SMART SCHOOL BUS :Ensuring Safety of School Children using Raspberry Pi

ABSTRACT

The bus arrival time is primary information to most city transport travelers. Excessively long waiting time at bus stops often discourages the travelers and makes them reluctant to take buses. In this paper, we present a Smart School Bus Ensuring Safety of School Children using Raspberrypi.With commodity mobile phones, the bus surrounding environmental context is effectively collected and utilized to estimate the bus Safety and predict bus location at various bus stops. The proposed system solely relies on the collaborative effort of the Students,so it can be easily adopted to support universal bus service systems without requesting support from particular bus operating companies. Instead of referring to GPS-enabled location information.

CHAPTER-1

1.1 INTRODUCTION

Bus service is the most important function of public transportation. Besides the major goal of carrying passengers around, providing a comfortable travel experience for passengers is also a key business consideration. To provide a comfortable travel experience, effective bus scheduling is essential. Traditional approaches are based on fixed timetables. The wide adoptions of smart card fare collection systems and GPS tracing systems in public transportation provide new opportunities for using the data-driven approaches to fit the demand of passengers.

Buses are the most widely used public transportation in many cities today.To improve the quality of bus service,a real-time system that can monitor and predict the Passenger Flow of the running buses is helpful. Here, Student Safety is implemented and reflect the collective human mobility along a route and the quality of bus service in term of comfort.

1.2 EXISTING SYSTEM:

In the Existing System,there is no Smart System implemented all are done manually due to Carefulness accidents may occur the Sensing Technologies was also not implemented.

1.2.1 DISADVANTAGES:

- More complex.
- Less accuracy
- Accidents may Occur.

1.3 PROPOSED SYSTEM:

RFID Technology is implemented for Students Safety the Message will be Send to Parents for that Two RFID Cards to be used one is Van and the Another one is School when they Reach ,the SMS will be Send through GSM based on the two Cards.Then Panic Switch is used for Emergency by Pressing the SMS will be Send to Parrents with Location with the help of GPS. Camera is used for View the Students in the Bus for Drivers View.

MEMS Sensor is used for high tempered movement in the Vehile if it goes abnormal the SMS will be Send with Location.Then Hall Effect Sensor is used to find the RPM of the Motor.

1.3.1 ADVANTAGES:

- Safety
- Reduction in expenditure

1.3.2 APPLICATIONS:

- College/Schools
- Hospitals Ambulance

CHAPTER-2

2.1. BLOCK DIAGRAM – MAIN SECTION:

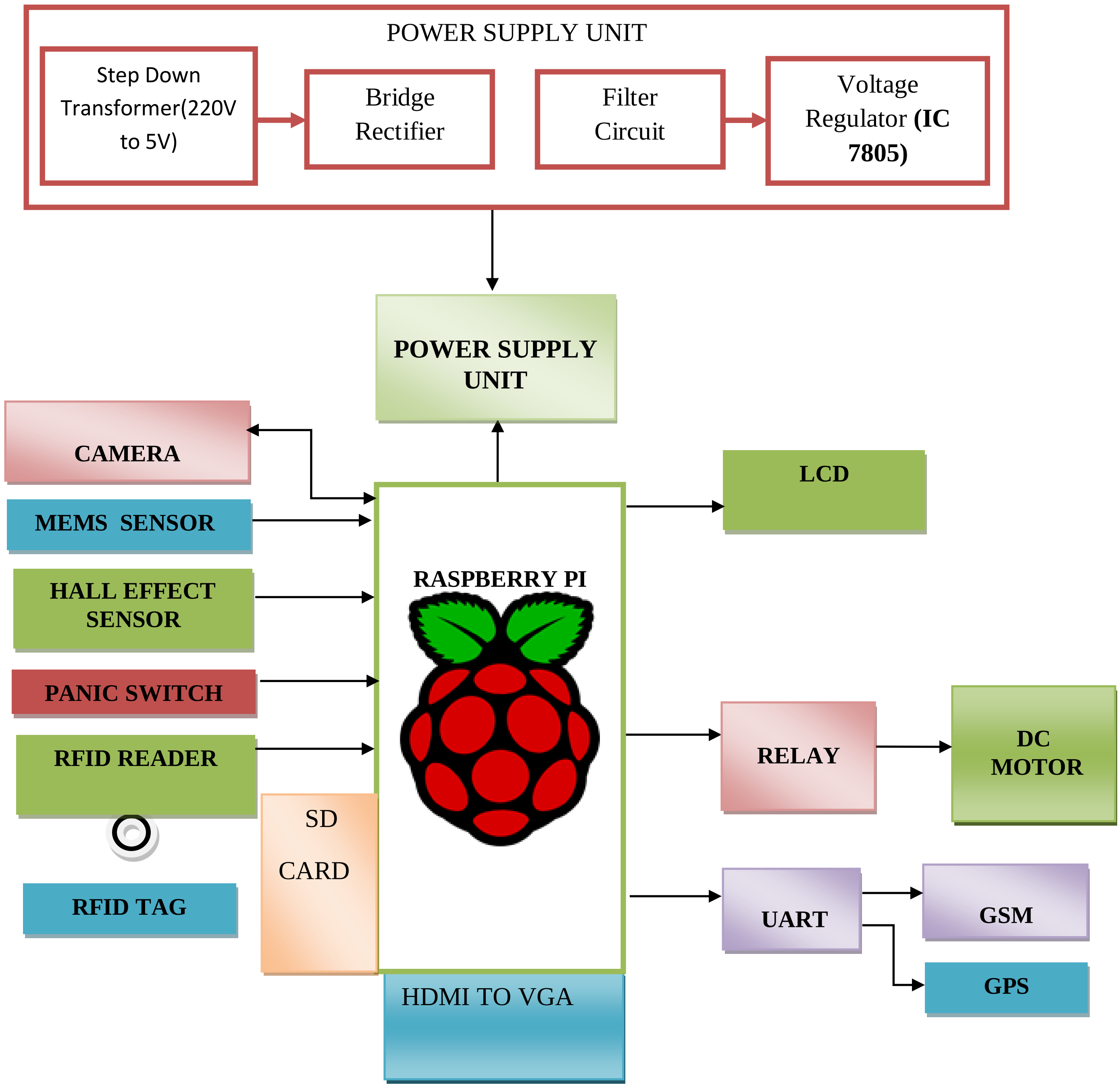


Fig 2.2.1 Proposed System - Hardware unit

2.3 HARDWARE REQUIREMENTS

- RASPBERRY PI
- PC MONITOR
- HDMI to VGA CABLE
- POWER SUPPLY UNIT
- CAMERA
- RELAY
- MEMS Sensor
- GPS
- GSM
- DC MOTOR
- RFID Reader
- Toggle Switch
- LCD 16x2 Display

2.4 SOFTWARE REQUIREMENTS:

- RASPBIAN OS
- PYTHON LANGUAGE
- OpenCV Package.

CHAPTER-3

MODULE DESCRIPTION

HARDWARE REQUIREMENTS

3.1 POWER SUPPLY UNIT:

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

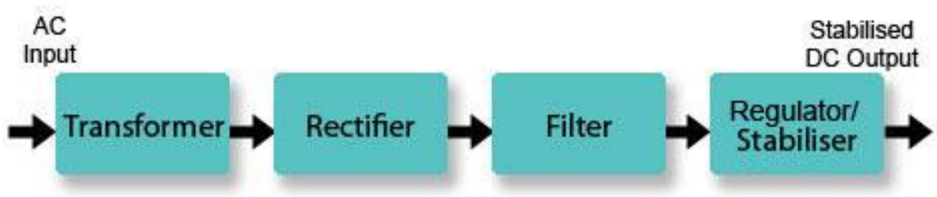


Fig 3.1.1 Power Supply unit

3.1.1STEP DOWN TRANSFORMER

Basic power supply the input power transformer has its primary winding connected to the mains (line) supply. A secondary winding, electro-magnetically coupled but electrically isolated from the primary is used to obtain an AC voltage of suitable amplitude, and after further processing by the PSU, to drive the electronics circuit it is to supply.

The transformer stage must be able to supply the current needed. If too small a transformer is used, it is likely that the power supply's ability to maintain full output voltage at full output current will be impaired. With too small a transformer, the losses will increase dramatically as full load is placed on the transformer.

As the transformer is likely to be the most costly item in the power supply unit, careful consideration must be given to balancing cost with likely current requirement. There may also be a need for safety devices such as thermal fuses to disconnect the transformer if overheating occurs, and electrical isolation between primary and secondary windings, for electrical safety.

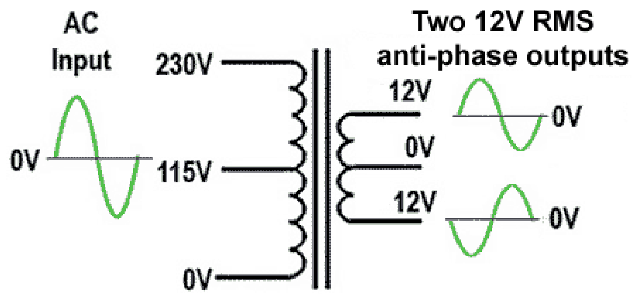


Fig 3.1.1.1 Step down Transformer

3.1.2 THE RECTIFIER STAGE

Rectifier circuit is used; to convert the AC input is converted to DC. The full wave bridge rectifier uses four diodes arranged in a bridge circuit to give full wave rectification without the need for a centre-tapped transformer. An additional advantage is that, as two diodes are conducting at any one time, the diodes need only half the reverse breakdown voltage capability of diodes used for half and conventional full wave rectification. The bridge rectifier can be built from separate diodes or a combined bridge rectifier can be used.

It can be seen that on each half cycle, opposite pairs of diodes conduct, but the current through the load remains in the same polarity for both half cycles.

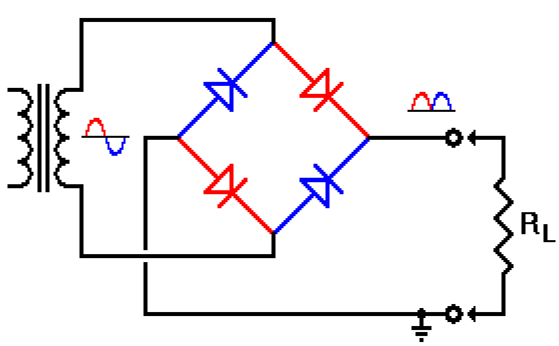


Fig 3.1.1.2 Bridge Rectifier

3.1.3 FILTER:

A typical power supply filter circuit can be best understood by dividing the circuit into two parts, the reservoir capacitor and the low pass filter. Each of these parts contributes to removing the remaining AC pulses, but in different ways.

Electrolytic capacitor used as a reservoir capacitor, so called because it acts as a temporary storage for the power supply output current. The rectifier diode supplies current to charge a reservoir capacitor on each cycle of the input wave. The reservoir capacitor is large electrolytic, usually of several hundred or even a thousand or more microfarads, especially in mains frequency PSUs. This very large value of capacitance is required because the reservoir capacitor, when charged, must provide enough DC to maintain a steady PSU output in the absence of an input current; i.e. during the gaps between the positive half cycles when the rectifier is not conducting.

Once the input wave passes Vpk the rectifier anode falls below the capacitor voltage, the rectifier becomes reverse biased and conduction stops. The load circuit is now supplied by the reservoir capacitor alone.

Of course, even though the reservoir capacitor has large value, it discharges as it supplies the load, and its voltage falls, but not by very much. At some point during the next cycle of the mains input, the rectifier input voltage rises above the voltage on the partly discharged capacitor and the reservoir is re-charged to the peak value Vpk again.

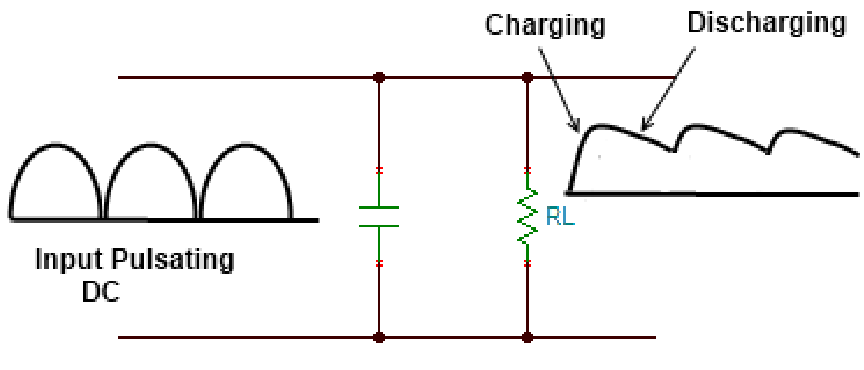


Fig 3.1.1.3 Filter Circuit

3.1.4 VOLTAGE REGULATOR

Voltage regulator ICs are available with fixed or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current and overheating.

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, Hi-Fi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and current.

1. Positive regulator
    1. Input pin
    2. Ground pin
    3. Output pin

2. It regulates the positive voltage
3. Negative regulator
4. Ground pin
5. Input pin
6. Output pin

It regulates the negative voltage. The regulated DC output is very smooth with no ripple. It is suitable for all electronic circuits.

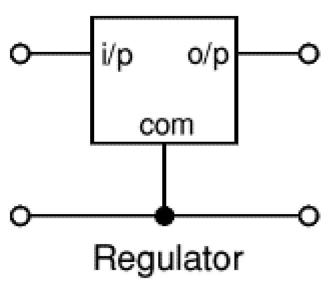


Fig 3.1.1.4 Regulator Circuit

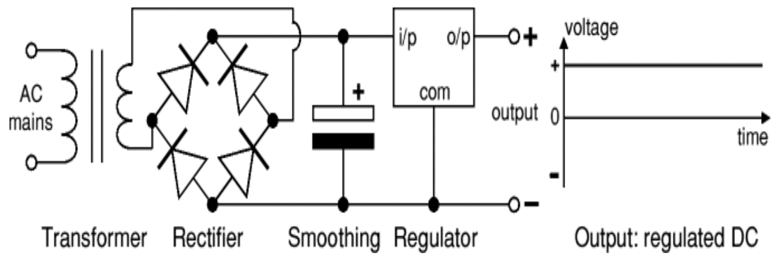


Fig 3.1.1.5 Power Supply Circuit

3.2 RASPBERRY PI

The Raspberry pi is a single computer board with credit card size, that can be used for many tasks that your computer does, like games, word processing, spreadsheets and also to play HD video. It was established by the Raspberry pi foundation from the UK. It has been ready for public consumption since 2012 with the idea of making a low-cost educational microcomputer for students and children. The main purpose of designing the raspberry pi board is, to encourage learning, experimentation and innovation for school level students. The raspberry pi board is a portable and low cost. Maximum of the raspberry pi computers is used in mobile phones. In the 2st century, the growth of mobile computing technologies is very high, a huge segment of this being driven by the mobile industries. The 98% of the mobile phones were using ARM technology.

The raspberry pi comes in two models , they are model A and model B. The main difference between model A and model B is USB port. Model board will consume less power and that does not include an Ethernet port. But, the model B board includes an Ethernet port and designed in china.

RASPBERRY PI HARDWARE SPECIFICATIONS

The raspberry pi comes with a set of open source technologies, i.e. communication and multimedia web technologies. In the year 2014, the foundation of the raspberry pi board launched the computer module that packages a model B raspberry pi board into module for use as a part of embedded systems, to encourage their use.

MEMORY

The raspberry pi model aboard is designed with 256MB of SDRAM and model B is designed with 51MB.Raspberry pi is a small size PC compare with other PCs. The normal PCs RAM memory is available in gigabytes. But in raspberry pi board, the RAM memory is available more than 256MB or 512MB

CPU (CENTRAL PROCESSING UNIT)

The Central processing unit is the brain of the raspberry pi board and that is responsible for carrying out the instructions of the computer through logical and mathematical operations. The raspberry pi uses ARM11 series processor, which has joined the ranks of the Samsung galaxy phone.

GPU (GRAPHICS PROCESSING UNIT)

The GPU is a specialized chip in the raspberry pi board and that is designed to speed up the operation of image calculations. This board designed with a Broadcom video core IV and it supports OpenGL

ETHERNET PORT

The Ethernet port of the raspberry pi is the main gateway for communicating with additional devices. The raspberry pi Ethernet port is used to plug your home router to access the internet.

GPIO PINS

The general purpose input & output pins are used in the raspberry pi to associate with the other electronic boards. These pins can accept input & output commands based on programming raspberry pi. The raspberry pi affords digital GPIO pins. These pins are used to connect other electronic components. For example, you can connect it to the temperature sensor to transmit digital data.

XBEE SOCKET

The XBee socket is used in raspberry pi board for the wireless communication purpose.

POWER SOURCE CONNECTOR

The power source cable is a small switch, which is placed on side of the shield. The main purpose of the power source connector is to enable an external power source.

UART

The Universal Asynchronous Receiver/ Transmitter is a serial input & output port. That can be used to transfer the serial data in the form of text and it is useful for converting the debugging code.

DISPLAY

The connection options of the raspberry pi board are two types such as HDMI and Composite. Many LCD and HD TV monitors can be attached using an HDMI male cable and with a low-cost adaptor. The versions of HDMI are 1.3 and 1.4 are supported and 1.4 version cable is recommended.

The O/Ps of the Raspberry Pi audio and video through HMDI, but does not support HDMI I/p. Older TVs can be connected using composite video. When using a composite video connection, audio is available from the 3.5mm jack socket and can be sent to your TV. To send audio to your TV, you need a cable which adjusts from 3.5mm to double RCA connectors.

SOME USES FOR THE RASPBERRY PI

Enthusiasts around the world use the Pi for far more than its original purpose. Media centre software exists as a version of XBMC, and there are several Linux distributions that can be installed.

Retro gaming is possible (modern titles since around 2000 require far greater hardware resources) as is multimedia playback; remarkably the Pi is capable of HD video. You might also use the device as a web server, NAS controller, home security computer… the possibilities are endless!

SPECIFICATION

- 256 MB SDRAM memory
- Single 2.0 USB connector
- Dual Core Video Core IV Multimedia coprocessor
- HDMI (rev 1.3 & 1.4) Composite RCA (PAL and NTSC) Video Out
- 3.5 MM Jack, HDMI, Audio Out
- SD, MMC, SDIO Card slot on board storage
- Linux Operating system
- Broadcom BCM2835 SoC full HD multimedia processor
- 8.6cm*5.4cm*1.5cm dimensions

MODEL B RASPBERRY PI BOARD

The Raspberry Pi is a Broadcom BCM2835 System on Chip board. It comes equipped with a 700 MHz, 512 MB of SDRAM and ARM1176JZF-S core CPU. The USB 2.0 port of the raspberry pi boars uses only external data connectivity options.

The Ethernet in the raspberry pi is the main gateway to interconnect with other devices and the internet in model B. This draws its power from a micro USB adapter, with a minimum range of 2.5 watts (500 MA). The graphics, specialized chip is designed to speed up the manipulation of image calculations. This is in built with Broadcom video core IV cable that is useful if you want to run a game and video through your raspberry pi.

