

If a transformers primary winding was connected to a DC supply, the inductive

reactance of the winding would be zero as DC has no frequency, so the effective impedance of the winding will therefore be very low and equal only to the resistance of the copper used. Thus the winding will draw a very high current from the DC supply causing it to overheat and eventually burn out, because as we know $I = V/R$.

Transformer Basics Example No3

A single phase transformer has 480 turns on the primary winding and 90 turns on the secondary winding. The maximum value of the magnetic flux density is 1.1T when 2200 volts, 50Hz is applied to the transformer primary winding. Calculate:

a). The maximum flux in the core.

$$E_{rms} = \frac{N\omega}{\sqrt{2}} \Phi_{max}$$

$$\Phi_{max} = \frac{E_{rms}}{N\omega} \times \sqrt{2} = \frac{2200}{480 \times 2\pi \times 50} \times \sqrt{2}$$

$$\therefore \Phi_{max} = 0.0206\,\text{Wb or } 20.6\,\text{mWb}$$

b). The cross-sectional area of the core.

$$\Phi_{max} = \beta \times A$$

$$\therefore A = \frac{\Phi_{max}}{\beta} = \frac{0.0206}{1.1} = 0.0187 m^2$$

c). The secondary induced emf.

$$T.R. = \frac{V_P}{V_S} = \frac{N_P}{N_S}$$

$$\therefore V_S = \frac{V_P \times N_S}{N_P} = \frac{2200 \times 90}{480} = 412.5\,\text{Volts}$$

CAPACITORS

A capacitor or condenser is a passive electronic component consisting of a pair of conductors separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between the plates. The effect is greatest between wide, flat, parallel, narrowly separated conductors.

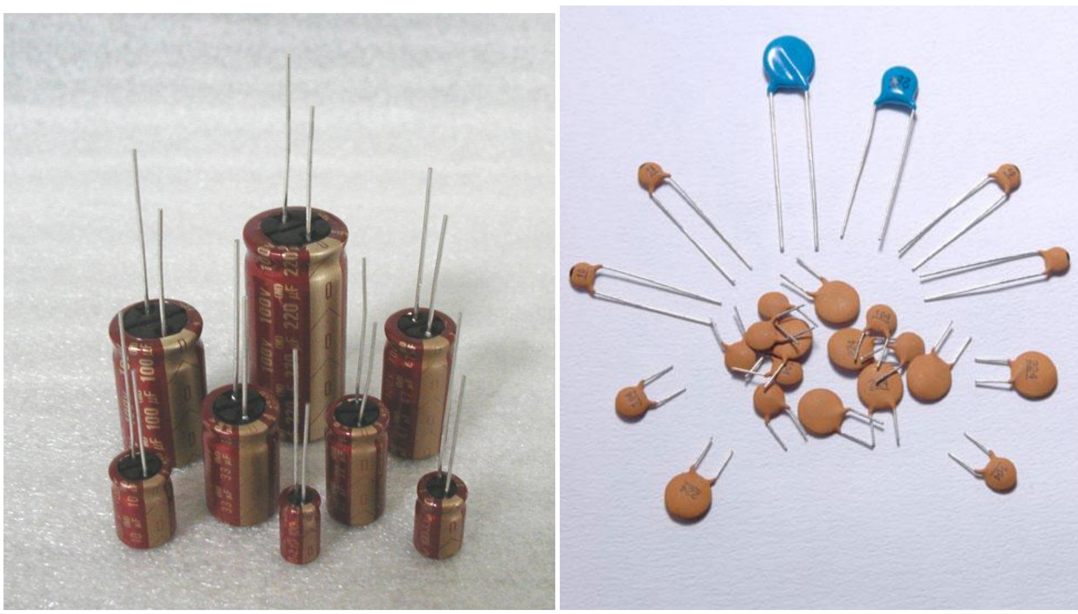


Fig 2.13

An ideal capacitor is characterized by a single constant value, capacitance, which is measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them. In practice, the dielectric between the plates passes a small amount of leakage current. The conductors and leads introduce an equivalent series resistance and the dielectric has an electric field strength limit resulting in a breakdown voltage.

The properties of capacitors in a circuit may determine the resonant frequency and quality factor of a resonant circuit, power dissipation and operating frequency in a digital logic circuit, energy capacity in a high-power system, and many other important aspects.

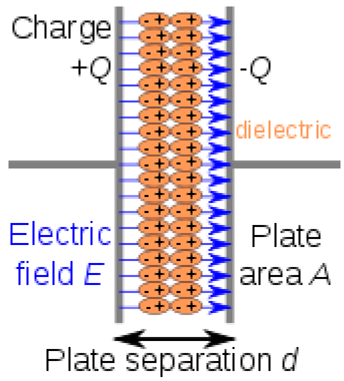
A capacitor (formerly known as condenser) is a device for storing electric charge. The forms of practical capacitors vary widely, but all contain at least two conductors separated by a non-conductor. Capacitors used as parts of electrical systems, for example, consist of metal foils separated by a layer of insulating film.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies and for many other purposes.