STORAGE

One of the most important elements of any computer is the storage, from where the operating system is run and data stored. The Pi doesn't have a hard disk drive – instead, it is equipped with a SD card reader.

FEATURES OF RASPBERRY PI MODEL B

- 512 MB SDRAM memory
- Broadcom BCM2835 SOC full high definition multimedia processor
- Dual Core Video Core IV Multimedia coprocessor
- Single 2.0 USB connector
- HDMI (rev 1.3 and 1.4) Composite RCA (PAL & NTSC) Video Out
- 3.5 MM Jack, HDMI Audio Out
- MMC, SD, SDIO Card slot on board storage
- Linux Operating system
- On board 10/100 Ethernet RJ45 jack

APPLICATIONS OF RASPBERRY PI

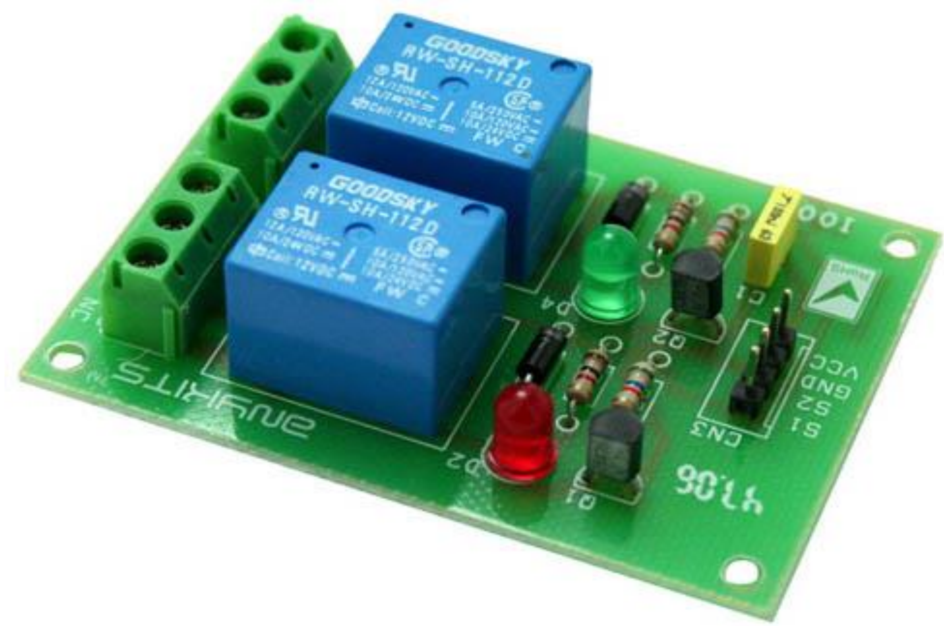
The raspberry pi boards are used in many applications like

- Media streamer
- Arcade machine

- Tablet computer
- Home automation
- Internet radio
- Controlling robots
- Cosmic Computer
- Hunting for meteorites

3.3 RELAY

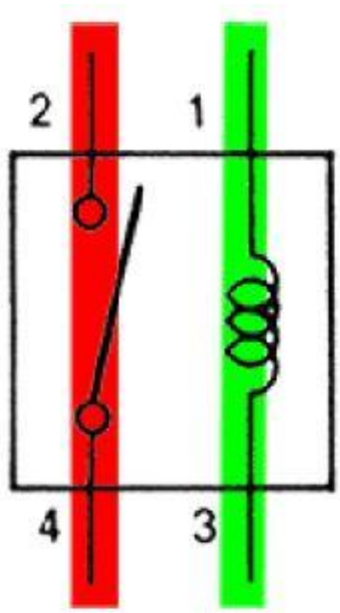
We know that most of the high end industrial application devices have relays for their effective working. Relays are simple switches which are operated both electrically and mechanically. Relays consist of a n electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its working. But they differ according to their applications. Most of the devices have the application of relays.



The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The application of relays started during the invention of telephones. They played an important role in switching calls in telephone exchanges. They were also used in long distance telegraphy. They were used to switch the signal coming from one source to another destination. After the invention of computers they were also used to perform Boolean and other logical operations. The high end applications of relays require high power to be driven by electric motors and so on. Such relays are called contactors.

RELAY BASICS

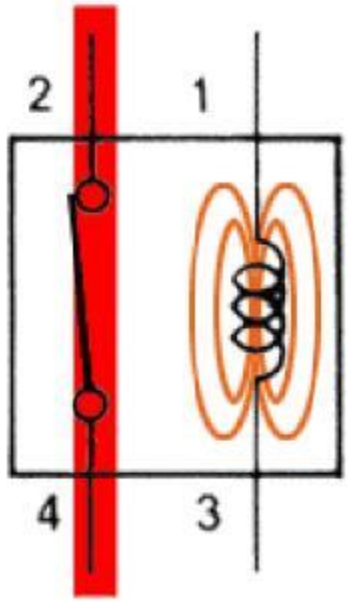
The basics for all the relays are the same. Take a look at a 4 – pin relay shown below. There are two colours shown. The green colour represents the control circuit and the red colour represents the load circuit. A small control coil is connected onto the control circuit. A switch is connected to the load. This switch is controlled by the coil in the control circuit. Now let us take the different steps that occour in a relay.



relay operation

ENERGIZED RELAY (ON)

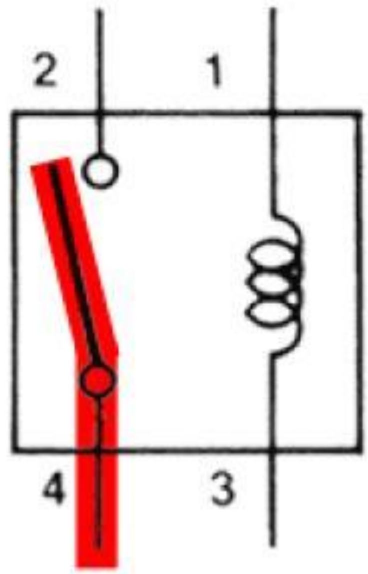
As shown in the circuit, the current flowing through the coils represented by pins 1 and 3 causes a magnetic field to be aroused. This magnetic field causes the closing of the pins 2 and 4. Thus the switch plays an important role in the relay working. As it is a part of the load circuit, it is used to control an electrical circuit that is connected to it. Thus, when the relay in energized the current flow will be through the pins 2 and 4.



Energized Relay (ON)

DE – ENERGIZED RELAY (OFF)

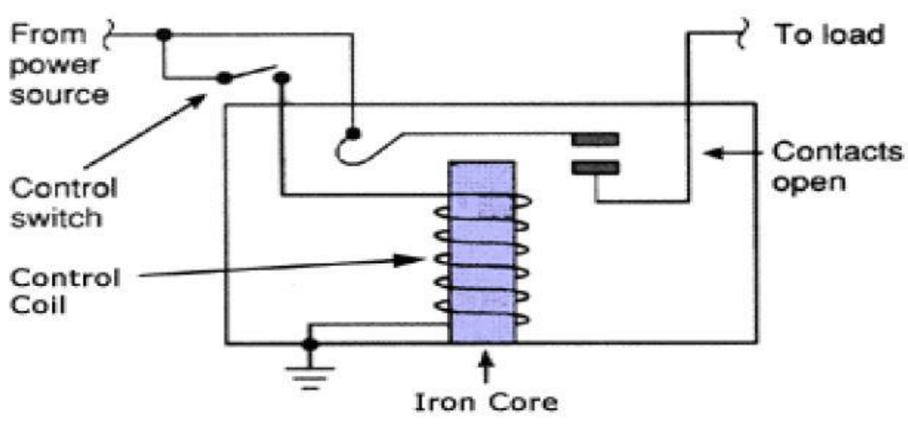
As soon as the current flow stops through pins 1 and 3, the switch opens and thus the open circuit prevents the current flow through pins 2 and 4. Thus the relay becomes de-energized and thus in off position.



De-Energized Relay (OFF)

In simple, when a voltage is applied to pin 1, the electromagnet activates, causing a magnetic field to be developed, which goes on to close the pins 2 and 4 causing a closed circuit. When there is no voltage on pin 1, there will be no electromagnetic force and thus no magnetic field. Thus the switches remain open.

WORKING PRINCIPLE



The diagram shows an inner section diagram of a relay. An iron core is surrounded by a control coil. As shown, the power source is given to the electromagnet through a control switch and through contacts to the load. When current starts flowing through the control coil, the electromagnet starts energizing and thus intensifies the magnetic field. Thus the upper contact arm starts to be attracted to the lower fixed arm and thus closes the contacts causing a short circuit for the power to the load. On the other hand, if the relay was already de-energized when the contacts were closed, then the contact move oppositely and make an open circuit.

As soon as the coil current is off, the movable armature will be returned by a force back to its initial position. This force will be almost equal to half the strength of the magnetic force. This force is mainly provided by two factors. They are the spring and also gravity.

Relays are mainly made for two basic operations. One is low voltage application and the other is high voltage. For low voltage applications, more preference will be given to reduce the noise of the whole circuit. For high voltage applications, they are mainly designed to reduce a phenomenon called arcing.

FEATURES:

- They are quick acting and can be reset fast.
- They are simple in construction.
- They are reliable.
- The values can be easily set. No special programming device is required.
- People can be trained on these relays easily

RELAY APPLICATIONS

- Relays are used to realize logic functions. They play a very important role in providing safety critical logic.
- Relays are used to provide time delay functions. They are used to time the delay open and delay close of contacts.

- Relays are used to control high voltage circuits with the help of low voltage signals. Similarly they are used to control high current circuits with the help of low current signals.
- They are also used as protective relays. By this function all the faults during transmission and reception can be detected and isolated.
- Relay Drive by Means of a Transistor
- Relay Drive by Means of SCR
- Relay Drive from External Contacts
- LED Series and Parallel Connections
- Electronic Circuit Drive by Means of a Relay
- Power Source Circuit
- PC Board Design Considerations

3.5 DC MOTOR

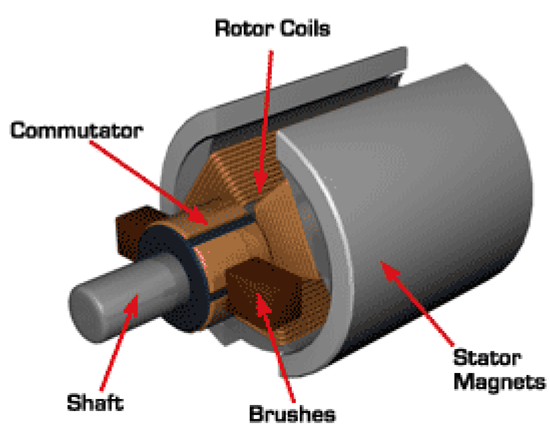
INTRODUCTION

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.)

PRINCIPLE OF DC MOTOR



An Electric DC motor is a machine which converts electric energy into mechanical energy. The working of DC motor is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force. The direction of mechanical force is given by Fleming's Left-hand Rule and its magnitude is given by F BIl Newton.

There is no basic difference in the construction of a DC generator and a DC motor. In fact, the same D.C. machine can be used interchangeably as a generator or as a motor. Like generators DC motors are also classified in to shunt-wound, series-wound and compound-wound.

A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.

DC motors are seldom used in ordinary applications because all electric supply companies furnish alternating current. However, for special applications such as in steel mills, mines and electric trains, it is advantageous to convert alternating current into direct current in order to use dc motors. The reason is that speed/torque characteristics of d.c. motors are much more superior to that of a.c. motors. Therefore, it is not surprising to note that for industrial drives, d.c. motors are as popular as 3-phase induction motors.

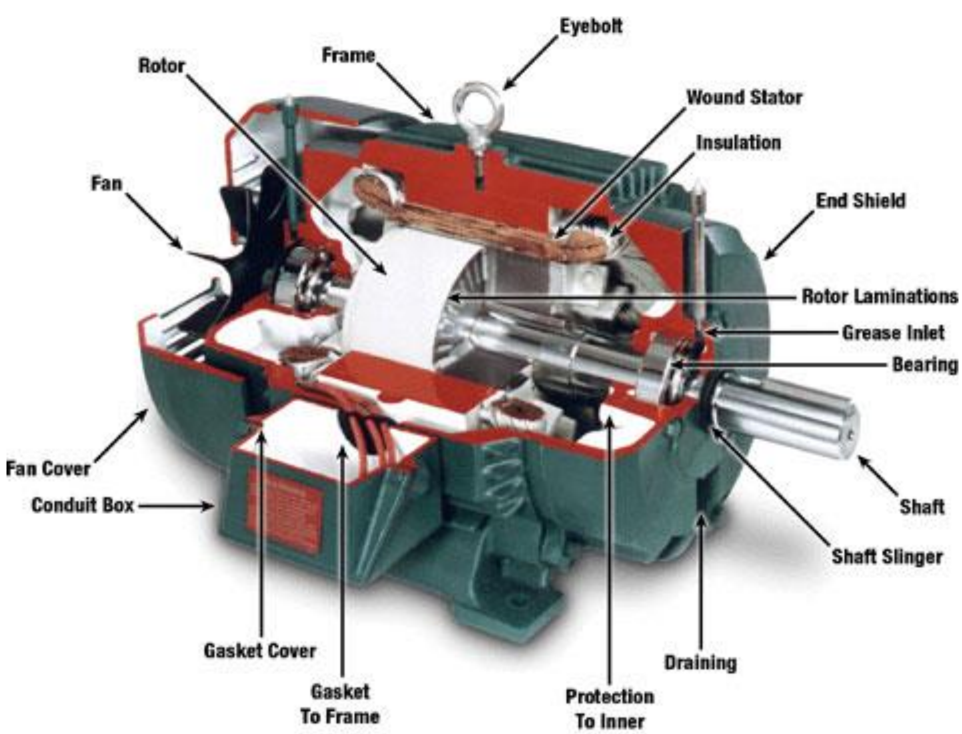


Figure 8 - Motor Construction

A machine which transforms the DC power into mechanical power is called as a DC motor. Its operation relies on the principle that once a current carrying conductor is placed in a very magnetic field, the conductor experiences a mechanical force. The direction of this force is given by Fleming’s left hand rule and magnitude is given by;

$$F=BIl \text{ Newton's}$$

Fundamentally, there's no constructional distinction between a DC motor and a DC generator. The same DC motor will be run as a generator or motor.

It is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left-hand rule and whose magnitude is given by

Force, $\mathbf{F = B\,I\,l}$ newton

Where B is the magnetic field in weber/m^2.

I is the current in amperes and

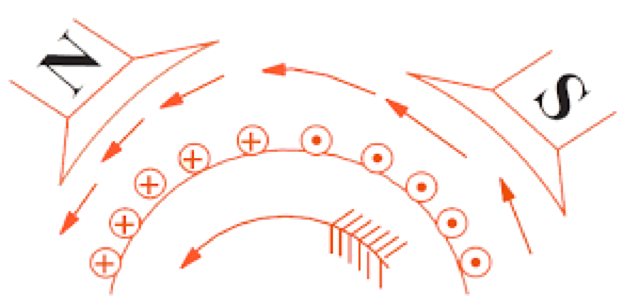
l is the length of the coil in meter.

The force, current and the magnetic field are all in different directions.

WORKING OF DC MOTOR

Consider a part of a multipolar d.c. motor as shown in Figure below.

The armature conductors carry currents. All conductors under N-pole carry currents in one direction while all the conductors under S-pole carry currents in the opposite direction.



Suppose the conductors under N-pole carry currents into the plane of the paper and those under S-pole carry currents out of the plane of the paper as shown in Figure. Since each armature conductor is carrying current and is placed in the magnetic field, mechanical force acts on it. On applying Fleming's left hand rule, it is clear that force on each conductor is tending to rotate the armature in anticlockwise direction.

The armature conductors carry currents. All conductors below N-pole carry currents in one direction whereas all the conductors below S-pole carry currents within the opposite direction. Assume the conductors below N-pole carry currents into the plane of the paper and those below S-pole carry currents out of the plane of the paper which is shown in Fig. Since each armature conductor is carrying current and is placed within the magnetic field, mechanical force acts on that. Stating to the Fig and applying Fleming's left hand rule, it's clear that force on every conductor is tending to rotate the armature in anticlockwise direction. All these forces add along to provide a driving torsion that sets the armature rotating.

BRUSHED DC ELECTRIC MOTOR

The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the carbon brushes and springs which carry the electric current, as well as cleaning or replacing the commutate. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor. Brushes consist of conductors.

BRUSHLESS DC ELECTRIC MOTOR

Typical brushless DC motors use one or more permanent magnets in the rotor and electromagnets on the motor housing for the stator. A motor controller converts DC to AC.

This design is mechanically simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor.

The motor controller can sense the rotor's position via Hall effect sensors or similar devices and can precisely control the timing, phase, etc., of the current in the rotor coils to optimize torque, conserve power, regulate speed, and even apply some braking. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

ELECTROMAGNETIC MOTORS

The total amount of current sent to the coil, the coil's size and what it's wrapped around dictate the strength of the electromagnetic field created.

The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a force on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor.

If external power is applied to a DC motor it acts as a DC generator, a dynamo. This feature is used to slow down and recharge batteries on hybrid car and electric cars or to return electricity back to the electric grid used on a street car or electric powered train line when they slow down. This process is called regenerative braking on hybrid and electric cars. In diesel electric locomotives they also use their DC motors as generators to slow down but dissipate the energy in resistor stacks. Newer designs are adding large battery packs to recapture some of this energy.

APPLICATIONS OF DC MOTORS

D.C SHUNT MOTORS

It is a constant speed motor.Where the speed is required to remain almost constant from no-load to full load.Where the load has to be driven at a number of speeds and any one of which is nearly constant.

INDUSTRIAL USE:

- Lathes
- Drills
- Boring mills
- Shapers
- Spinning and weaving machines.

D.C SERIES MOTOR:

It is a variable speed motor. The speed is low at high torque. At light or no load ,the motor speed attains dangerously high speed. The motor has a high starting torque.(elevators, electric traction)

INDUSTRIAL USES:

- Electric traction
- Cranes
- Elevators
- Air compressor
- Vacuum cleaner
- Hair drier
- Sewing machine

D.C COMPOUND MOTOR:

Differential compound motors are rarely used because of its poor torque characteristics. Industrial uses:

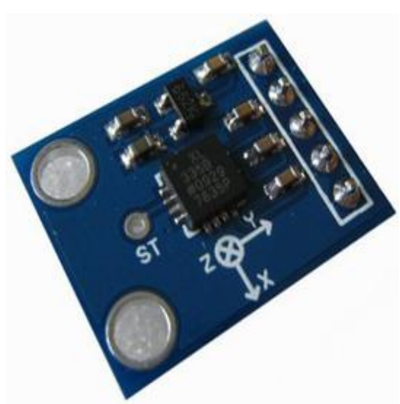
- Presses Shears
- Reciprocating machine.

3.6 MEMS SENSOR

MEMS TECHNOLOGY

MEMS is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements that are made using the techniques of micro fabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several milli meters. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move. The term used to define MEMS varies in different parts of the world.

While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable elements are the microsensors and microactuators. Microsensors and microactuators are appropriately categorized as “transducers”, which are defined as devices that convert energy from one form to another. In the case of microsensors, the device typically converts a measured mechanical signal into an electrical signal.



More recently, the MEMS research and development community has demonstrated a number of micro actuators including: micro valves for control of gas and liquid flows; optical switches and mirrors to redirect or modulate light beams; independently controlled micro mirror arrays for displays, micro resonators for a number of different applications, micro pumps to develop positive fluid pressures, micro flaps to modulate airstreams on airfoils as well as many others.

ADVANTAGES

- MEMS device are very small and can be applicable for many mechanical purposes where large measurements are needed.
- The small size of the device has also helped in reducing its cost.
- If two or three different devices are needed to deploy a particular process, all of them can be easily integrated in an MEMS chip with the help of microelectronics. Thus, data reception, filtering, storing, transfer, interfacing, and all other processes can be carried out with a single chip.

APPLICATIONS

- The device is highly applicable as an **accelerometer** and thus can be deployed as airbag sensors or in digital cameras in order to stabilize the image.
- Can be used as a pressure sensor so as to calculate the pressure difference in blood, manifold pressure and also tire pressure.
- It is commonly used in a gyroscope, DNA chips and also inkjet printer nozzle.
- Optical MEMS is used for making projectors, optical fiber switch.
- RF MEMS is used for making antennas, filters, switches, relays, RAM’s microphones, microphones.

3.7 HALL EFFECT SENSOR

INTRODUCTION

A Hall Effect sensor is a solid state device, which converts magnetic or magnetically encoded information into electrical signals. It varies its output voltage in response to a magnetic field. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced. Hall Effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications. These sensors operate as an analog transducer, directly returning a voltage.

PRODUCT DESCRIPTION

When a beam of charged particles passes through a magnetic field, forces act on the particles and the beam is deflected from a straight path. The flow of electrons through a conductor is known as a beam of charged carriers. When a conductor is placed in a magnetic field perpendicular to the direction of the electrons, they will be deflected from a straight path. As a consequence, one plane of the conductor will become negatively charged and the opposite side will become positively charged. The voltage between these planes is called Hall voltage.

When the force on the charged particles from the electric field balances the force produced by magnetic field, the separation of them will stop. If the current is not changing, then the Hall voltage is a measure of the magnetic flux density. Basically, there are two kinds of Hall Effect sensors. One is linear which means the output of voltage linearly depends on magnetic flux density,the other is called threshold which means there will be a sharp decrease of output voltage at each magnetic flux density.

Fig.Hall Effect Sensor

FEATURES

- Operating voltage: 5v DC
- Output: Digital (0-5v)
- Detecting range: 7 mm
- LM393 comparator with threshold preset

APPLICATIONS

- Tachometer
- Speed Detecting of fan and motors
- door switches in refrigerators
- Automotive fuel level indicator

3.8 RFID READER

INTRODUCTION

RFID is abbreviation of Radio Frequency Identification. RFID signifies to tiny electronic gadgets that comprise of a small chip and an antenna. This small chip is competent of accumulating approx 2000 bytes of data or information.

RFID devices is used as a substitute of bar code or a magnetic strip which is noticed at the back of an ATM card or credit card, it gives a unique identification code to each item. And similar to the magnetic strip or bar code, RFID devices too have to be scanned to get the details (identifying information).

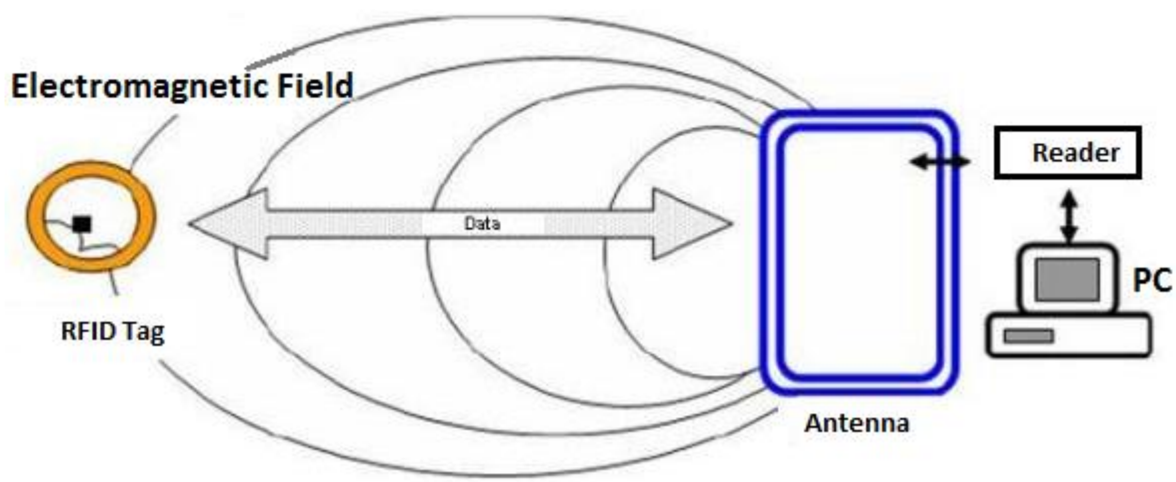
A fundamental advantage of RFID gadgets above the other stated devices is that the RFID device is not required to be placed exactly near to the scanner or RFID code reader. As all of us are well aware of the difficulty which store billers face while scanning the bar codes and but obviously the credit cards & ATM cards need to be swiped all though a special card reader. In comparison to it, RFID device can function from few feet away (approx 20 feet for high frequency devices) of the scanner machine.

RFID or Radio Frequency Identification, is a technology where information stored on a microchip can be read remotely, without physical contact using energy in the RF spectrum. An RFID system consists of a reader, or interrogator, which emits an RF signal via an antenna. The microchip receives the energy via an attached antenna (termed an RFID tag) and varies the electromagnetic response its antenna in such a way that information can be transferred to the reader.

An RFID reader combines the functions of radio transmitter, receiver and data interface. The transmitter activates the tag, the receiver reads the tag's response and the interface passes information along to a computer or other equipment.

FUNCTIONING PRINCIPLE OF RFID DEVICE:

- **RFID** (radio frequency identification) is a technique facilitating identification of any product or item without the requirement of any line of sight amid transponder and reader.
- **RFID Structure** is continuously composed of 2 main hardware components. The transponder which is located on the product to be scanned and the reader which can be either just a reader or a read & write device, depending upon the system design, technology employed and the requirement. The RFID reader characteristically comprise of a radio frequency module, a controlling unit for configurations, a monitor and an antenna ti investigate the RFID tags. In addition, a number of RFID readers are in-built with an extra interface allowing them to forward the data received to another system (control system or PC).
- **RFID Tag –** The actual data carrying tool of an RFID structure, in general comprise of an antenna (coupling element) and an electronic micro-chip.



ACTIVE & PASSIVE TAGS:

Before we move ahead to the working of the RFID systems let us know what active & passive RFID tags are

RFID is a common term employed to describe a device which is employed in transferring data with the help of radio waves. RFID tags comprise of a RFID transceiver for transferring data from one system to another. There are 2 kinds of RFID tags- Active tags & Passive tags.

PASSIVE RFID TAGS

Passive tags comprise of 3 key components, namely, an in-built chip, a substrate and an antenna. The in-built chip is also known as a circuit and is utilized to perform some precise tasks along with accumulating data. Passive RFID tags can comprise of various kinds of micro-chips depending on the structural design of a particular tag. These chips can be MO (read only) or WORM (write once chip other than read many) or RW (read write) chip.

A general RFID chip is competent of accumulating 96 bits of data but some other chips have a capacity of storing 1000-2000 bits. Passive tag has an antenna which is attached to the micro-chip. This antenna is employed for transferring data using radio waves. The passive tag's performance is reliant on the size of the antenna. In the performance of tags the shape of the antenna also plays a significant role.

ACTIVE RFID TAGS

Active tags comprise of same components that exists in passive tags. They too comprise of a micro-chip and an antenna but the only comparison between the two is that the size of the micro-chip in active tags is larger than passive tags' chip. An active tag is incorporated with a built-in power supply. Maximum of the active tags make use of batteries whereas some of them work on solar cells. The inbuilt power system facilitates the tag to be used as an independent reader which is competent of transferring information devoid of outer assistance.

Active RFID tags are available with some extra features such as microprocessors, serial ports & sensors. The highly developed technology in existing in active RFID tag formulates it more capable in comparison to passive tags as the active tags can be easily employed for a large array of tasks.

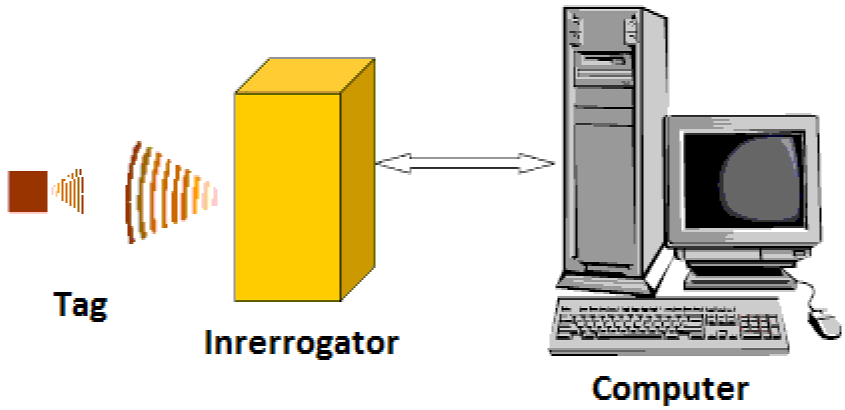
RFID Micro-Chip tags are basically fabricated to function at certain frequencies which are license free.

These are:

- High Frequency (HF) 13.56 MHz
- Microwave 2.45 GHz
- Ultra High Frequency (UHF) 868-930 MHz
- Low Frequency (LF) 125-135 KHz
- Microwave 5.8 GHz

WORKING PRINCIPLE

The diagram below describes the fundamental working of all RFID systems. The transponder or tag can be either active of passive tag. It reacts to the signals from the reader or writer or interrogator which in turn conveys signals to the computer.



USES

Many companies use RFID tags to track the flow of goods through warehousing, distribution and retail. In the case of recycling, they can even track goods returned. The tiny size of the tags makes them ideal for tracking pets. A veterinarian can implant the tag just under the animal's skin and programs the tag with the owner's name and address. Security companies

Place tags in access cards. A reader detects the card's presence in your pocket and automatically unlocks doors and turns on lights.

RFID APPLICATIONS

RFID technology is used in a number of industries to carry out various tasks such as:

- Asset tracking
- Inventory management
- Controlling access to confined areas
- Personnel tracking
- Supply chain management
- ID badging
- Counterfeit forestalling (e.g., in the pharmaceutical industry)

Even though RFID technology has been in used by humans ever since from World War II, the stipulate for RFID devices is rising quickly, in fact owing to orders given by the U.S. DOD (Department of Defence) and Wal-Mart needing their suppliers to modify products to be tracked by RFID technology.

RFID IS ALSO EMPLOYED IN A NUMBER OF OTHER THINGS

- The keys to unlock your car door;
- The automatic deduction of payment while using toll booths;
- Building access systems;
- Payment cards, student ID cards and even Passports
- Wireless sensors & mesh networks.

3.9 SWITCH

INTRODUCTION

The switch is then said to be on, and electric current flows around the circuit. When the spring is released so that it does not push against the metal strips, the switch is open and the current flow is cut off.

An electrical switch is any device used to interrupt the flow of electrons in a circuit. Switches are essentially binary devices: they are either completely on ("closed") or completely off ("open"). There are many different types of switches.

The simplest type of switch is one where two electrical conductors are brought in contact with each other by the motion of an actuating mechanism. Other switches are more complex, containing electronic circuits able to turn on or off depending on some physical stimulus (such as light or magnetic field) sensed.

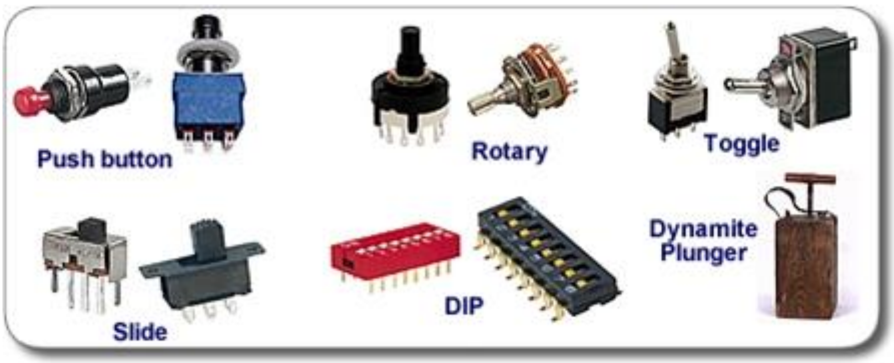
In any case, the final output of any switch will be (at least) a pair of wire-connection terminals that will either be connected together by the switch's internal contact mechanism ("closed"), or not connected together ("open").

Any switch designed to be operated by a person is generally called a hand switch, and they are manufactured in several varieties:

TYPES

- Rotary
- Push button
- Toggle switch

- Slide
- DIP
- Dynamite plunger



DESCRIPTION

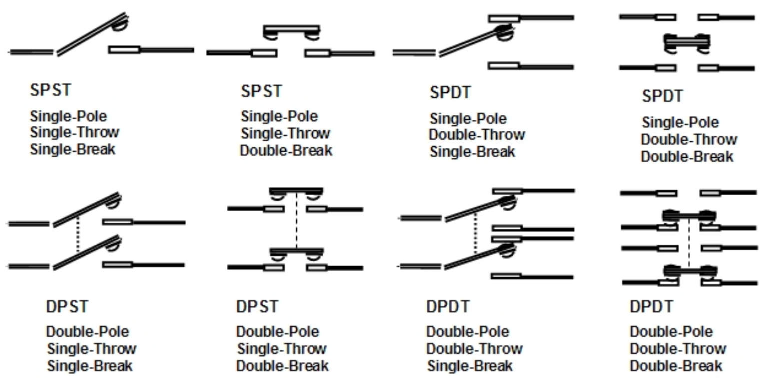
The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or open, meaning the contacts are separated and the switch is no conducting.

The mechanism actuating the transition between these two states (open or closed) can be either a toggle or momentary type. An ideal switch would have no voltage drop when closed, and would have no limits on voltage or current rating. It would have zero rise time and fall time during state changes, and would change state without "bouncing" between on and off positions.

CONTACT TERMINOLOGY

In electronics, switches are classified according to the arrangement of their contacts. A pair of contacts is said to be closed when current can flow from one to the other. When the contacts are separated by an insulating air gap, it should be in the state of open and no current can flow between them at normal voltages.

In a switch where the contacts remain in one state unless actuated, such as a push-button switch, the contacts can either be normally open until closed by operation of the switch, or normally closed and opened by the switch action. A switch with both types of contact is called a changeover switch. These may be make-before-break which momentarily connects both circuits, or may be break-before-make which interrupts one circuit before closing the other.



TYPES OF SWITCH

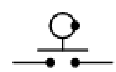
Toggle switch

- Toggle switches are actuated by a lever angled in one of two or more positions. The common light switch used in household wiring is an example of a toggle switch.
- Most toggle switches will come to rest in any of their lever positions, while others have an internal spring mechanism returning the lever to a certain normal position, allowing for what is called momentary operation.

Pushbutton switch

- Pushbutton switches are two-position devices actuated with a button that is pressed and released.
- Most pushbutton switches have an internal spring mechanism returning the button to its out or un pressed position, for momentary operation. Some pushbutton switches will latch alternately on or off with every push of the button.
- Other pushbutton switches will stay in their in or pressed position until the button is pulled back out. These last types of pushbutton switches usually have a mushroom-shaped button for easy push-pull action.

Joystick switch



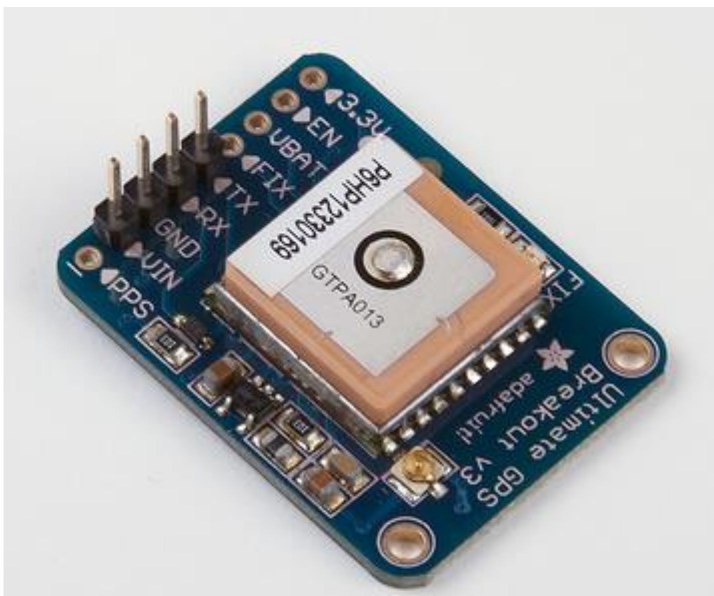
- A joystick switch is actuated by a lever free to move in more than one axis of motion. One or more of several switch contact mechanisms are actuated depending on which way the lever is pushed, and sometimes by how far it is pushed.
- The circle-and-dot notation on the switch symbol represents the direction of joystick lever motion required to actuate the contact. Joystick hand switches are commonly used for crane and robot control.

4.0 GPS

GPS stands for Global Positioning System and was developed by the US Department of Defence as a worldwide navigation and positioning facility for both military and civilian use. It is a space-based radio-navigation system consisting of 24 satellites and ground support. GPS provides users with accurate information about their position and velocity, as well as the time, anywhere in the world and in all weather conditions.

Navigation in three dimensions is the primary function of GPS. Navigation receivers are made for aircraft, ships, ground vehicles, and for hand carrying by individuals. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.

Good GPS receivers can calculate their position, anywhere on earth, to within one hundred metres and can continuously update their position more than once a second. Of course, various factors, such as terrain and atmospherics can affect the GPS signals. In spite of this however, accuracy of one hundred metres for GPS will commonly be exceeded.



WORKING PRINCIPLE OF GPS

The Global Positioning System consists of a network of 24 broadcasting satellites orbiting the earth at a height of 20,200km. GPS also consists of receivers on the ground, which listen to and interpret the transmissions of the satellites.

The concept of ranging is best illustrated by example. Consider one satellite that is a distance of 25,000 kilometres from a person holding a GPS receiver. Then the person's position is known to be somewhere on a sphere 25,000 km in radius, cantered on the satellite. However, the exact location of the person on that sphere is yet unknown. If, at the same time, the distance from the person to a second satellite can be discovered to be 20,000 km, then a second sphere of radius 20,000 km on which the person is positioned can be determined.