A capacitor is a passive electronic component consisting of a pair of conductors separated by a dielectric (insulator). When there is a potential difference (voltage) across the conductors, a static electric field develops in the dielectric that stores energy and produces a mechanical force between the conductors. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

The capacitance is greatest when there is a narrow separation between large areas of conductor, hence capacitor conductors are often called "plates", referring to an early means of construction. In practice the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, resulting in a breakdown voltage, while the conductors and leads introduce an undesired inductance and resistance.

Principle of operation



Charge separation in a parallel-plate capacitor causes an internal electric field. A dielectric (orange) reduces the field and increases the capacitance.

A capacitor consists of two conductors separated by a non-conductive region[8]. The non-conductive region is called the dielectric or sometimes the dielectric medium. In simpler terms, the dielectric is just an electrical insulator. Examples of dielectric mediums are glass, air, paper, vacuum, and even a semiconductor depletion region chemically identical to the conductors. A capacitor is assumed to be self-contained and isolated, with no net electric charge and no influence from any external electric field. The conductors thus hold equal and opposite charges on their facing surfaces,[9] and the dielectric develops an electric field. In SI units, a capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device.[10]

The capacitor is a reasonably general model for electric fields within electric circuits. An ideal capacitor is wholly characterized by a constant capacitance C, defined as the ratio of charge ±Q on each conductor to the voltage V between them:[8]

$$C = \frac{Q}{V}$$

Sometimes charge build-up affects the capacitor mechanically, causing its capacitance to vary. In this case, capacitance is defined in terms of incremental changes:

$$C = \frac{\mathrm{d}q}{\mathrm{d}v}$$

RESISTORS

A resistor is a two-terminal electronic component designed to oppose an electric current by producing a voltage drop between its terminals in proportion to the current, that is, in accordance with Ohm's law:

$$V = IR$$

Resistors are used as part of electrical networks and electronic circuits. They are extremely commonplace in most electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel/chrome).

Fig 2.14

The primary characteristics of resistors are their resistance and the power they can dissipate. Other characteristics include temperature coefficient, noise, and inductance. Less well-known is critical resistance, the value below which power dissipation limits the maximum permitted current flow, and above which the limit is applied voltage. Critical resistance depends upon the materials constituting the resistor as well as its physical dimensions; it's determined by design. Resistors can be integrated into hybrid and printed circuits, as well as integrated circuits. Size, and position of leads (or terminals) are relevant to equipment designers; resistors must be physically large enough not to overheat when dissipating their power.

A resistor is a two-terminal passive electronic component which implements electrical resistance as a circuit element. When a voltage V is applied across the terminals of a resistor, a current I will flow through the resistor in direct proportion to that voltage. The reciprocal of the constant of proportionality is known as the resistance R, since, with a given voltage V, a larger value of R further "resists" the flow of current I as given by Ohm's law:

$$I = \frac{V}{R}$$

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in most electronic equipment. Practical resistors can

be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits.

The electrical functionality of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than 9 orders of magnitude. When specifying that resistance in an electronic design, the required precision of the resistance may require attention to the manufacturing tolerance of the chosen resistor, according to its specific application. The temperature coefficient of the resistance may also be of concern in some precision applications. Practical resistors are also specified as having a maximum power rating which must exceed the anticipated power dissipation of that resistor in a particular circuit: this is mainly of concern in power electronics applications.

Resistors with higher power ratings are physically larger and may require heat sinking. In a high voltage circuit, attention must sometimes be paid to the rated maximum working voltage of the resistor.

The series inductance of a practical resistor causes its behaviour to depart from ohms law; this specification can be important in some high-frequency applications for smaller values of resistance. In a low-noise amplifier or pre-amp the noise characteristics of a resistor may be an issue. The unwanted inductance, excess noise, and temperature coefficient are mainly dependent on the technology used in manufacturing the resistor. They are not normally specified individually for a particular family of resistors manufactured using a particular technology.[1] A family of discrete resistors is also characterized according to its form factor, that is, the size of the device and position of its leads (or terminals) which is relevant in the practical manufacturing of circuits using them.

Units

The ohm (symbol: Ω) is the SI unit of electrical resistance, named after Georg Simon Ohm. An ohm is equivalent to a volt per ampere. Since resistors are specified and manufactured over a very large range of values, the derived units of milliohm (1 mΩ = 10^{-3} Ω), kilohm (1 kΩ = 10^{3} Ω), and megohm (1 MΩ = 10^{6} Ω) are also in common usage.

The reciprocal of resistance R is called conductance G = 1/R and is measured in Siemens (SI unit), sometimes referred to as a mho. Thus a Siemens is the reciprocal of an ohm: $S = \Omega^{-1}$. Although the concept of conductance is often used in circuit analysis, practical resistors are always specified in terms of their resistance (ohms) rather than conductance.

Principle of operation

Ohm's law

The behavior of an ideal resistor is dictated by the relationship specified in Ohm's law:

$$V = I \cdot R$$

Ohm's law states that the voltage (V) across a resistor is proportional to the current (I) passing through it, where the constant of proportionality is the resistance (R).