Thus the person must be on the circle formed by the intersection of the two spheres of position. A third satellite provides yet a third sphere, which narrows down the location of the person to exactly two points. One of these points is often an impossible solution, frequently several thousand kilometres off in space, thus three satellite ranges can determine the precise position of the person.

Three satellites provide enough information to find the x, y, and z coordinates (measured from the centre of mass of the earth). However, in practice, four satellites are required to pinpoint a position, for reasons that will soon become clear.

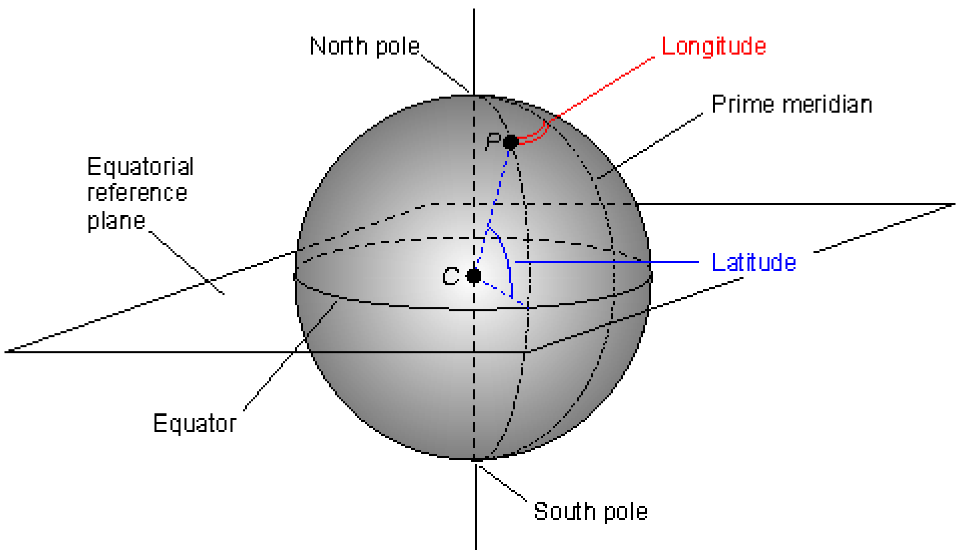
- 21 GPS satellites and three spare satellites are in orbit at 10,600 miles above the Earth. The satellites are spaced so that from any point on Earth, four satellites will be above the horizon.
- Each satellite contains a computer, an atomic clock, and a radio. With an understanding of its own orbit and the clock, it continually broadcasts its changing position and time. (Once a day, each satellite checks its own sense of time and position with a ground station and makes any minor correction.)
- On the ground, any GPS receiver contains a computer that "triangulates" its own position by getting bearings from three of the four satellites. The result is provided in the form of a geographic position - longitude and latitude - to, for most receivers, within 100 meters.
- If the receiver is also equipped with a display screen that shows a map, the position can be shown on the map.
- If a fourth satellite can be received, the receiver/computer can figure out the altitude as well as the geographic position.
- If you are moving, your receiver may also be able to calculate your speed and direction of travel and give you estimated times of arrival to specified destinations.

The GPS is being used in science to provide data that has never been available before in the quantity and degree of accuracy that the GPS makes possible. Scientists are using the GPS to measure the movement of the arctic ice sheets, the Earth's tectonic plates, and volcanic activity.

LATITUDE AND LONGITUDE

Latitude and longitude are angles that uniquely define points on a sphere. Together, the angles comprise a coordinate scheme that can locate or identify geographic positions on the surfaces of planets such as the earth.

Latitude is defined with respect to an equatorial reference plane. This plane passes through the centre *C* of the sphere, and also contains the great circle representing the equator. The latitude of a point *P* on the surface is defined as the angle that a straight line, passing through both *P* and *C*, subtends with respect to the equatorial plane.



Longitude is defined in terms of meridians, which are half-circles running from pole to pole. A reference meridian, called the prime meridian, is selected, and this forms the reference by which longitudes are defined. On the earth, the prime meridian passes through Greenwich, England; for this reason it is also called the Greenwich meridian. The longitude of a point *P* on the surface is defined as the angle that the plane containing the meridian passing through *P* subtends with respect to the plane containing the prime meridian.

GPS IN THREE STAGES

STAGE 1

The satellites act as reference points.

The nominal GPS Operational Constellation consists of 24 satellites at an altitude of 20,100 km (12,500 mi) and with a period of 12 hours. The satellite orbits repeat almost the same ground track (as the earth turns beneath them) once each day. There are six orbital planes with nominally four satellites in each, equally spaced (60 degrees apart), and inclined at about 55 degrees with respect to the equatorial plane to ensure coverage of Polar Regions.

This constellation provides the user with between five and eight satellites visible from any point on the earth. Powered by solar cells, the satellites continuously orient themselves to point their solar panels toward the sun and their antennas toward the earth. Each satellite contains four atomic clocks.

STAGE 2

The signal travel time gives distance information.

GPS satellites carry atomic clocks that provide extremely accurate time. The time information is placed in the codes broadcast by the satellite so that a receiver can continuously determine the time the signal was broadcast.

The receiver uses the time difference between the time of signal reception and the broadcast time to compute the distance, or range, from the receiver to the satellite. The receiver must account for propagation delays, or decreases in the signal's speed caused by the atmosphere. To calculate the distance between itself and any given satellite the receiver multiplies the travel time by the speed of light. This principal is fundamental to GPS.

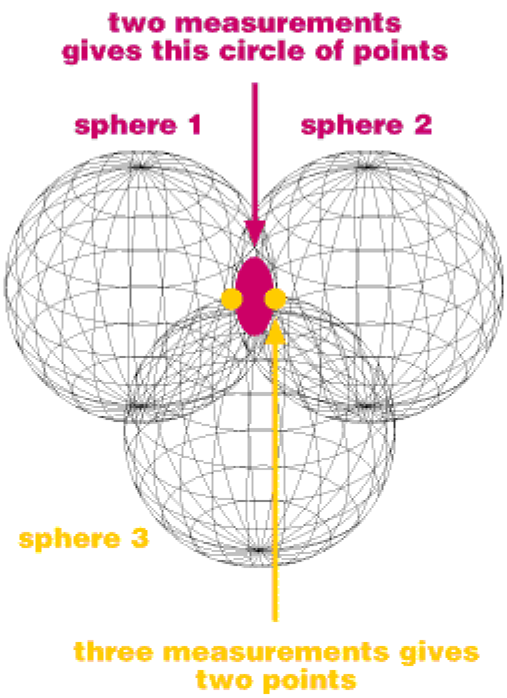
STAGE 3

Three distances gives the position.

Once stages 1 and 2 have been accomplished we now have distance information to a number of satellites the locations of which we know with great precision. From this data, the receiver triangulates an exact position. Three satellites are needed to determine latitude and longitude, while a fourth satellite is necessary to determine altitude. An atomic clock synchronized to GPS is required in order to compute ranges from these three signals. Let's assume that the receiver determines that it is 20,000km from a particular satellite.

This means that the receiver could be anywhere on an imaginary sphere with the satellite as its centre. If it also determines that it is 25,000km from a second satellite this narrows its location down even further. The only location in space where it can be both 20,000km from the first satellite and 25,000km from the second is where these two spheres intersect. That intersection is a circle of points.

A third measurement adds another sphere which intersects the circle formed by the first two. This intersection occurs at two points, and so, with these three measurements, the GPS receiver has narrowed down its location to just two points in the entire universe.



A fourth measurement will intersect exactly with one of the two points. In practice, however, you may not need this fourth measurement as one of the two points will normally be located thousands of kilometres out into space, and therefore is unlikely to be your position!

However a fourth measurement is used to calculate altitude. It also ensures that the receiver's clock is truly synchronised with universal time.

FEATURES:

1. Telling you where you are: When you press the button Where Am I, the system will look at your gps position and will query the server to obtain information about your location. This feature is subject to the remote service limitations and may not work if the servers are too busy, if too many queries have been sent in a day or in a limited amount of time, etc.

2. Letting you explore what's around you: This feature is related to the visualization of a map of what's around you. This map is accessible with voice over. When you touch a point, after a short delay, you will be told the street information. Pointing your device toward a certain direction, you will have what's in front of you on the top half of the screen and what's behind you on the bottom half of the screen. Your position corresponds to center of the screen. This feature is also subject to the previously mentioned limitations.

3. Letting you explore a specific zone: Everything like the previous point except that you can choose a zone by inserting street and city data.

4. Periodically checking your position and telling where you are (by only telling you the details changed since last check).This feature, called monitor, will periodically give you the information about your position.

5. Letting you add and list your favorites points: You can give a description of the point and the system will add the rest (Street, number, coordinates, etc.);

6. Alerting you when you are close to one of your favourite points. The app will inform you, on screen and via voice over, that you are close to a certain point you previously stored in your favourites list.

GPS APPLICATION

- Military
- Navigation
- Target Tracking
- Land, sea, air
- Mapping and surveying
- Missile and projectile guidance
- Search and rescue.

4.1 LCD

INTRODUCTION

Liquid crystal cell displays (LCDs) used to display of display of numeric and alphanumeric characters in dot matrix and segmental displays.They are all around us in laptop computers, digital clocks and watches, microwave, CD players and many other electronic devices. LCDs are common because they offer some real advantages over other display technologies. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it.

An LCD is made with either a passive matrix or an active matrix display grid. An active matrix has a transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active matrix display can be switched on and off more frequently, improving the screen refresh time.Passive matrix LCD's have dual scanning, meaning that they scan the grid twice with current in the same

WORKING

When sufficient voltage is applied to the electrodes the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarizer, which would result in activating/highlighting the desired characters. The power supply should be of +5v, with maximum allowable transients of 10mv. To achieve a better/suitable contrast for the display the voltage at pin 3 should be adjusted properly.

The ground terminal of the power supply must be isolated properly so that voltage is induced in it. The module should be isolated properly so that stray voltages are not induced, which could cause a flicking display.

LCD is lightweight with only a few, millimeters thickness since the LCD consumes less power, they are compatible with low power electronic circuits, and can be powered for long durations. LCD does not generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. LCDs have long life and a wide operating temperature range. Before LCD is used for displaying proper initialization should be done. LCDs with a small number of segments, such as those used in digital watches and pocket calculators, have individual electrical contacts for each segment. An external dedicated circuit supplies an electric charge to control each segment.

This display structure is unwieldy for more than a few display elements. Small monochrome displays such as those found in personal organizers, or older laptop screens. The pixels are addressed one at a time by row and column addresses. This type of display is called passive-matrix addressed because the pixel must retain its state between refreshes without the benefit of a steady electrical charge. As the number of pixels increases, this type of display becomes less feasible.

Very slow response times and poor contrast are typical of passive matrix addressed LCDs. High-resolution color displays such as modern LCD computer monitors and televisions use an active matrix structure. A matrix of thin-film transistors (TFTs) is added to the polarizing and color filters. Each pixel has its own dedicated transistor, allowing each column line to access one pixel. When a row line is activated, all of the column lines are connected to a row of pixels and the correct voltage is driven onto all of the column lines.

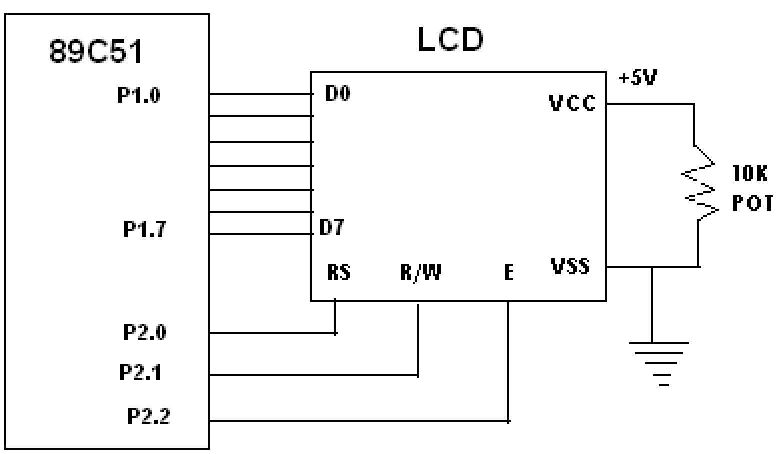
The row line is then deactivated and the next row line is activated. All of the row lines are activated in sequence during a refresh operation. Active-matrix addressed displays look "brighter" and "sharper" than passive-matrix addressed displays of the same size, and generally have quicker response times, producing much better images. A general purpose alphanumeric LCD, with two lines of 16 characters. So the type of LCD used in this project is16 characters * 2 lines with 5*7 dots with cursor, built in controller, +5v power supply, 1/16 duty cycle.

PIN DESCRIPTION FOR LCD

PIN NO	SYMBOL	FUNCTION
1	Vss	Ground terminal of Module
2	Vdd	Supply terminal of Module, + 5v
3	Vo	Power supply for liquid crystal drive
4	RS	Register select RS=0…Instruction register RS=1…Data register
5	R/W	Read/Write R/W=1…Read R/W=0…Write
6	EN	Enable
7-14	DB0-DB7	Bi-directional Data Bus. Data Transfer is performed once ,thru DB0-DB7,incase of interface data

		length is 8-bits;and twice, thru DB4-DB7 in the case of interface data length is 4-bits.Upper four bits first then lower four bits.
15	LAMP-(L-)	LED or EL lamp power supply terminals
16	LAMP+(L+) (E2)	Enable

LCD INTERFACING WITH MICROCONTROLLER



ADVANTAGES

- Consume much lesser energy when compared to LEDs.
- Utilizes the light available outside and no generation of light.

- Since very thin layer of liquid crystal is used, more suitable to act as display elements.
- Since reflectivity is highly sensitive to temperature, used as temperature measuring sensor.

DISADVANTAGES

- Angle of viewing is very limited.
- External light is a must for display.
- Since not generating its own light and makes use of external light for display, contrast is poor.
- Cannot be used under wide range of temperature.

APPLICATIONS

- Watches
- Fax & Copy machines & Calculators.

4.2 SD Card

A Secure Digital (SD) card is a tiny memory card used to make storage portable among phones, eBooks, PDAs,smartphones, digital cameras, music players, camcorders, and personal computers. An SD card features a high data transfer rate and low battery consumption, both primary considerations for portable devices. It uses flash memory to provide non-volatile storage, which means that a power source is not required to retain stored data.

An SD card is about the size of a postage stamp and weighs approximately two grams. It is similar in size to a Multimedia Card, but smaller than older memory card types such as the Smart Media card and the Compact Flash card. Both MMC and SD cards provide encryption capabilities for protected content to ensure secure distribution of copyrighted material, such as digital music, video, and eBooks. SD cards are available with storage capacities as high as 4 gigabytes.

SD cards are more rugged than traditional storage media. They have an operating shock rating (basically, the height you can drop them from and still have them work) of 2,000 Gs, compared to a 100-200 G rating for the mechanical drive of the typical portable computing device. This translates to a drop to the floor from 10 feet, as compared to a single foot for the mechanical disk drive. Both MMC and SD cards use metal connector contacts, instead of the traditional pins-and-plugs, so they aren't as prone to damage during handling.

Secure Digital (SD) cards are a form of flash memory used to store data from many modern digital devices. They differ from other storage media in that they can be written to thousands of times and do not require power to retain their contents. This makes them an ideal choice for electronics such as digital cameras, which have strict power requirements and need media that can be written to multiple times. In contrast to traditional hard drives, SD cards also contain no moving parts, so they are significantly more resilient to accidental bumps and falls.

SD STANDARD OVERVIEW

SD standards enable manufacturers to deliver high-performance products that enhance the experience of millions of people every day who listen to music, record videos, take photos.As the industry standard, the SD standard is utilized across multiple market segments of the portable storage industry, including mobile phones, digital cameras, MP3 players, personal computers, tablets, printers, car navigation systems, electronic books, and many other consumer electronic devices.

SD standards let users transfer data from one device to another. This unique feature gives consumers the ultimate flexibility and convenience to store and share digital contents anytime Memory cards developed to the SD standard are solid state, rugged, reliable, interoperable and easy to use. Plus, they are available in a variety of formats, capacities, speed classes, and shapes, including SD memory cards, miniSD memory cards and microSD memory cards.

TYPES OF SD CARD

	Full SD	Mini SD	Micro SD	Capacity
SD				≲16GB
SDHC				4GB-64GB
SDXC		––		64GB-2TB

FEATURES

CARD SECURITY

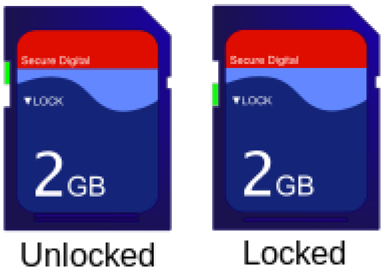
Cards can protect their contents from erasure or modification, prevent access by non-authorised users, and protect copyrighted content using digital rights management (DRM).

COMMANDS TO DISABLE WRITES

The host device can command the SD card to become read-only (to reject subsequent commands to write information to it). There are both reversible and irreversible host commands that achieve this.

WRITE-PROTECT NOTCH

The user can designate most full-size SD cards as read-only by use of a sliding tab that covers a notch in the card. (The minis and microsSD formats do not support a write protection notch.)



When looking at the SD card from the top, the right side (the side with the beveled corner) must be notched.

On the left side, there may be a write-protection notch. If the notch is omitted, the card can be read and written. If the card is notched, it is read-only. If the card has a notch and a sliding tab which covers the notch, the user can slide the tab upward (toward the contacts) to declare the card read/write, or downward to declare it read-only. The diagram to the right shows a green sliding write-protect tab in both the unlocked and locked positions.

The presence of a notch, and the presence and position of a tab, have no effect on the SD card's operation. A host device that supports write protection should refuse to write to an SD card that is designated read-only in this way. Cards sold with content that must not be altered are permanently marked read-only by having a notch and no sliding tab.

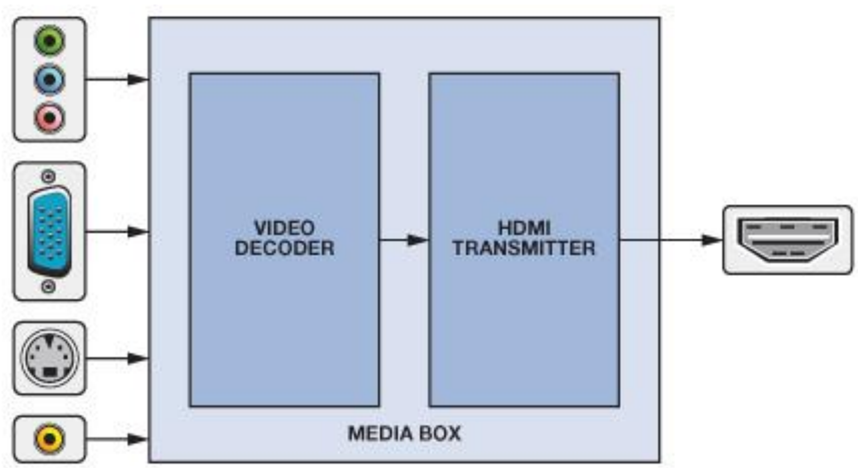
4.3 HDMI to VGA

INTRODUCTION

HDMI stands for High Definition Multimedia Interface. A HDMI cable is a single cable that serves as link for audio as well as video applications. For a video recorded in high definition, a standard Audio-video component cable gives an output of 480 pixels per inch. On the other hand, HDMI connectors give at least a 720 pixel/inch output, thus giving a more rich and lively video that can recreate the actual scene with more accuracy.

There are similar enhancements in audio side too (2.1 channel sound and above). This means that a single HDMI cable can replace up to 11 analogue signal cables not only in aspects like reduced clutter, but in bandwidth, content transmission and presentation quality too. HDMI is constantly worked upon and improved by HDMI Consortium, which also handles certifying HDMI

The HDMI to VGA Converter is your affordable solution for transferring HDMI signal into VGA and Audio signal. The Converter gives you the freedom to use HDMI devices with your existing VGA display devices, including monitors and projectors. You can avoid costly and unnecessary upgrades of your VGA devices with this simple unit.



SPECIFICATIONS

The HDMI specification defines the protocols, signals, electrical interfaces and mechanical requirements of the standard. The maximum pixel clock rate for HDMI 1.0 was 165 MHz, which was sufficient to allow 1080p and WUXGA (1920×1200) at 60 Hz. HDMI 1.3 increased that to 340 MHz, which allows for higher resolution (such as WQXGA, 2560×1600) across a single digital link. An HDMI connection can either be single-link (type A/C/D) or dual-link (type B) and can have a video pixel rate of 25 MHz to 340 MHz (for a single-link connection) or 25 MHz to 680 MHz (for a dual-link connection). Video formats with rates below 25 MHz (e.g., 13.5 MHz for 480i/NTSC) are transmitted using a pixel-repetition scheme.

HDMI

High-**D**efinition **M**ultimedia **I**nterface, it is the first industry-supported uncompressed, all-digital audio/video interface. It's a single cable and user-friendly connector that replaces the maze of cabling behind the home entertainment centre. HDMI provides an interface between any audio/video source, such as a set-top box, DVD player, or A/V receiver and an audio and/or video monitor, such as a digital television (DTV), over a single cable. HDMI supports standard, enhanced, or high-definition video, plus multi-channel digital audio on a single cable. It transmits all ATSC HDTV standards and supports 8-channel digital audio with bandwidth to spare to accommodate future enhancements and requirements.

HDMI was defined to carry 8 channels, of 192 kHz, 24-bit uncompressed audio, which exceeds all current consumer media formats. In addition, HDMI can carry any flavor of compressed audio format such as Dolby or DTS. HDMI has the capacity to support existing high-definition video formats such as 720p, 1080i, and 1080p, along with support of enhanced definition formats like 480p, as well as standard definition formats such as NTSC or PAL.

VGA

Abbreviation of **video graphics array** a graphics display system for PCs developed by IBM. VGA has become one of the de facto standards for PCs. In text mode, VGA systems provide a resolution of 720 by 400 pixels. In graphics mode, the resolution is either 640 by 480 (with 16 colours) or 320 by 200 (with 256 colours). The total palette of colours is 262,144.

Since its introduction in 1987, several other standards have been developed that offer greater resolution and more colons but VGA remains the lowest common denominator. All PCs made today support VGA, and possibly some other more advanced standard.

HDMI APPLICATION AND VIDEO STANDARDS

HDMI interfaces use transition-minimized differential signaling (TMDS) lines to carry video, audio, and data in the form of packets. In addition to these multimedia signals, the interface includes display data channel (DDC) signals for exchanging extended display identification data (EDID) and for high-bandwidth digital content protection (HDCP).

Additionally, HDMI interfaces can be equipped with consumer electronics control (CEC), audio return channel (ARC), and home Ethernet channel (HEC). Since these are not essential to the application described here, they are not discussed in this article.

EDID data comprises a 128-byte long (VESA—Video Equipment Standards Association) or 256-byte long (CEA-861—Consumer Electronics Association) data block that describes the video and (optionally) audio capabilities of the video receiver (Rx). EDID is read by a video source (player) from the video sink over DDC lines using an I^2C protocol. A video source must send the preferred or the best video mode supported and listed in EDID by a video sink. EDID may also contain information about the audio capabilities of the video sink and a list of the supported audio modes and their respective frequencies.

AUDIO/VIDEO

HDMI uses the Consumer Electronics Association/Electronic Industries Alliance 861 standards. HDMI 1.0 to HDMI 1.2a uses the EIA/CEA-861-B video standard, HDMI 1.3 uses the CEA-861-D video standard, and HDMI 1.4 uses the CEA-861-E video standard.

The CEA-861-E document defines "video formats and waveforms; colorimetric and quantization; transport of compressed and uncompressed, as well as Linear Pulse Code Modulation (LPCM), audio; carriage of auxiliary data; and implementations of the Video Electronics Standards Association (VESA) Enhanced Extended Display Identification Data Standard (E-EDID)"On July 15, 2013, the CEA announced the publication of CEA-861-F which is a standard that can be used by interfaces such as DVI, HDMI, and LVDS.CEA-861-F adds the ability to transmit several Ultra HD video formats and additional color spaces.

VERSIONS

HDMI devices are manufactured to adhere to various versions of the specification, in which each version is given a number and/or letter, such as 1.0, 1.2, or 1.4b

VERSION 1.0

HDMI 1.0 was released December 9, 2002 and is a single-cable digital audio/video connector interface with a maximum TMDS bandwidth of 4.95 Gbit/s. It defines up to 3.96 Gbit/s of video bandwidth (1080p/60 Hz or UXGA) and 8 channel LPCM/192 kHz/24-bit audio.

VERSION 1.1

HDMI 1.1 was released on May 20, 2004 and added DVD-Audio.

VERSION 1.2

HDMI 1.2 was released August 8, 2005 and added the option of One Bit Audio, used on Super Audio CDs, at up to 8 channels. It also added the availability of HDMI type A connectors for PC sources, the ability for PC sources to implement only the sRGB color space while retaining the option to implement the YCbCr color space, and required HDMI 1.2 and later displays to allow low-voltage sources.

HDMI 1.2a was released on December 14, 2005 and fully specifies Consumer Electronic Control (CEC) features, command sets and CEC compliance tests.

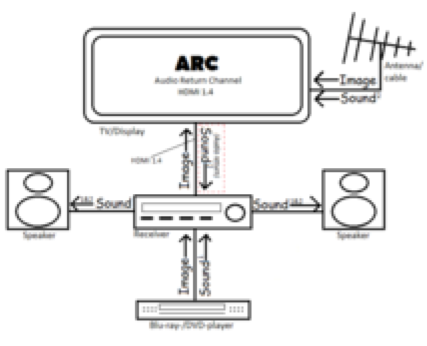
VERSION 1.3

HDMI 1.3 was released June 22, 2006 and increased the single-link bandwidth to 340 MHz (10.2 Gbit/s).It optionally allows deep color, with 30-bit, 36-bit and 48-bit xvYCC, sRGB, or YCbCr, compared to 24-bit SRGB or YCbCr in previous HDMI versions. It also optionally allows output of Dolby True HD and DTS-HD Master Audio streams for external decoding by AV receivers.

HDMI 1.3a was released on November 10, 2006 and had Cable and Sink modifications for type C, source termination recommendations, and removed undershoot and maximum rise/fall time limits.

HDMI 1.3b, 1.3b1 and 1.3c were released on March 26, 2007, November 9, 2007, and August 25, 2008 respectively. They do not introduce differences on HDMI features, functions, or performance, but only describe testing for products based on the HDMI 1.3a specification regarding HDMI compliance the HDMI type C Mini connector and active HDMI cables

VERSION 1.4



HDMI 1.4 with audio return channel

HDMI 1.4 was released on May 28, 2009, and the first HDMI 1.4 products were available in the second half of 2009. HDMI 1.4 increases the maximum resolution to 4K × 2K, i.e. 4096×2160 at 24 Hz (which is a resolution used with digital theatres) or 3840×2160 (Ultra HD) at 24 Hz/25 Hz/30 Hz; adds an HDMI Ethernet Channel (HEC), which allows for a

100 Mbit/s Ethernet connection between the two HDMI connected devices so they can share an Internet connection.

4.4 Pi CAMERA

6.0 Camera Hardware

This chapter provides an overview of how the camera works under various conditions, as well as an introduction to the software interface that picamera uses.

6.1. Theory of Operation

Many questions I receive regarding picamera are based on misunderstandings of how the camera works. This chapter attempts to correct those misunderstandings and gives the reader a basic description of the operation of the camera. The chapter deliberately follows a lie-to-children model, presenting first a technically inaccurate but useful model of the camera's operation, then refining it closer to the truth later on.

6.1.1. Misconception #1

The Pi's camera module is basically a mobile phone camera module. Mobile phone digital cameras differ from larger, more expensive, cameras (DSLRs) in a few respects. The most important of these, for understanding the Pi's camera, is that many mobile cameras (including the Pi's camera module) use a rolling shutter to capture images. When the camera needs to capture an image, it reads out pixels from the sensor a row at a time rather than capturing all pixel values at once.

In fact, the "global shutter" on DSLRs typically also reads out pixels a row at a time. The major difference is that a DSLR will have a physical shutter that covers the sensor. Hence in a DSLR the procedure for capturing an image is to open the shutter, letting the sensor "view" the scene, close the shutter, then read out each line from the sensor.

The notion of "capturing an image" is thus a bit misleading as what we actually mean is "reading each row from the sensor in turn and assembling them back into an image".

6.1.2. Misconception #2

The notion that the camera is effectively idle until we tell it to capture a frame is also misleading. Don't think of the camera as a still image camera. Think of it as a video camera. Specifically one that, as soon as it is initialized, is constantly streaming frames (or rather rows of frames) down the ribbon cable to the Pi for processing.

The camera may seem idle, and your script may be doing nothing with the camera, but still numerous tasks are going on in the background (automatic gain control, exposure time, white balance, and several other tasks which we'll cover later on).

This background processing is why most of the picamera example scripts seen in prior chapters include a `sleep(2)` line after initializing the camera. The `sleep(2)` statement pauses your script for a couple of seconds. During this pause, the camera's firmware continually receives rows of frames from the camera and adjusts the sensor's gain and exposure times to make the frame look "normal" (not over- or under-exposed, etc).

So when we request the camera to "capture a frame" what we're really requesting is that the camera give us the next complete frame it assembles, rather than using it for gain and exposure then discarding it (as happens constantly in the background otherwise).

6.1.3. Exposure time

What does the camera sensor *actually detect*? It detects photon counts; the more photons that hit the sensor elements, the more those elements increment their counters. As our camera has no physical shutter (unlike a DSLR) we can't prevent light falling on the elements and incrementing the counts. In fact we can only perform two operations on the sensor: reset a row of elements, or read a row of elements.

6.1.3.1. Minimum exposure time

There are naturally limits to the minimum exposure time: reading out a line of elements must take a certain minimum time. For example, if there are 500 rows on our hypothetical sensor, and reading each row takes a minimum of 20ns then it will take a minimum of to read a full frame. This is the *minimum* exposure time of our hypothetical sensor.

6.1.3.2. Maximum framerate is determined by the minimum exposure time

The framerate is the number of frames the camera can capture per second. Depending on the time it takes to capture one frame, the exposure time, we can only capture so many frames in a specific amount of time. For example, if it takes 10ms to read a full frame, then we cannot capture more than frames in a second. Hence the maximum framerate of our hypothetical 500 row sensor is 100fps.

This can be expressed in the word equation: from which we can see the inverse relationship. The lower the minimum exposure time, the larger the maximum framerate and vice versa.

6.1.3.3. Maximum exposure time is determined by the minimum framerate

To maximise the exposure time we need to capture as few frames as possible per second, i.e. we need a very low framerate. Therefore the *maximum* exposure time is determined by the camera's *minimum* framerate. The minimum framerate is largely determined by how slow the sensor can be made to read lines (at the hardware level this is down to the size of registers for holding things like line read-out times).

This can be expressed in the word equation:

If we imagine that the minimum framerate of our hypothetical sensor is ½fps then the maximum exposure time will be .

6.1.3.4. Exposure time is limited by current framerate

More generally, the **framerate** setting of the camera limits the maximum exposure time of a given frame. For example, if we set the framerate to 30fps, then we cannot spend more than capturing any given frame.

Therefore, the **exposure_speed** attribute, which reports the exposure time of the last processed frame (which is really a multiple of the sensor's line read-out time) is limited by the camera's **framerate**.

6.1.4. Sensor gain

The other important factor influencing sensor element counts, aside from line read-out time, is the sensor's gain. Specifically, the gain given by the **analog_gain** attribute (the corresponding **digital_gain** is simply post-processing which we'll cover later). However, there's an obvious issue: how is this gain "analog" if we're dealing with digital photon counts?

Time to reveal the first lie: the sensor elements are not simple digital counters but are in fact analog components that build up charge as more photons hit them. The analog gain influences how this charge is built-up. An analog-to-digital converter (ADC) is used to convert the analog charge to a digital value during line read-out (in fact the ADC's speed is a large portion of the minimum line read-out time).

The analog gain cannot be *directly* controlled in picamera, but various attributes can be used to "influence" it.

- Setting **exposure_mode** to 'off' locks the analog (and digital) gains at their current values and doesn't allow them to adjust at all, no matter what happens to the scene, and no matter what other camera attributes may be adjusted.
- Setting **exposure_mode** to values other than 'off' permits the gains to "float" (change) according to the auto-exposure mode selected. Where possible, the camera firmware prefers to adjust the analog gain rather than the digital gain, because increasing the digital gain produces more noise. Some examples of the adjustments made for different auto-exposure modes include:
    - 'sports' reduces motion blur by preferentially increasing gain rather than exposure time (i.e. line read-out time).
    - 'night' is intended as a stills mode, so it permits very long exposure times while attempting to keep gains low.
- The **iso** attribute effectively represents another set of auto-exposure modes with specific gains:
    - With the V1 camera module, ISO 100 attempts to use an overall gain of 1.0. ISO 200 attempts to use an overall gain of 2.0, and so on.
    - With the V2 camera module, ISO 100 produces an overall gain of ~1.84. ISO 60 produces overall gain of 1.0, and ISO 800 of 14.72 (the V2 camera module was calibrated against the ISO film speed standard).

  Hence, one might be tempted to think that **iso** provides a means of fixing the gains, but this isn't entirely true: the **exposure_mode** setting takes precedence (setting the exposure mode to 'off' will fix the gains no matter what ISO is later set, and some exposure modes like 'spotlight' also override ISO-adjusted gains).

6.1.5. Division of labor

At this point, a reader familiar with operating system theory may be questioning how a non real-time operating system (non-RTOS) like Linux could possibly be reading lines from the sensor? After all, to ensure each line is read in exactly the same amount of time (to ensure a constant exposure over the whole frame) would require extremely precise timing, which cannot be achieved in a non-RTOS.

Time to reveal the second lie: lines are not actively "read" from the sensor. Rather, the sensor is configured (via its registers) with a time per line and number of lines to read. Once started, the sensor simply reads lines, pushing the data out to the Pi at the configured speed.

That takes care of how each line's read-out time is kept constant, but it still doesn't answer the question of how we can guarantee that Linux is actually listening and ready to accept each line of data? The answer is quite simply that Linux *doesn't*. The CPU doesn't talk to the camera directly. In fact, none of the camera processing occurs on the CPU (running Linux) at all. Instead, it is done on the Pi's GPU (VideoCore IV) which is running its own real-time OS (VCOS).

The following diagram illustrates that the BCM2835 system on a chip (SoC) is comprised of an ARM Cortex CPU running Linux (under which is running `myscript.py` which is using picamera), and a VideoCore IV GPU running VCOS. The VideoCore Host Interface (VCHI) is a message passing system provided to permit communication between these two components. The available RAM is split between the two components (128Mb is a typical GPU memory split when using the camera). Finally, the camera module is shown above the SoC. It is connected to the SoC via a CSI-2 interface (providing 2Gbps of bandwidth).

The scenario depicted is as follows:

1. The camera's sensor has been configured and is continually streaming frame lines over the CSI-2 interface to the GPU.
2. The GPU is assembling complete frame buffers from these lines and performing post-processing on these buffers (we'll go into further detail about this part in the next section).
3. Meanwhile, over on the CPU, `myscript.py` makes a `capture` call using picamera.

4. The picamera library in turn uses the MMAL API to enact this request (actually there's quite a lot of MMAL calls that go on here but for the sake of simplicity we represent all this with a single arrow).
5. The MMAL API sends a message over VCHI requesting a frame capture (again, in reality there's a lot more activity than a single message).
6. In response, the GPU initiates a DMA transfer of the next complete frame from its portion of RAM to the CPU's portion.
7. Finally, the GPU sends a message back over VCHI that the capture is complete.
8. This causes an MMAL thread to fire a callback in the picamera library, which in turn retrieves the frame (in reality, this requires more MMAL and VCHI activity).
9. Finally, picamera calls `write` on the output object provided by `myscript.py`.

6.1.6. Background processes

We've alluded briefly to some of the GPU processing going on in the sections above (gain control, exposure time, white balance, frame encoding, etc). Time to reveal the final lie: the GPU is not, as depicted in the prior section, one discrete component. Rather it is composed of numerous components each of which play a role in the camera's operation.

The diagram below depicts a more accurate representation of the GPU side of the BCM2835 SoC. From this we get our first glimpse of the frame processing "pipeline" and why it is called such. In the diagram, an H264 video is being recorded. The components that data passes through are as follows:

1. Starting at the camera module, some minor processing happens. Specifically, flips (horizontal and vertical), line skipping, and pixel binning are configured on the sensor's registers. Pixel binning actually happens on the sensor itself, prior to the ADC to improve signal-to-noise ratios. See **`hflip`**, **`vflip`**, and **`sensor_mode`**.
2. As described previously, frame lines are streamed over the CSI-2 interface to the GPU. There, it is received by the Unicam component which writes the line data into RAM.
3. Next the GPU's image signal processor (ISP) performs several post-processing steps on the frame data.