Equivalently, Ohm's law can be stated:

$$I = \frac{V}{R}$$

This formulation of Ohm's law states that, when a voltage (V) is present across a resistance (R), a current (I) will flow through the resistance. This is directly used in practical computations. For example, if a 300 ohm resistor is attached across the terminals of a 12 volt battery, then a current of 12 / 300 = 0.04 amperes (or 40 milliamperes) will flow through that resistor.

LM35

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ºC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With **LM35**, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 ºC temperature rise in still air.

The LM35 datasheet specifies that this ICs are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade)temperature.

The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centi-grade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4˚C at room temperature and ±3⁄4˚C over a full −55 to +150˚C temperature range.

The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ºC rise/fall in ambient temperature,*i.e.,* its scale factor is 0.01V/ ºC.

Pin Diagram:

Fig 2.15

Pin Description:

Pin No	Function	Name
1	Supply voltage; 5V (+35V to -2V)	Vcc
2	Output voltage (+6V to -1V)	Output
3	Ground (0V)	Ground

In this project, we will demonstrate how to build temperature sensor circuit using a LM35 sensor.

As a temperature sensor, the circuit will read the temperature of the surrounding environment and relay thi temperature to us back in degrees celsius.

The IC we will use to measure the temperature is the LM35 IC. We will integrate this with the PIC Micro controller to measure the temperature. The PIC will then read this measured value from the LM35 and translate into degrees Fahrenheit and celsius. The LM35 is a low voltage IC which uses approximately +5VDC of power. This is ideal because the pic microcontroller power pin gives out 5V of power. The IC has just 3 pins, 2 for the power supply and one for the analog output. The output pin provides an analog voltage output that is linearly proportional to the Celsius (centigrade) temperature. Pin 2 gives an output of 1 millivolt per 0.1°C (10mV per degree). So to get the degree value in celsius, all that must be done is to take the voltage output and divide it by 10- this give out the value degrees in celsius.So, for example, if the output pin, pin 2, gives out a value of 315mV (0.315V), this is equivalent to a temperature of 31.5°C.We can then easily convert this celsius value into Fahrenheit by plugging in the appropriate conversion equation. All we must do is write this code and upload it to the arduino to convert this celsius temperature into Fahrenheit. The code is shown below. Pin 1 receives positive DC voltage in order for the IC to work. This, again, is voltage approximately 5 volts. Pin 3 is the ground, so it receives the ground or negative terminal of the DC power supply. And Pin 2 is the output of the IC, outputting an analog voltage in proportion to the temperature it measures .The arduino, with suitable code, can then interpret this measured analog voltage and output to us the temperature in degrees celsius and Fahrenheit.

LM35 Features

- Calibrated directly in ^{o} Celsius (Centigrade)
- Linear + 10.0 mV/^{o}C scale factor
- 0.5^{o}C accuracy guaranteeable (at +25^{o}C)
- Rated for full −55^{o} to +150^{o}C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08^{o}C in still air
- Nonlinearity only ±1⁄4^{o}C typical
- Low impedance output, 0.1 Ω for 1 mA load

Potentiometer

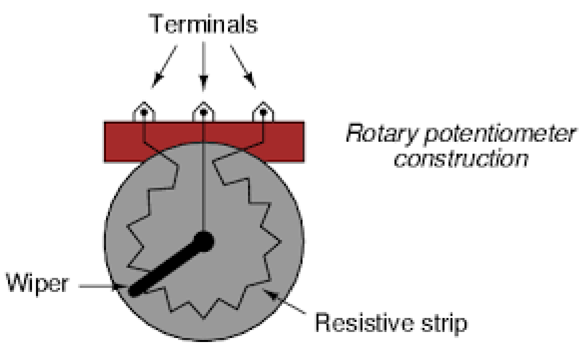
Potentiometer is a small sized electronic component whose resistance can be adjusted manually. Increasing or decreasing the value of resistance controls the amount of current flowing in a circuit. The potentiometer is used in various electronics, for example: is used as volume knob in music systems, as fan regulators etc. Potentiometer has two strips made on it resistive and conductive.

Resistive strip is made of carbon and is responsible for potentiometer's resistance variance feature. Conductive strip helps the potentiometer to carry the current into the circuit in accordance with the resistance. To understand the theory of our humble potentiometers (or pots), let us know the **parts of the potentiometer:**

· Lugs**:** Potentiometers by convention have three lugs

Resistive Strip: This is the heart of the potentiometer. It is a carbon strip that is printed on a phenolic strip. There are metal contacts in the end to connect it to the lugs.

Metal Wiper: When we rotate the shaft, it in turn rotates a metallic wiper which connects the lug 1 and lug2.



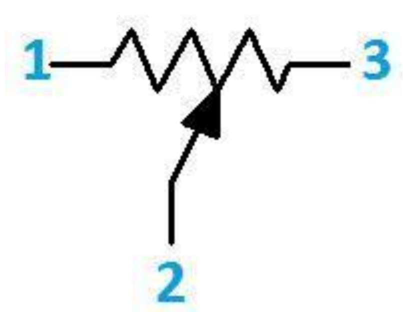


Fig 2.16

Working of Potentiometers

The metallic wiper acts as a conducting path between the lug 1 and lug 2. So the resistance between the left lug and the centre lug is the resistance of the part of
carbon strip over which the metallic wiper has traversed. When we rotate the shaft of the potentiometer, we actually rotate the metallic wiper attached to it and hence change the resistance. This way the pot acts as a variable resistance

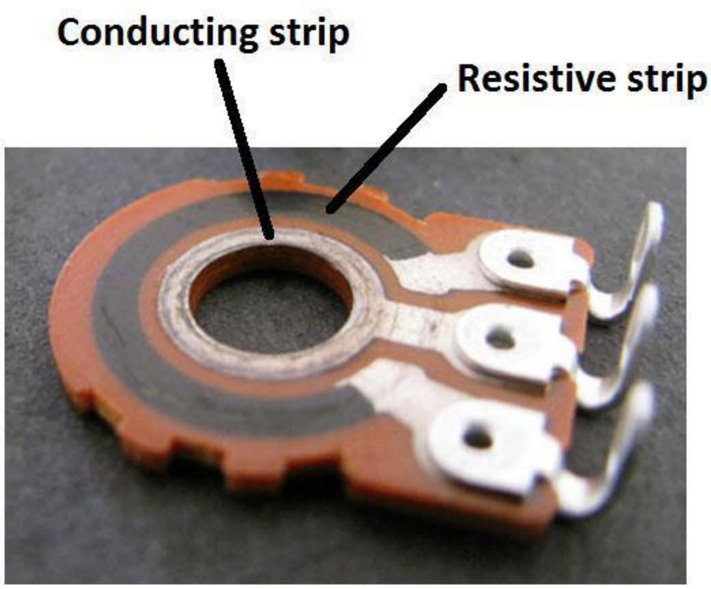


Fig 2.17

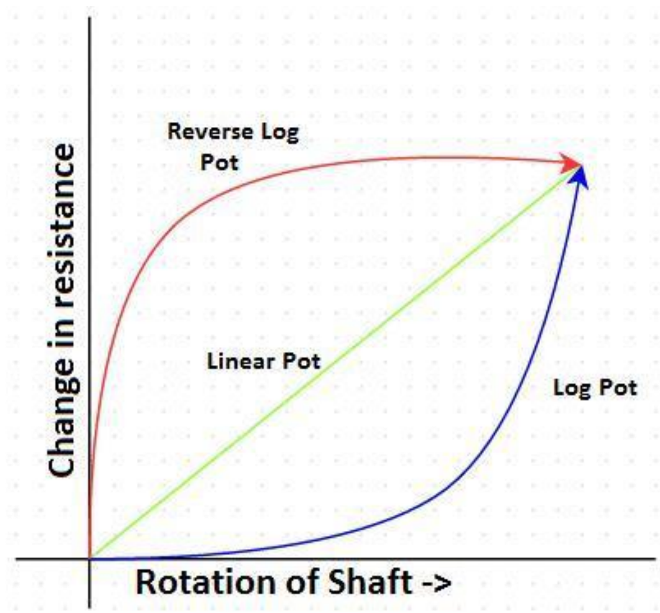
Taper

The relation between the position of wiper and the resistance is called the taper of the potentiometer. In other words taper decides how the resistance will vary when we turn the pot. Taper divides potentiometers broadly into two types:

Linear Pots: In these pots, the resistance between lug 1 and lug 2 is directly proportional to the distance moved by the wiper. These are the common pots found in labs and are inexpensive.

Logarithmic Pots: In these pots, the resistance between lug1 and lug 2 is a logarithmic function of the wiper position. Actually their taper graph looks more like a 10^x graph. They are expensive and not readily available. Also there are reverse logarithmic pots which are similar to logarithmic pots, which have a taper opposite to that of log pots. More about logarithmic pots in the next section.

How to check the taper with an ohm meter? Set the pot to the centre position (50% rotation) and measure the resistance between the centre pin and each of the outer pins. If the resistance is equal (50% of the pots value) the pot is linear. If the values are not equal, the pot is an log taper.