   These include (in order):

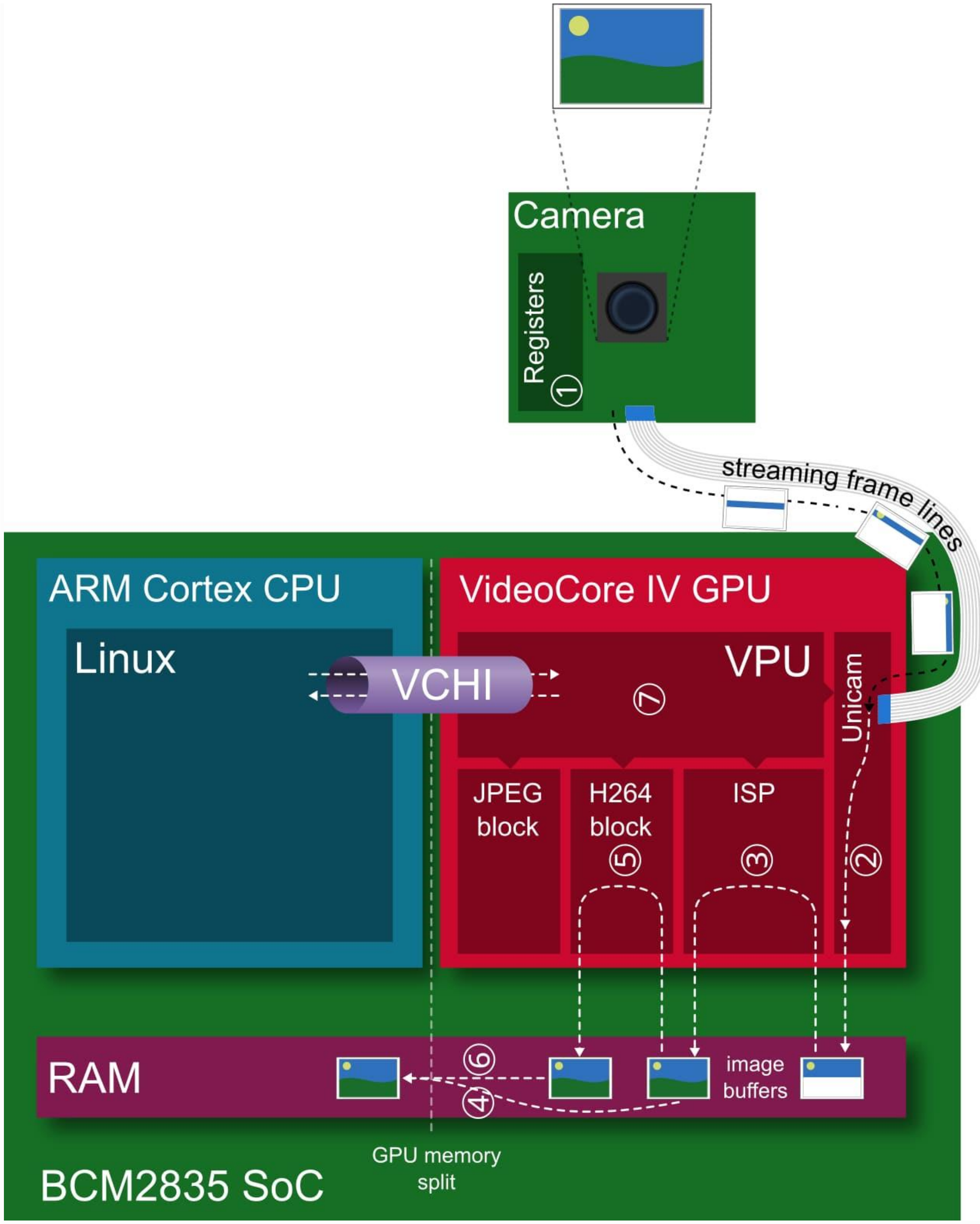
- **Transposition**: If any rotation has been requested, the input is transposed to rotate the image (rotation is always implemented by some combination of transposition and flips).
- **Black level compensation**: Use the non-light sensing elements (typically in a covered border) to determine what level of charge represents "optically black".
- **Lens shading**: The camera firmware includes a table that corrects for chromatic distortion from the standard module's lens. This is one reason why third party modules incorporating different lenses may show non-uniform color across a frame.
- **White balance**: The red and blue gains are applied to correct the color balance. See **awb_gains** and **awb_mode**.
- **Digital gain**: As mentioned above, this is a straight-forward post-processing step that applies a gain to the Bayer values. See **digital_gain**.
- **Bayer de-noise**: This is a noise reduction algorithm run on the frame data while it is still in Bayer format.
- **De-mosaic:** The frame data is converted from Bayer format to YUV420 which is the format used by the remainder of the pipeline.
- **YUV de-noise**: Another noise reduction algorithm, this time with the frame in YUV420 format. See **image_denoise** and **video_denoise**.
- **Sharpening**: An algorithm to enhance edges in the image. See **sharpness**.
- **Color processing**: The **brightness**, **contrast**, and **saturation** adjustments are implemented.
- **Distortion**: The distortion introduced by the camera's lens is corrected. At present this stage does nothing as the stock lens isn't a fish-eye lens; it exists as an option should a future sensor require it.
- **Resizing**: At this point, the frame is resized to the requested output resolution (all prior stages have been performed on "full" frame data at whatever resolution the sensor is configured to produce). See **resolution**.

Some of these steps can be controlled directly (e.g. brightness, noise reduction), others can only be influenced (e.g. analog and digital gain), and the remainder are not user-configurable at all (e.g. demosaic and lens shading).

At this point the frame is effectively "complete".

4. If you are producing "unencoded" output (YUV, RGB, etc.) the pipeline ends at this point, with the frame data getting copied over to the CPU via DMA. The ISP might be used to convert to RGB, but that's all.

5. If you are producing encoded output (H264, MJPEG, MPEG2, etc.) the next step is one of the encoding blocks, the H264 block in this case. The encoding blocks are specialized hardware designed specifically to produce particular encodings. For example, the JPEG block will include hardware for performing lots of parallel discrete cosine transforms (DCTs), while the H264 block will include hardware for performing motion estimation.
6. Once encoded, the output is copied to the CPU via DMA.
7. Coordinating these components is the VPU, the general purpose component in the GPU running VCOS (ThreadX). The VPU configures and controls the other components in response to messages from VCHI. Currently the most complete documentation of the VPU is available from the Video Core IV repository.



6.1.7. Feedback loops

There are a couple of feedback loops running within the pipeline described above.
When **exposure_mode** is not 'off', automatic gain control (AGC) gathers statistics from each frame (prior to the de-mosaic phase in the ISP). It tweaks the analog and digital gains, and the

exposure time (line read-out time) attempting to nudge subsequent frames towards a target Y (luminance) value.

Likewise, when **awb_mode** is not 'off', automatic white balance (AWB) gathers statistics from frames (again, prior to de-mosaic). Typically AWB analysis only occurs on 1 out of every 3 streamed frames as it is computationally expensive. It adjusts the red and blue gains (**awb_gains**) attempting to nudge subsequent frames towards the expected color balance.

You can observe the effect of the AGC loop quite easily during daylight. Ensure the camera module is pointed at something bright like the sky or the view through a window, and query the camera's analog gain and exposure time:

```
>>> camera = PiCamera()
>>> camera.start_preview(alpha=192)
>>> float(camera.analog_gain)
1.0
>>> camera.exposure_speed
3318
```

Force the camera to use a higher gain by setting **iso** to 800. If you have the preview running, you'll see very little difference in the scene. However, if you subsequently query the exposure time you'll find the firmware has drastically reduced it to compensate for the higher sensor gain:

```
>>> camera.iso = 800
>>> camera.exposure_speed
198
```

You can force a longer exposure time with the **shutter_speed** attribute at which point the scene will become quite washed out (because both the gain and exposure time are now fixed). If you let the gain float again by setting **iso** back to automatic (0) you should find the gain reduces accordingly and the scene returns more or less to normal:

```
>>> camera.shutter_speed = 4000
>>> camera.exposure_speed
3998
>>> camera.iso = 0
>>> float(camera.analog_gain)
1.0
```

The camera’s AGC loop attempts to produce a scene with a target Y (luminance) value (or values) within the constraints set by things like ISO, shutter speed, and so forth. The target Y’ value can be adjusted with the **exposure_compensation** attribute which is measured in increments of 1/6th of an f-stop. So if, whilst the exposure time is fixed, you increase the luminance that the camera is aiming for by a couple of stops, then wait a few seconds you should find that the gain has increased accordingly:

```
>>> camera.exposure_compensation = 12
>>> float(camera.analog_gain)
1.48046875
```

If you allow the exposure time to float once more (by setting **shutter_speed** back to 0), then wait a few seconds, you should find the analog gain decreases back to 1.0, but the exposure time increases to maintain the deliberately over-exposed appearance of the scene:

```
>>> camera.shutter_speed = 0
>>> float(camera.analog_gain)
1.0
>>> camera.exposure_speed
4244
```

6.2. Sensor Modes

The Pi’s camera modules have a discrete set of modes that they can use to output data to the GPU. On the V1 module these are as follows:

#	Resolution	Aspect Ratio	Framerates	Video	Image	FoV	Binning
1	1920x1080	16:9	1 < fps <= 30	x		Partial	None
2	2592x1944	4:3	1 < fps <= 15	x	x	Full	None
3	2592x1944	4:3	1/6 <= fps <= 1	x	x	Full	None
4	1296x972	4:3	1 < fps <= 42	x		Full	2x2
5	1296x730	16:9	1 < fps <=	x		Full	2x2

#	Resolution	Aspect Ratio	Framerates	Video	Image	FoV	Binning
			49				
6	640x480	4:3	42 < fps <= 60	x		Full	4x4
7	640x480	4:3	60 < fps <= 90	x		Full	4x4

On the V2 module, these are:

#	Resolution	Aspect Ratio	Framerates	Video	Image	FoV	Binning
1	1920x1080	16:9	1/10 <= fps <= 30	x		Partial	None
2	3280x2464	4:3	1/10 <= fps <= 15	x	x	Full	None
3	3280x2464	4:3	1/10 <= fps <= 15	x	x	Full	None
4	1640x1232	4:3	1/10 <= fps <= 40	x		Full	2x2
5	1640x922	16:9	1/10 <= fps <= 40	x		Full	2x2
6	1280x720	16:9	40 < fps <= 90	x		Partial	2x2
7	640x480	4:3	40 < fps <= 90	x		Partial	2x2

Modes with full field of view (FoV) capture from the whole area of the camera's sensor (2592x1944 pixels for the V1 camera, 3280x2464 for the V2 camera). Modes with partial FoV capture from the center of the sensor. The combination of FoV limiting, and binning is used to achieve the requested resolution.

The image below illustrates the difference between full and partial field of view for the V1 camera:

While the various fields of view for the V2 camera are illustrated in the following image:

The sensor's mode can be forced with the *sensor_mode* parameter in the **PiCamera** constructor (using one of the values from the # column in the tables above). This parameter defaults to 0 indicating that the mode should be selected automatically based on the requested **resolution** and **framerate**. The rules governing which sensor mode is selected are as follows:

- The capture mode must be acceptable. All modes can be used for video recording, or for image captures from the video port (i.e. when *use_video_port* is True in calls to the various capture methods). Image captures when *use_video_port* is False must use an image mode (of which only two exist, both with the maximum resolution).
- The closer the requested **resolution** is to the mode's resolution the better, but downscaling from a higher sensor resolution to a lower output resolution is preferable to upscaling from a lower sensor resolution.
- The requested **framerate** should be within the range of the sensor mode.

- The closer the aspect ratio of the requested **resolution** to the mode's resolution, the better. Attempts to set resolutions with aspect ratios other than 4:3 or 16:9 (which are the only ratios directly supported by the modes in the tables above) will choose the mode which maximizes the resulting field of view (FoV).

A few examples are given below to clarify the operation of this heuristic (note these examples assume the V1 camera module):

- If you set the **resolution** to 1024x768 (a 4:3 aspect ratio), and **framerate** to anything less than 42fps, the 1296x972 mode (4) will be selected, and the GPU will downscale the result to 1024x768.
- If you set the **resolution** to 1280x720 (a 16:9 wide-screen aspect ratio), and **framerate** to anything less than 49fps, the 1296x730 mode (5) will be selected and downscaled appropriately.
- Setting **resolution** to 1920x1080 and **framerate** to 30fps exceeds the resolution of both the 1296x730 and 1296x972 modes (i.e. they would require upscaling), so the 1920x1080 mode (1) is selected instead, despite it having a reduced FoV.
- A **resolution** of 800x600 and a **framerate** of 60fps will select the 640x480 60fps mode, even though it requires upscaling because the algorithm considers the framerate to take precedence in this case.
- Any attempt to capture an image without using the video port will (temporarily) select the 2592x1944 mode while the capture is performed (this is what causes the flicker you sometimes see when a preview is running while a still image is captured).

6.3. Hardware Limits

The are additional limits imposed by the GPU hardware that performs all image and video processing:

- The maximum resolution for MJPEG recording depends partially on GPU memory. If you get "Out of resource" errors with MJPEG recording at high resolutions, try increasing `gpu_mem` in `/boot/config.txt`.
- The maximum horizontal resolution for default H264 recording is 1920 (this is a limit of the H264 block in the GPU). Any attempt to record H264 video at higher horizontal resolutions will fail.

- The maximum resolution of the V2 camera may require additional GPU memory when operating at low framerates (<1fps). Increase `gpu_mem` in `/boot/config.txt` if you encounter "out of resources" errors when attempting long-exposure captures with a V2 module.
- The maximum resolution of the V2 camera can also cause issues with previews. Currently, picamera runs previews at the same resolution as captures (equivalent to `-fp` in `raspistill`). You may need to increase `gpu_mem` in `/boot/config.txt` to achieve full resolution operation with the V2 camera module, or configure the preview to use a lower **resolution** than the camera itself.
- The maximum framerate of the camera depends on several factors. With overclocking, 120fps has been achieved on a V2 module but 90fps is the maximum supported framerate.
- The maximum exposure time is currently 6 seconds on the V1 camera module, and 10 seconds on the V2 camera module. Remember that exposure time is limited by framerate, so you need to set an extremely slow **framerate** before setting **shutter_speed**.

6.4. MMAL

The MMAL layer below picamera provides a greatly simplified interface to the camera firmware running on the GPU. Conceptually, it presents the camera with three "ports": the still port, the video port, and the preview port. The following sections describe how these ports are used by picamera and how they influence the camera's behaviour.

6.4.1. The Still Port

Firstly, the still port. Whenever this is used to capture images, it (briefly) forces the camera's mode to one of the two supported still modes (see Sensor Modes) so that images are captured using the full area of the sensor. It also uses a strong noise reduction algorithm on captured images so that they appear higher quality.

The still port is used by the various **capture()** methods when their *use_video_port* parameter is `False` (which it is by default).

6.4.2. The Video Port

The video port is somewhat simpler in that it never changes the camera's mode. The video port is used by the **start_recording()** method (for recording video), and is also used by the various **capture()** methods when their *use_video_port* parameter is `True`. Images captured from the video port tend to have a “grainy” appearance, much more akin to a video frame than the images captured by the still port (this is due to the still port using the stronger noise reduction algorithm).

6.4.3. The Preview Port

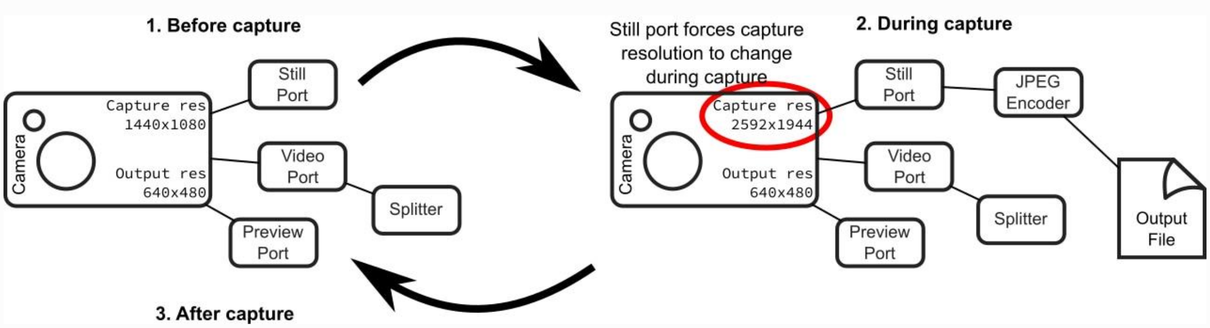
The preview port operates more or less identically to the video port. The preview port is always connected to some form of output to ensure that the auto-gain algorithm can run. When an instance of **PiCamera** is constructed, the preview port is initially connected to an instance of **PiNullSink**. When **start_preview()** is called, this null sink is destroyed and the preview port is connected to an instance of **PiPreviewRenderer**. The reverse occurs when **stop_preview()** is called.

6.4.4. Pipelines

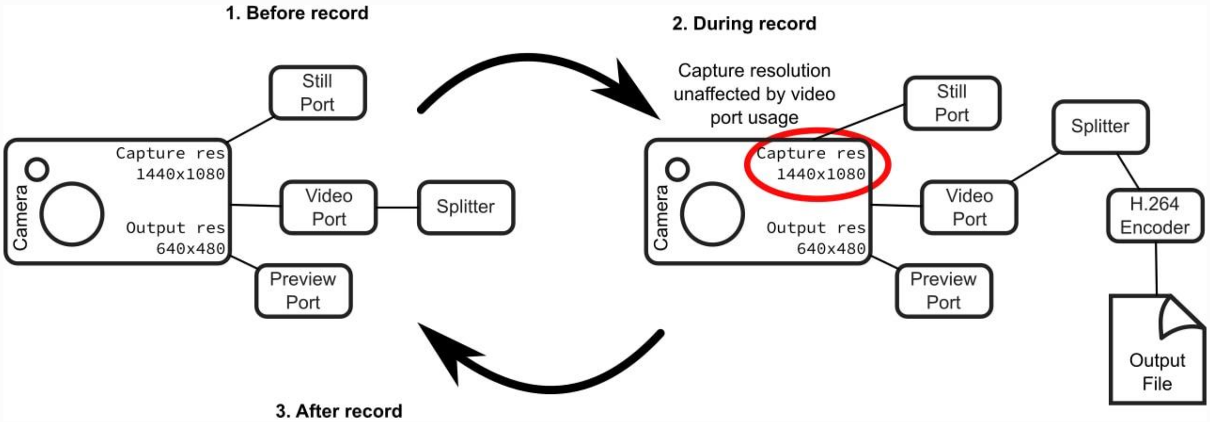
This section attempts to provide detail of what MMAL pipelines picamera constructs in response to various method calls.

The firmware provides various encoders which can be attached to the still and video ports for the purpose of producing output (e.g. JPEG images or H.264 encoded video). A port can have a single encoder attached to it at any given time (or nothing if the port is not in use).