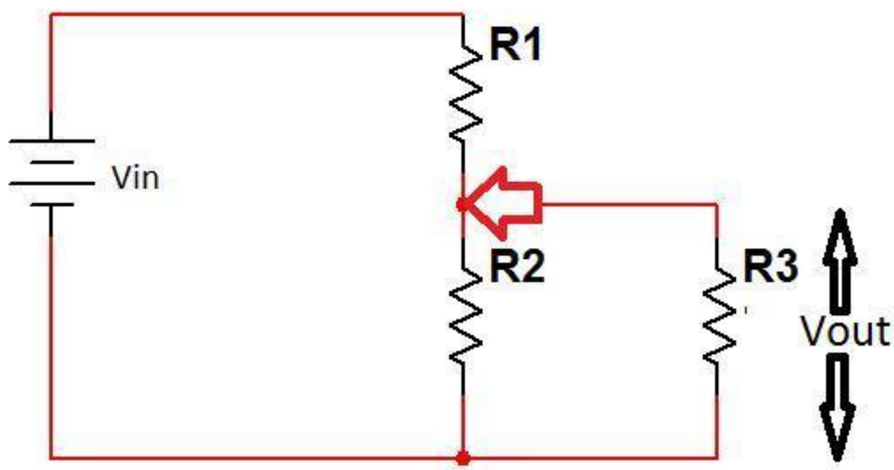


Logarithmic Pots

These pots are extensively used in audio electronics and hence are also called audio pots. The reason for their wide use in audio electronics especially in volume control owes to the perception of loudness by human ears. If two sources produce sound, then the human ear will perceive one source twice as loud as the other only if the intensity of sound of one source is ten times the other. So by using audio pots we are able to achieve perceivable change in loudness by slight turning of the pot. If a linear pot is used instead, we will notice that loudness changes only when the pot is turned to its full extent.

How logarithmic tapering is achieved? Well to answer this, we need to go back to the heart of the potentiometer, the resistive strip. One way to achieve log taper is to change the width of the cross section of the resistive strip. For cheaper log pots, the cross section width remains same but two or three resistive materials of different resistivity are used to approximate a log taper.

How to make a linear pot behave like a logarithmic pot? Log pots are expensive and tough to find. One idea is to make a circuit whose transfer function is *not exactly but similar* to logarithmic function. One such circuit is as follows:

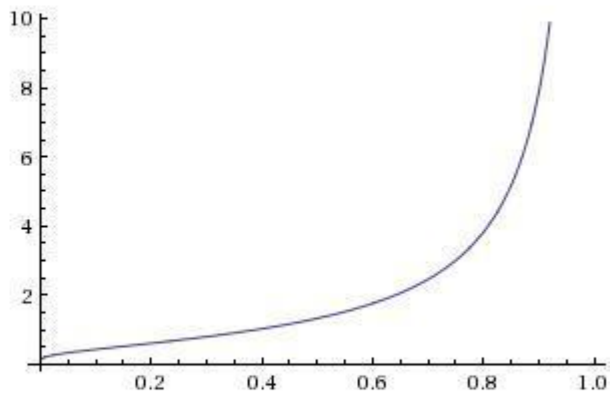


Let the total resistance of the pot be R, R1 be the resistance between lug 3 and lug 1 and R2 be the resistance between lug 1 and lug 2. R3 is a resistance put in parallel to R2. We define x=R2/R (the fraction of resitance swept by the wiper) and y=R3/R.

The relation between input voltage Vin and output voltage across R3 come out to be

$$\frac{Vout}{Vin} = \frac{1}{\frac{1}{x} + \frac{1-x}{y}}$$

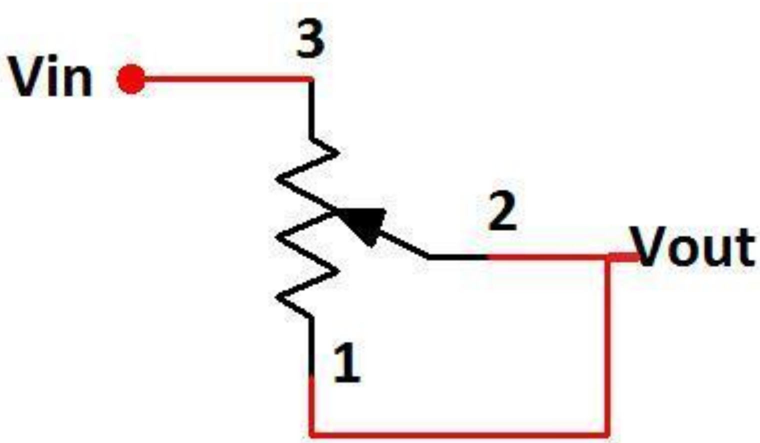
Below is the graph of Vin/Vout when y=4 and x is varied between 0 to 1 which looks similar to a log graph (isn't it?)



The only catch here is that using the above circuit in place of a log pot will reduce the input resistance that the source voltage will see. So some amount of experimentation should be done to choose the value of y. Similarly, **reverse log pots** can be emulated using linear pot by simply putting R3 resistance across R1 and taking the output voltage across R2.

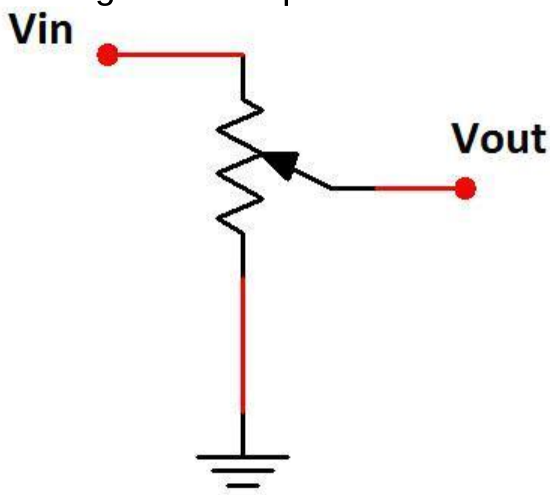
Ways to Connect Pot

Trimmer resistance: Connecting pot as shown in the figure way makes it behave like a variable resistance. When you turn the shaft you are basically reducing the resistance.



It is advisable to short lug 1 and lug 2 because if the wiper shorts then there is resistance which will prevent the full signal to pass to Vout.

Voltage Divider: This is generally used to control the amount of input signal passing to the output.



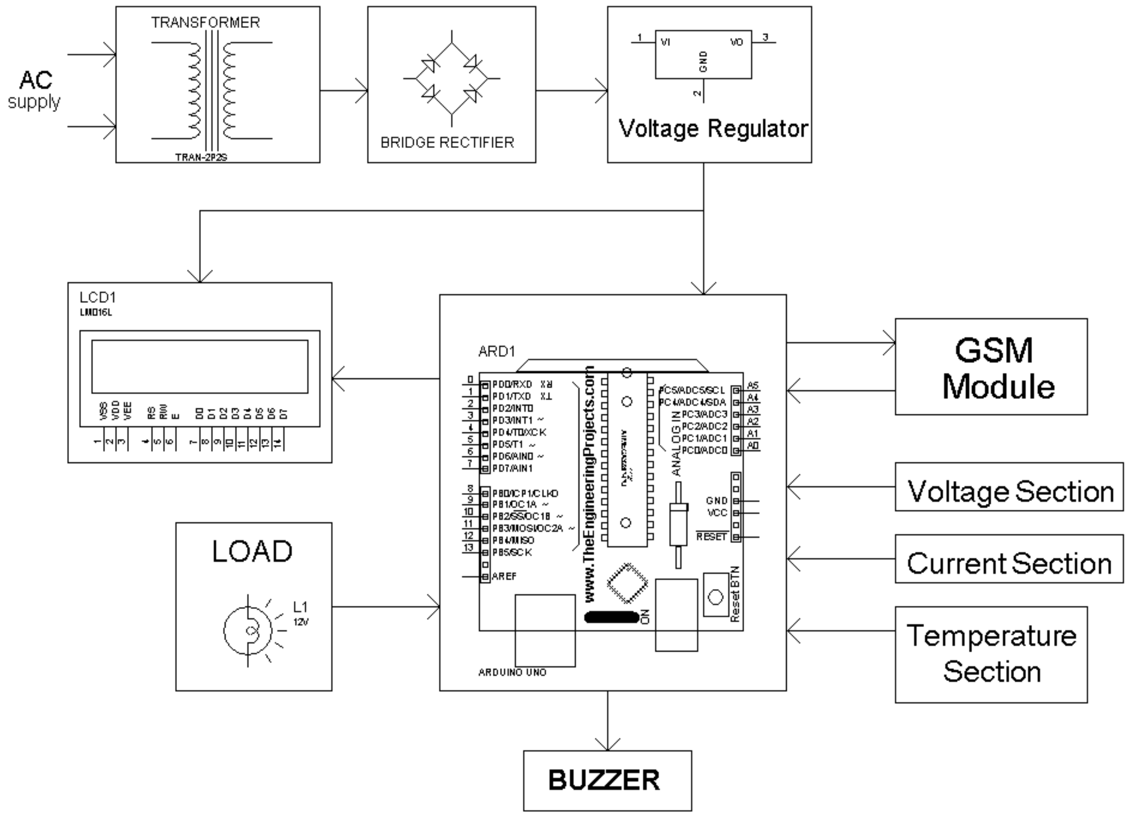
CHAPTER – 3

CHAPTER – 3

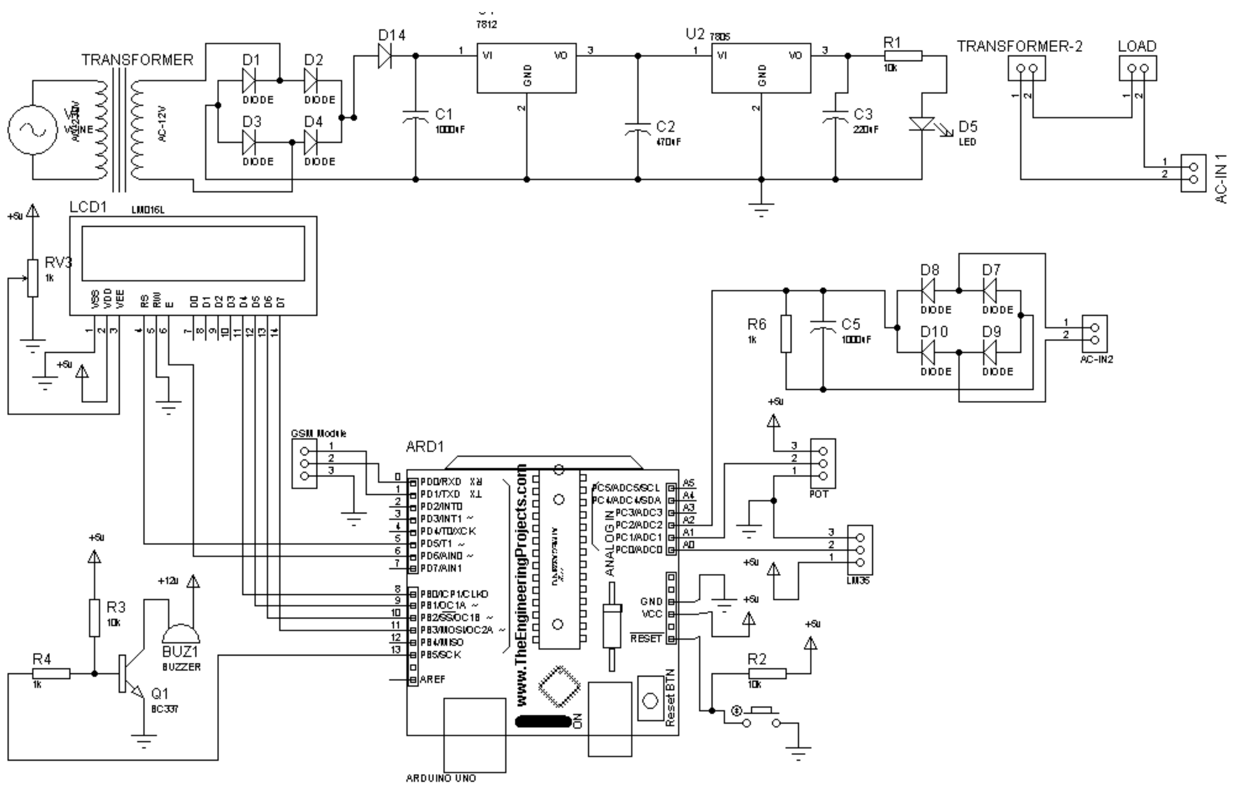
WORKING PROCEDURE

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 condition sat the substations, the risk of blackouts, brownouts and fire are rapidly increasing. Substations consist of different the controller consists of a sensing unit which collects the essential parameters such as current, voltage and the oil temperature within the distribution transformer. The digital display connected to the processing unit displays corresponding parameter values at the substation for any technical operations. The controller also senses the over load and high current flow conditions in the internal windings that may lead to breakdown of the corresponding unit. The Arduino controller is programmed in such a manner so as to continuously scan the transformer and update the parameters at a particular time interval. The parameter values sensed by the Arduino-controller are transmitted through the ADC transmitter connected to the Arduino controller unit. Temperature sensor is interfaced with the arduino to monitor the temperature of oil of transformer. The maximum values of oil are fed in arduino. If the oil temperature exceeds the safer value then the alarm is activated to alert the authorities. To display all this parameters LCD is used which is interfaced with the arduino