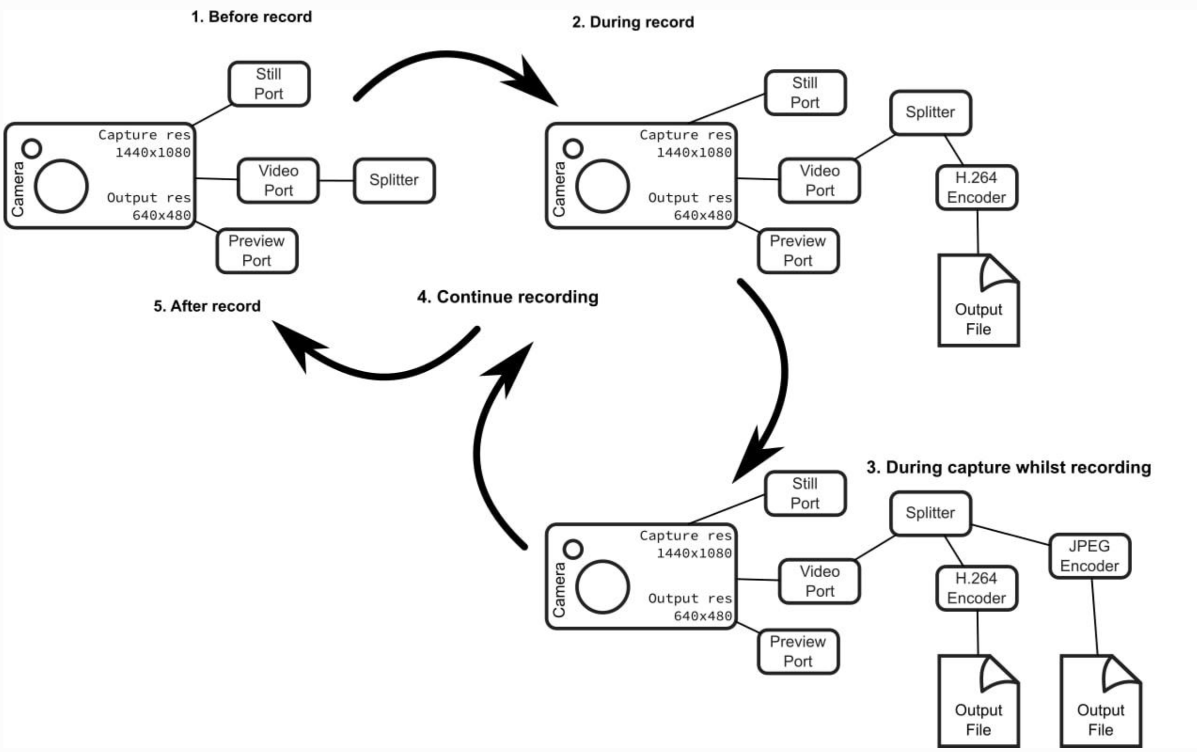
Encoders are connected directly to the still port. For example, when capturing a picture using the still port, the camera’s state conceptually moves through these states:



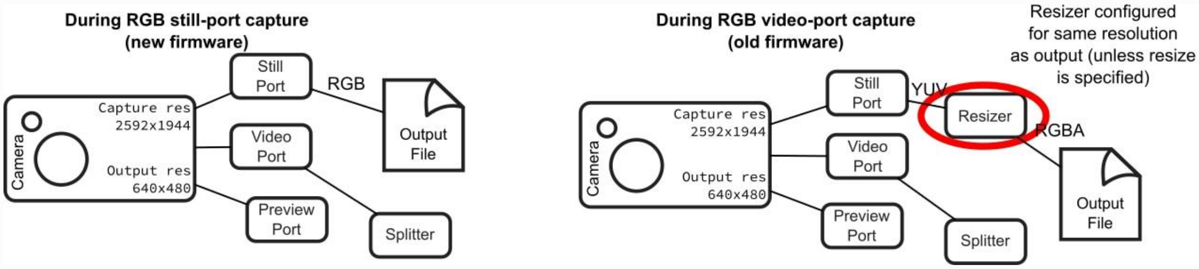
As you have probably noticed in the diagram above, the video port is a little more complex. In order to permit simultaneous video recording and image capture via the video port, a “splitter” component is permanently connected to the video port by picamera, and encoders are in turn attached to one of its four output ports (numbered 0, 1, 2, and 3). Hence, when recording video the camera's setup looks like this:



And when simultaneously capturing images via the video port whilst recording, the camera's configuration moves through the following states:



When the `resize` parameter is passed to one of the aforementioned methods, a resizer component is placed between the camera's ports and the encoder, causing the output to be resized before it reaches the encoder. This is particularly useful for video recording, as the H.264 encoder cannot cope with full resolution input (the GPU hardware can only handle frame widths up to 1920 pixels). Hence, when performing full frame video recording, the camera's setup looks like this:



Finally, when performing unencoded captures an encoder is (naturally) not required. Instead data is taken directly from the camera's ports. However, various firmware limitations require acrobatics in the pipeline to achieve requested encodings.

For example, in older firmwares the camera's still port cannot be configured for RGB output (due to a faulty buffer size check). However, they can be configured for YUV output so in this case picamera configures the still port for YUV output, attaches as resizer (configured with the same input and output resolution), then configures the resizer's output for RGBA (the resizer doesn't support RGB for some reason). It then runs the capture and strips the redundant alpha bytes off the data.

Recent firmwares fix the buffer size check, so with these picamera will simply configure the still port for RGB output (since 1.11):

6.4.5. Encodings

The ports used to connect MMAL components together pass image data around in particular encodings. Often, this is the YUV420 encoding (this is the "preferred" internal format for the pipeline). On rare occasions, it is RGB (RGB is a large and rather inefficient format). However, another format sometimes used is the "OPAQUE" encoding.

“OPAQUE” is the most efficient encoding to use when connecting MMAL components as it simply passes pointers around under the hood rather than full frame data (as such it’s not really an encoding at all, but it’s treated as such by the MMAL framework). However, not all OPAQUE encodings are equivalent:

- The preview port’s OPAQUE encoding contains a single image.
- The video port’s OPAQUE encoding contains two images (used for motion estimation by various encoders).
- The still port’s OPAQUE encoding contains strips of a single image.
- The JPEG image encoder accepts the still port’s OPAQUE strips format.
- The MJPEG video encoder does *not* accept the OPAQUE strips format, only the single and dual image variants provided by the preview or video ports.
- The H264 video encoder in older firmwares only accepts the dual image OPAQUE format (it will accept full-frame YUV input instead though). In newer firmwares it now accepts the single image OPAQUE format too (presumably constructing the second image itself for motion estimation).
- The splitter accepts single or dual image OPAQUE input, but only outputs single image OPAQUE input (or YUV; in later firmwares it also supports RGB or BGR output).
- The VPU resizer (`MMALResizer`) theoretically accepts OPAQUE input (though the author hasn’t managed to get this working at the time of writing) but will only produce YUV, RGBA, and BGRA output, not RGB or BGR.
- The ISP resizer (`MMALISPResizer` , not currently used by picamera’s high level API, but available from the `mmalobj` layer) accepts OPAQUE input, and will produce almost any unencoded output (including YUV, RGB, BGR, RGBA, and BGRA) but not OPAQUE.

The `mmalobj` layer introduced in picamera 1.11 is aware of these OPAQUE encoding differences and attempts to configure connections between components using the most efficient formats possible. However, it is not aware of firmware revisions so if you’re playing with MMAL components via this layer be prepared to do some tinkering to get your pipeline working.

Please note that the description above is MMAL’s greatly simplified presentation of the imaging pipeline. This is far removed from what actually happens at the GPU’s ISP level (described roughly in earlier sections). However, as MMAL is the API under-pinning the picamera library (along with the official `raspistill` and `raspivid` applications) it is worth understanding.

In other words, by using picamera you are passing through (at least) two abstraction layers which necessarily obscure (but hopefully simplify) the “true” operation of the camera.

4.5 GSM

GSM is a mobile communication modem; it is stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.

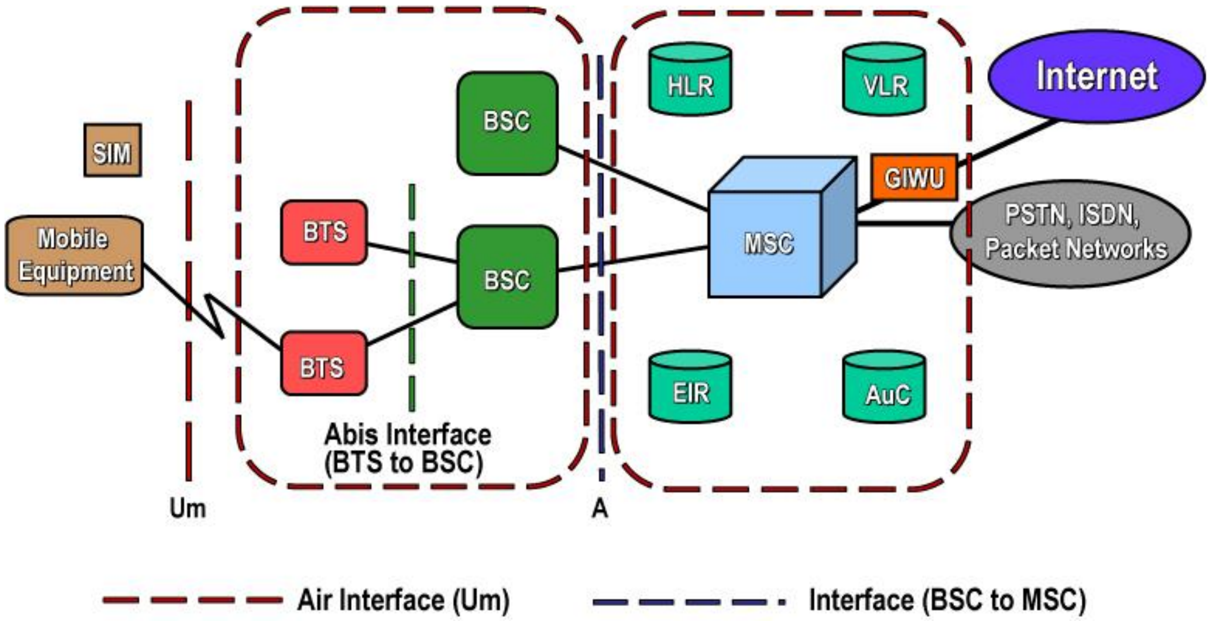
GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates.

There are various cell sizes in a GSM system such as macro, micro, pico and umbrella cells. Each cell varies as per the implementation domain. There are five different cell sizes in a GSM network macro, micro, pico and umbrella cells. The coverage area of each cell varies according to the implementation environment.

GSM ARCHITECTURE

A GSM network consists of the following components:

- **A Mobile Station:** It is the mobile phone which consists of the transceiver, the display and the processor and is controlled by a SIM card operating over the network.
- **Base Station Subsystem:** It acts as an interface between the mobile station and the network subsystem. It consists of the Base Transceiver Station which contains the radio transceivers and handles the protocols for communication with mobiles. It also consists of the Base Station Controller which controls the Base Transceiver station and acts as a interface between the mobile station and mobile switching centre.
- **Network Subsystem:** It provides the basic network connection to the mobile stations. The basic part of the Network Subsystem is the Mobile Service Switching Centre which provides access to different networks like ISDN, PSTN etc. It also consists of the Home Location Register and the Visitor Location Register which provides the call routing and roaming capabilities of GSM. It also contains the Equipment Identity Register which maintains an account of all the mobile equipments wherein each mobile is identified by its own IMEI number. IMEI stands for International Mobile Equipment Identity.



GSM MODEM WORKING PRINCIPLE

A GSM modem is a device which can be either a mobile phone or a modem device which can be used to make a computer or any other processor communicate over a network. A GSM modem requires a SIM card to be operated and operates over a network range subscribed by the network operator. It can be connected to a computer through serial, USB or Bluetooth connection.

A GSM modem can also be a standard GSM mobile phone with the appropriate cable and software driver to connect to a serial port or USB port on your computer. GSM modem is usually preferable to a GSM mobile phone. The GSM modem has wide range of applications in transaction terminals, supply chain management, security applications, weather stations and GPRS mode remote data logging.

Some GSM Modems also has GPRS feature that allows tramission of data over TCP/IP (internet).To transmit data using GSM Modem, there are various methods that can be used, such as:

- SMS
- CSD or HSCSD
- GPRS / UMTS

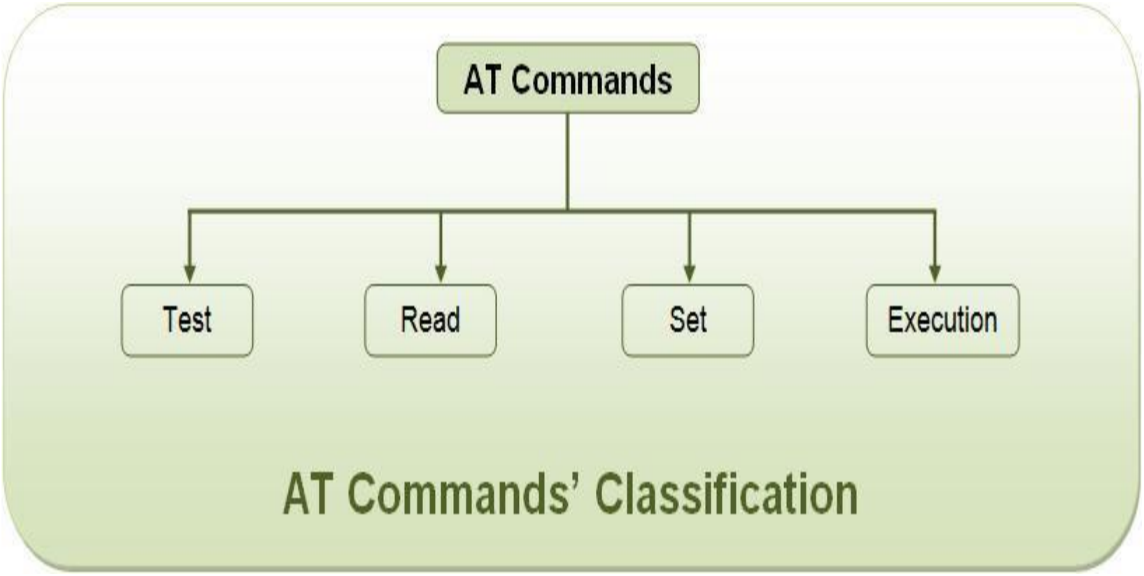
AT commands with a GSM/GPRS MODEM or mobile phone can be used to access following information and services:

- Information and configuration pertaining to mobile device or MODEM and SIM card.
- SMS services.
- MMS services.
- Fax services.
- Data and Voice link over mobile network.

TYPES OF AT COMMANDS

There are two types of AT commands:

- **Basic commands** are AT commands that do not start with "+". For example, D (Dial), A (Answer), H (Hook control), and O (Return to online data state) are basic commands.
- **Extended commands** are AT commands that start with "+". All GSM AT commands are extended commands. For example, +CMGS (Send SMS message), +CMGL (List SMS messages), and +CMGR (Read SMS messages) are extended commands.



- Reading, writing and deleting SMS messages.
- Sending SMS messages.
- Monitoring the signal strength.
- Monitoring the charging status and charge level of the battery.
- Reading, writing and searching phone book entries.

The number of SMS messages that can be processed by a GSM modem per minute is very low only about six to ten SMS messages per minute.Here are some of the tasks that can be done using AT commands with a GSM/GPRS modem or mobile phone:

- Get basic information about the mobile phone or GSM/GPRS modem. For example, name of the manufacturer (AT+CGMI), model number (AT+CGMM), IMEI number (International Mobile Equipment Identity) (AT+CGSN), and the software version (AT+CGMR).
- Get basic information about the subscriber. For example, MSISDN (AT+CNUM) and IMSI number (International Mobile Subscriber Identity) (AT+CIMI).
- Get the current status of the mobile phone or GSM/GPRS modem. For example, mobile phone activity status (AT+CPAS), mobile network registration status (AT+CREG), radio signal strength (AT+CSQ), battery charge level, and battery charging status (AT+CBC).
- Establish a data connection or voice connection to a remote modem (ATD, ATA, etc.).
- Send and receive fax (ATD, ATA, AT+F*).

- Send (AT+CMGS, AT+CMSS), read (AT+CMGR, AT+CMGL), write (AT+CMGW), or delete (AT+CMGD) SMS messages and obtain notifications of newly received SMS messages (AT+CNMI).
- Read (AT+CPBR), write (AT+CPBW), or search (AT+CPBF) phonebook entries.
- Perform security-related tasks, such as opening or closing facility locks (AT+CLCK), checking whether a facility is locked (AT+CLCK), and changing passwords (AT+CPWD). (Facility lock examples: SIM lock [a password must be given to the SIM card every time the mobile phone is switched on] and PH-SIM lock [a certain SIM card is associated with the mobile phone; to use other SIM cards with the mobile phone, a password must be entered.])
- Control the presentation of result codes / error messages of AT commands. For example, you can control whether to enable certain error messages (AT+CMEE), and whether error messages should be displayed in numeric format or verbose format (AT+CMEE=1 or AT+CMEE=2).
- Get or change the configurations of the mobile phone or GSM/GPRS modem. For example, change the GSM network (AT+COPS), bearer service type (AT+CBST), radio link protocol parameters (AT+CRLP), SMS centre address (AT+CSCA), and storage of SMS messages (AT+CPMS).
- Save and restore configurations of the mobile phone or GSM/GPRS modem. For example, save (AT+CSAS) and restore (AT+CRES) settings related to SMS messaging such as the SMS centre address.

FEATURES:

- GSM supports multiple frequency levels like 900 MHz, 1800 MHz, 1900 MHz. 1900MHz frequency is used.
- GSM technology facilitates with high speed integrated data, voice data, fax, mail, voice mail and mostly used SMS feature.
- GSM also make sure that all the communication made between networks are secured and protected from intruders and frauds.

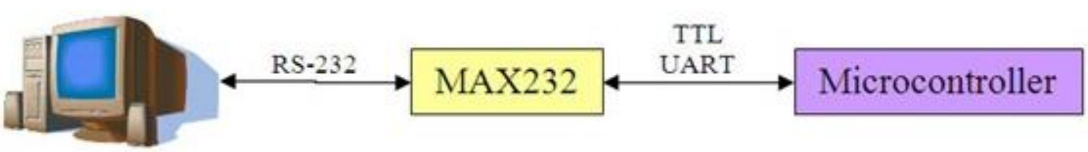
APPLICATIONS

- SMS Gateway ie. to send and receive SMS
- Telemetric to collect data from remote terminals
- call-back service for VOIP
- SMS application, SMS solution, or SMS programme
- automatic reloading of pre-paid account with STK API
- machine to machine communication
- sending SMS from PC
- automating business process
- vehicle tracking with cell broadcast feature or with integrated GPS terminal

4.6 UART

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. UART is also a common integrated feature in most microcontrollers. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes.

Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. Communication can be "full duplex" (both send and receive at the same time) or "half duplex" (devices take turns transmitting and receiving).



A UART (Universal Asynchronous Receiver/Transmitter) is the microchip with programming that controls a computer's interface to its attached serial devices. Specifically, it provides the computer with the RS-232C Data Terminal Equipment (DTE) interface so that it can "talk" to and exchange data with modems and other serial devices. As part of this interface, the UART also:

- Converts the bytes it receives from the computer along parallel circuits into a single serial bit stream for outbound transmission
- On inbound transmission, converts the serial bit stream into the bytes that the computer handles
- Adds a parity bit (if it's been selected) on outbound transmissions and checks the parity of incoming bytes (if selected) and discards the parity bit
- Adds start and stop delineators on outbound and strips them from inbound transmissions
- Handles interrupt s from the keyboard and mouse (which are serial devices with specialport s)
- May handle other kinds of interrupt and device management that require coordinating the computer's speed of operation with device speeds

THE ASYNCHRONOUS RECEIVING AND TRANSMITTING PROTOCOL

Asynchronous transmission allows data to be transmitted without the sender having to send a clock signal to the receiver. In this case, the sender and receiver must agree on timing parameters (Baud Rate) prior transmission and special bits are added to each word to synchronize the sending and receiving units. In asynchronous transmission, the sender sends a Start bit, 5 to 8 data bits (LSB first), an optional Parity bit, and then 1, 1.5 or 2 Stop bits.