BLOCK DIAGRAM



CIRCUIT DIAGRAM



Our work includes the process of monitoring the transformer performance in which the over voltage, over current, winding temperature is measured and it is compared with the nominal value in the comparator. If the measured value exceeds or decreases, the system will send an error alert to the concern person.

Case No.1- Voltage level

When device detects low voltage or high voltage(set values), it will send the message to set number that “Transformer no.--- Low/High Voltage Occur”, also it will trigger circuit breaker for cut off supply.

Case No. 2- Over Load

When device detects current flowing through system high then it assumed that system is overloaded. After detect overloading device send message “Transformer No. --- Overload Occur”, and will break system through line by opening circuit breaker.

Case No.3- Temperature Raise

Ambient temperature of Transformer is high or it will be increase it sense through the sensor LM-35 and gives message through GSM by mobile we can notify.

Temperature analysis

S.No	Temperature level	Load(on/off) condition
1	-10°C <t<45°C	On condition
2	-10°C >t>45°C	Off condition

Current analysis

S.No	Current level	Load(on/off) condition
1	Less than 1amps	Off condition
2	More than 1amps	On condition

Voltage analysis

S.No	Voltage level	Load(on/off)condition
1	Less than 230volt	On condition
2	More than 230volt	Off condition

HARDWARE WORKING MODEL:

Fig.3.1

PROGRAM:

```
/*
  Analog input, analog output, serial output

 Reads an analog input pin, maps the result to a range from 0 to 255
 and uses the result to set the pulsewidth modulation (PWM) of an output pin.
 Also prints the results to the serial monitor.

 The circuit:
 * potentiometer connected to analog pin 0.
   Center pin of the potentiometer goes to the analog pin.
   side pins of the potentiometer go to +5V and ground
 * LED connected from digital pin 9 to ground

 created 29 Dec. 2008
 modified 9 Apr 2012
 by Tom Igoe

 This example code is in the public domain.

 */

// These constants won't change.  They're used to give names
```

```
// to the pins used:
#defineTempPin A0
#include<LiquidCrystal.h>

int TempValue;

const int buzzer=13;
LiquidCrystallcd(5,6,8,9,10,11);




const int analog1InPin = A1;

const int analog2InPin = A2;
//Analog input pin that the potentiometer is attached to
// Analog output pin that the LED is attached to

int sensorValue1 = 0;


int sensorValue2 = 0;// value read from the pot        // value output to the PWM
(analog out)
float s1=0;
float s2=0,w;
```

```
int x;
int ot,ov,uv,oc;




void setup() {
  // initialize serial communications at 9600 bps:
Serial.begin(9600);
pinMode(buzzer,OUTPUT);
lcd.begin(16,2);



}
 void sendsms(int x)
{
Serial.print("AT\r");
delay(1000);
Serial.print("AT+CMGF=1\r");
delay(1000);
Serial.print("AT+CMGS=\"+917507545146\"\r");    //Phone number you want to
send the sms
delay(1000);
  if(x==1)
  {
Serial.print("OVER TEMPERATURE \r");   //Text message you want to send
```

```
delay(1000);
  }
   else if(x==2)
  {
Serial.print("OVER VOLTAGE \r");   //Text message you want to send
delay(1000);
  }
   else if(x==3)
  {
Serial.print("UNDER VOLTAGE \r");   //Text message you want to send
delay(1000);
  }
  else if(x==4)
  {
Serial.print("OVER CURRENT \r");   //Text message you want to send
delay(1000);
  }
Serial.write(0x1A); //sends ctrl+z end of message
delay(1000);
}


void loop() {
```

```
 //Serial.print("TEMPRATURE in Celsius = "); //Displaying temperature in Celsius
 //Serial.print(TempCel);
 //Serial.print("*C");

 //Serial.print("current = ");
 //Serial.println(s2);



while(1)
  {
   int T=0;
TempValue = analogRead(TempPin); // Getting LM35 value and saving it in variable
 float TempCel = ( TempValue/1024.0)*500; // Getting the celsius value from 10 bit analog value

lcd.setCursor(0,0);
lcd.print("T=");
lcd.print(TempCel);
  sensorValue1 = analogRead(A1);
 s1=sensorValue1/17.47572815;
  s1=s1*54.36;
```

```
lcd.setCursor(9,0);
lcd.print("V=");
lcd.print(s1);
   sensorValue2 = analogRead(A2);
   s2=sensorValue2/51.75;
lcd.setCursor(0,1);
lcd.print("C=");
lcd.print(s2);
if(TempCel>=35.00)
  {
    if(ot==0)
    {
sendsms(1);
ot=1;
    }

lcd.setCursor(8,1);
lcd.print("OT");


  T=1;
  }
   else
  {

lcd.setCursor(8,1);
```

```
lcd.print("NT");
ot=0;
}

delay(1000);



  // read the analog in value:

 //Serial.print("sensor1 = ");
  //Serial.println(sensorValue1);

  //Serial.println("voltage = ");
Serial.println(s1) ;
   if(s1>=250)
  {
    if(ov==0)
    {
sendsms(2);
ov=1;
    }

lcd.setCursor(11,1);
lcd.print("OV");
  T=1;
```

```
 }

 else if(s1<=180)
 {
   if(uv==0)
   {
sendsms(3);
uv=1;
   }

lcd.setCursor(11,1);
lcd.print("UV");

   T=1;
 }
  else
 {
lcd.setCursor(11,1);
lcd.print("NV");
ov=0;
uv=0;
 }

delay(1000);
```

```
  //Serial.print("sensor2 = ");
  //Serial.println(sensorValue2);



  if(s2>=1)
  {

    if(oc==0)
    {
sendsms(4);
oc=1;
    }

lcd.setCursor(14,1);
lcd.print("OC");

  T=1;
  }
   else
  {

lcd.setCursor(14,1);
lcd.print("NC");
oc=0;
```

```
}



  //w=s2*230;

  //Serial.print("current = = ");
  //Serial.println(w);


  // wait 2 milliseconds before the next loop
  // for the analog-to-digital converter to settle
  // after the last reading:
  if(T==1)
{
digitalWrite(buzzer,HIGH);
}
else
{
digitalWrite(buzzer,LOW);


}
   }
}
```

CHAPTER -4

CHAPTER – 4

APPLICATIONS AND ADVANTAGES

4.1 ADVANTAGES:

- Transformer Protection.
- Automatic Detection.
- Transformer Health Monitoring will help to identify or recognize unexpected situations before any serious failure which leads to greater reliability and significant cost savings.
- If transformer is in abnormal condition we can know from anywhere. No human power need to monitor the transformer

4.2 APPLICATIONS:

- Distribution transformer monitoring
- Smart Grid
- Power Transformer Monitoring

4.3 FUTURE WORK:

In future work we can develop database of all parameters of distribution transformer which are placed at different places. We can get all information by placing the proposed system modules at every transformer. We can send the data through Wi-Fi module and also through Ethernet shield. With Ethernet shield we can make remote terminal unit as a server and store data on webpage or website. A Wi-Fi module connects to nearby network and sends information to
monitoring node.

4.4 CONCLUSION:

The proposed technique with results has shown that the protection scheme works properly with accuracy, sensitivity of this scheme very high for the abnormal and faulty conditions. Transformer Health Monitoring will help to identify or recognize unexpected situations before any serious failure which leads to greater reliability and significant cost savings. If transformer is in abnormal condition, we can know from anywhere. No human power need to monitor the transformer. Details about the transformer are automatically updated in webpage when the transformer is in Abnormal condition.

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