When a word is passed to the UART for asynchronous transmissions, the Start bit is added at beginning of the word. The Start bit is used to inform the receiver that a word of data is about to be send, thereby forcing the clock in the receiver to be in sync with the clock in the transmitter. It is important to note that the frequency drift between these two clocks must not exceed 10%. In other words, both the transmitter and receiver must have identical baud rate.

After the Start bit, the individual bits of the word of data are sent, beginning with the Least Significant Bit (LSB). When data is fully transmitted, an optional parity bit is sent to the transmitter. This bit is usually used by receiver to perform simple error checking. Lastly, Stop bit will be sent to indicate the end of transmission.

When the receiver has received all of the bits in the data word, it may check for the Parity Bits (both sender and receiver must agree on whether a Parity Bit is to be used), If the Stop Bit does not appear when it is supposed to, the UART considers the entire word to be garbled and will report a Framing Error to the host processor when the data word is read.

THE PHYSICAL LAYER STANDARDS

There are actually quite a number of different standards that utilizes similar protocol. For instances, TTL level UART, RS-232, RS-422, RS-485 and etc. We will only discuss about TTL level UART and RS-232 in this article.

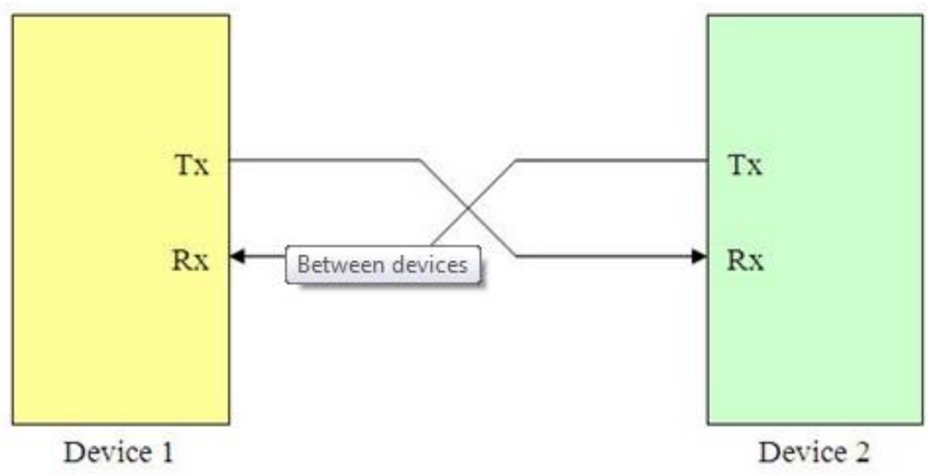
TTL level UART

Most microcontrollers with UART use TTL (Transistor-transistor Logic) level UART. It is the simplest form of UART. Both logic 1 and 0 are represented by 5V and 0V respectively.

Logic	**Voltage**
Low	0V
High	5V

Voltage level for TTL level UART

The TTL level UART is commonly used in the communications between microcontrollers and ICs. Only 2 wires are required for the full duplex communications as illustrated in the picture below.



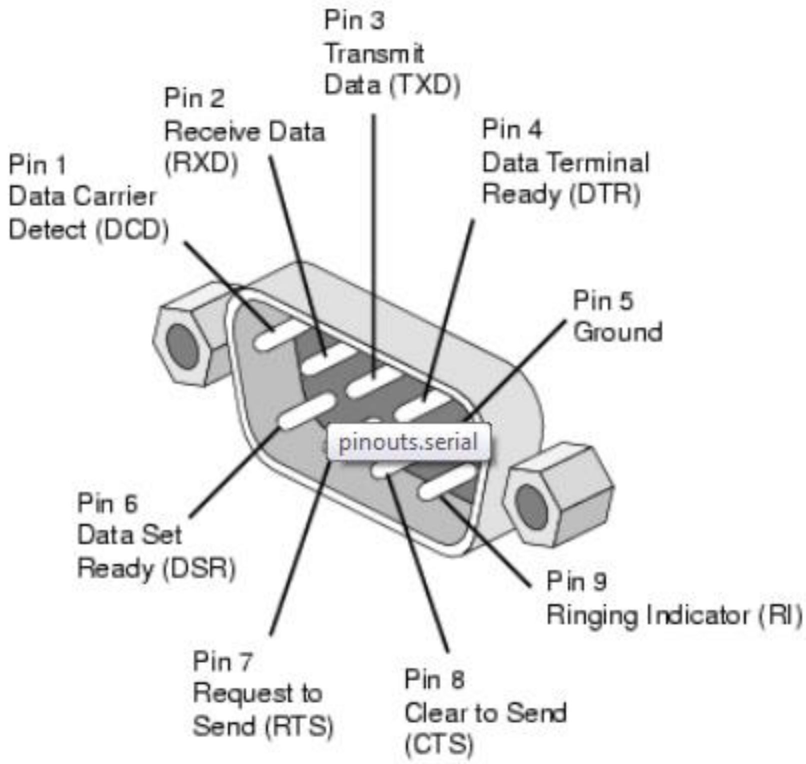
RS-232

RS-232 (Recommended Standard 232) is a standard for serial binary data signals connecting between a Data Terminal Equipment (DTE) and a Data Communication Equipment (DCE). It is commonly used in computer serial ports. One of the significant differences between TTL level UART and RS-232 is the voltage level. Valid signals in RS-232 are ±3 to – ±15V, and signals near 0V is not a valid RS-232 level.

Logic	Voltage
Low	+3 to +15V
High	-3 to -15V

Voltage level for RS-232

Besides voltage level, the RS-232 also has a few extra pins specifically designed for the communication between PC and modem. The pinots of the DB-9 and their functions are shown below.



PINOUTS AND DESCRIPTION OF A SERIAL PORT

Name	**Pin**	**Description**
Transmitted Data (TxD)	3	Serial data output
Received Data (RxD)	2	Serial data input
Request to Send (RTS)	7	This line informs the DCE (Modem) that the DTE (PC) is ready to exchange data
Clear to Send (CTS)	8	This line indicates that the DCE is ready to exchange data
Data Terminal	4	Asserted by DTE to indicate that it is ready to

Ready (DTR)		be connected
Data Set Ready (DSR)	6	Asserted by DCE to indicate the DCE is powered on and is ready to receive commands or data for transmission from the DTE
Data Carrier Detect (DCD)	1	Asserted by DCE when a connection has been established with remote equipment
Ring Indicator (RI)	9	Asserted by DCE when it detects a ring signal from the telephone line

FEATURES:

- The ability to convert data from serial to parallel, and from parallel to serial, using shift registers.
- An on-chip bit rate (baud rate) generator to control transmit and receive data rate.
- Handshake lines for control of an external modem, controllable by software.
- An interrupt function to the host microprocessor.
- An on-chip FIFO buffer for both incoming and outgoing data; this gives the host system more time to respond to an interrupt generated by the UART, without loss of data.

CHAPTER 4

LITERATURE SURVEY

TITLE: SMART BUS: A TRACKING SYSTEM FOR SCHOOL BUSES

AUTHOR : Majd Ghareeb, Athar Ghamlous, Hawraa Hamdan, Ali Bazzi and Samih Abdul-Nabi

YEAR : 2017

An increased concern for parents is the safety of their children on the way back home from school and the timing of their arrival. Waiting school buses in the morning and then in the afternoon to return kids back is a time wasting daily mission on parents, especially with the increasing traffic jams at these hours. In this paper we present a mobile and web application that is designed to address this issue. The system will help parents, the school and the bus to communicate automatically and easily via the application in order to detect kids' arrival time.
The bus application side will notify parents few minutes before its approaching to their home. Furthermore, the system will allow parents to inform the school and hence the bus application side about the absence of their kid. The system has been efficiently and dynamically designed and implemented so it can be hosted and used by any school administration without the need to any major modifications.

TITLE: Identification of the Weakest Buses in Unbalanced Multiphase Smart Grids with Plug-In Electric Vehicle Charging Stations

AUTHOR : P. Juanuwattanakul and Mohammad A.S. Masoum

YEAR : 2011

Charging stations will be increasing in popularity as they can promote and support the increasing number of Plug-in Electric Vehicles (PEVs) entering into smart grid to reduce emissions and fuel consumptions. However, the locations, relatively large ratings and unpredictable charging characteristics of these stations can have a significant impact on the performance of smart grid. This paper proposes identification of the weakest buses over 24 hours in order to study and compensate the detrimental impacts of PEV charging stations on voltage profiles and voltage stability of smart grid. Assuming a smart grid communication infrastructure, the positive sequence voltage ranking index V/Vo is utilized in hourly bases to identify the weakest buses in unbalanced multiphase distribution networks without/with PEV charging stations. Simulation results are performed and compared for an unbalanced multiphase 13 node test feeder with different locations of PEV charging stations using DIgSILENT PowerFactory software.

TITLE: Developing a Smart Bus for Smart City using IOT Technology

AUTHOR: MR. ANILKUMAR J KADAM, MR. VIRENDRA PATIL, MR. KAPISH KAITH, MS. DHANASHREE PATIL, MS.SHAM

YEAR **:** 2018

Trustworthiness in public transport is of great importance today.Citizens who uses public buses waste a lot of time waiting for the bus at bus stop. In daily operation of a bus system, the movement of buses is affected by unknown conditions as the day progresses such as traffic or dispatching buses at irregular time from the depo. If people travelling by bus get exact location of bus and the approximate arrival time based on normal traffic conditions and also the count of passengers in bus it will increase the trustworthiness in the public transport.This paper proposes a system to track public bus using GPS (Global Positioning System), tell the count of number of passengers in bus and also the estimated time arrival to the user. The Location of Bus can be tracked by public using Android Application. The Android application will also contain the details of all the bus like Bus number, Bus routes, Bus Stops, Bus timings or the frequency.

TITLE : Smart E-Ticketing System for Public Transport Bus

AUTHOR : Sanam Kazi ,Farheen Shaikh,Anamta Sayyed

YEAR **:** 2018

Buses are an integral means of public transport in India. In metropolitan cities like Mumbai and Delhi, 10-15 million people travel through public transport buses daily. Today, in the era of Digital India (a campaign launched by the Government of India) and Cashless Economy, public transport needs to adapt the technology advancement. Even though the public transport buses have been providing fairly satisfactory services, there is a need for smart and reliable system. The major problems experienced by the passengers are undue waiting time at bus stops, non-refund of balance, negligence to provide seat to other passengers, etc. Thus, to provide an agile and smooth ticketing experience, we have proposed the smart application that will automatically allocate the seat to passenger, can reserve ticket digitally and mode of payment will be cashless thereby promoting digitalization and smart cities initiatives. The source of the user will be added automatically when connected to the device installed at the bus stop. The user can check the availability of seats, book tickets, get the seat automatically through efficient novel algorithm and the expected waiting time. If seats are not vacant, our algorithm will efficiently allot the seat that will be vacant in shortest time. The user will be able to book the ticket only when they connect to the device installed at the bus stop and will pay digitally through our portal thereby experiencing very comfortable and smart booking bus service. Users who do not have a smart phone will be able to perform all the functions mentioned above via the device installed at the bus stop. The ticket booking will generate an acknowledgment which will act as an e-Ticket that will be verified by the bus conductor. For the convenience of the passengers speaking and understanding different languages our application will be available in multiple languages.

TITLE : Readiness of Operating Bus Rapid Transit (BRT) Purwokerto-Purbalingga towards Smart City Concept

AUTHOR : Yudha Saintika,Purwokerto

YEAR: 2019

Recently, smart city is a popular discussion. In Indonesia, some cities have been implemented to follow Government Information Communication and Technology (ICT) development program. One of smart city domain is society and it has transportation as the component. One of the approaches to encounter the urban complexities are developed public transportation.

The used methods are quantitative and qualitative analysis. Quantitative analysis is using statistical method to find correlation between socioeconomic or demographics and BRT ridership perceptions. The result is there is significantly difference BRT perception as reliable transportation for residences and routines of BRT use. Moreover, there is statistically difference between perception of BRT as alternative mass transportation with ridership residence and gender. As smart city initiative measurement using qualitative methods, supported smart city in BRT operation gain readiness of ICT, governance and human or society. By this finding, BRT operation shall improve governance and ICT enablers to come up with smart city initiative.

TITLE **:** Probabilistic Prediction of Bus Headway Using Relevance Vector Machine Regression

AUTHOR : Haiyang Yu, Zhihai Wu, Dongwei Chen, and Xiaolei Ma

YEAR: 2016

Bus headway regularity heavily affects transit riders' attitude for choosing public transportation and also serves as an important indicator for transit performance evaluation.Therefore, an accurate estimate of bus headway can benefit both transit riders and transit operators. This paper proposed a relevance vector machine (RVM) algorithm to predict bus headway by incorporating the time series of bus headways,travel time, and passenger demand at previous stops. Different from traditional computational intelligence approaches, RVMcan output the probabilistic prediction result, in which the upper and lower bounds of a predicted headway within a certain probability are yielded. An empirical experiment with two bus routes in Beijing, China, is utilized to confirm the high precision and strong robustness of the proposed model. Five algorithms[support vector machine (SVM), genetic algorithm SVM, Kalman filter, k-nearest neighbor, and artificial neural network] are used for comparison with the RVM model and the result indicates that RVM outperforms these algorithms in terms of accuracy and confidence intervals. When the confidence level is set to 95%, more than 95% of actual bus headways fall within the prediction bands. With the probabilistic bus headway prediction information, transit riders can better schedule their trips to avoid late and early arrivals at bus stops, while transit operators can adopt the targeted correction actions to maintain regular headway for bus bunching prevention.

CHAPTER 5
SOFTWARE UNIT

5.1 PYTHON

Python is an interpreted, high-level, general-purpose programming language. Created by Guido van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects.Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library.

Python was conceived in the late 1980s as a successor to the ABC language. Python 2.0, released in 2000, introduced features like list comprehensions and a garbage collection system capable of collecting reference cycles. Python 3.0, released in 2008, was a major revision of the language that is not completely backward-compatible, and much Python 2 code does not run unmodified on Python 3.The Python 2 language, i.e. Python 2.7.x, was officially discontinued on 1 January 2020 (first planned for 2015) after which security patches and other improvements will not be released for it.With Python 2's end-of-life, only Python 3.5.x and later are supported.

Python interpreters are available for many operating systems. A global community of programmers develops and maintains CPython, an open source reference implementation. A non-profit organization, the Python Software Foundation, manages and directs resources for Python and CPython development.

5.1.1 Features and Philosophy

Python is a multi-paradigm programming language. Object-oriented programming and structured programming are fully supported, and many of its features support functional programming and aspect-oriented programming (including by metaprogramming and metaobjects (magic methods)).Many other paradigms are supported via extensions, including design by contract and logic programming.

Python uses dynamic typing and a combination of reference counting and a cycle-detecting garbage collector for memory management. It also features dynamic name resolution (late binding), which binds method and variable names during program execution.

Python's design offers some support for functional programming in the Lisp tradition. It has filter, map, and reduce functions; list comprehensions, dictionaries, sets, and generator expressions. The standard library has two modules (itertools and functools) that implement functional tools borrowed from Haskell and Standard ML.

The language's core philosophy is summarized in the document The Zen of Python (PEP 20), which includes aphorisms such as:

- Beautiful is better than ugly.
- Explicit is better than implicit.
- Simple is better than complex.
- Complex is better than complicated.
- Readability counts.

Rather than having all of its functionality built into its core, Python was designed to be highly extensible. This compact modularity has made it particularly popular as a means of adding programmable interfaces to existing applications. Van Rossum's vision of a small core language with a large standard library and easily extensible interpreter stemmed from his frustrations with ABC, which espoused the opposite approach.

Python strives for a simpler, less-cluttered syntax and grammar while giving developers a choice in their coding methodology. In contrast to Perl's "there is more than one way to do it" motto, Python embraces a "there should be one—and preferably only one—obvious way to do it" design philosophy.Alex Martelli, a Fellow at the Python Software Foundation and Python book author, writes that "To describe something as 'clever' is not considered a compliment in the Python culture."

Python's developers strive to avoid premature optimization, and reject patches to non-critical parts of the CPython reference implementation that would offer marginal increases in speed at the cost of clarity. When speed is important, a Python programmer can move time-critical functions to extension modules written in languages such as C, or use PyPy, a just-in-time compiler. Cython is also available, which translates a Python script into C and makes direct C-level API calls into the Python interpreter.

An important goal of Python's developers is keeping it fun to use. This is reflected in the language's name—a tribute to the British comedy group Monty Python and in occasionally playful approaches to tutorials and reference materials, such as examples that refer to spam and eggs (from a famous Monty Python sketch) instead of the standard foo and bar.

A common neologism in the Python community is pythonic, which can have a wide range of meanings related to program style. To say that code is pythonic is to say that it uses Python idioms well, that it is natural or shows fluency in the language, that it conforms with Python's minimalist philosophy and emphasis on readability. In contrast, code that is difficult to understand or reads like a rough transcription from another programming language is called unpythonic.

Users and admirers of Python, especially those considered knowledgeable or experienced, are often referred to as Pythonistas.

5.2 OpenCV:

OpenCV (*Open source computer vision*) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then Itseez (which was later acquired by Intel). The library is cross-platform and free for use under the open-source BSD license. OpenCV supports some models from deep learning frameworks like TensorFlow, Torch, PyTorch (after converting to an ONNX model) and Caffe according to a defined list of supported layers.It promotes OpenVisionCapsules., which is a portable format, compatible with all other formats.

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc. OpenCV has more than 47 thousand people of user community and estimated number of downloads exceeding 18 million. The library is used extensively in companies, research groups and by governmental bodies.

Along with well-established companies like Google, Yahoo, Microsoft, Intel, IBM, Sony, Honda, Toyota that employ the library, there are many startups such as Applied Minds, VideoSurf, and Zeitera, that make extensive use of OpenCV. OpenCV's deployed uses span the range from stitching streetview images together, detecting intrusions in surveillance video in Israel, monitoring mine equipment in China, helping robots navigate and pick up objects at Willow Garage, detection of swimming pool drowning accidents in Europe, running interactive art in Spain and New York, checking runways for debris in Turkey, inspecting labels on products in factories around the world on to rapid face detection in Japan.

It has C++, Python, Java and MATLAB interfaces and supports Windows, Linux, Android and Mac OS. OpenCV leans mostly towards real-time vision applications and takes advantage of MMX and SSE instructions when available. A full-featured CUDAand OpenCL interfaces are being actively developed right now. There are over 500 algorithms and about 10 times as many functions that compose or support those algorithms. OpenCV is written natively in C++ and has a templated interface that works seamlessly with STL containers.

History:

Officially launched in 1999 the OpenCV project was initially an Intel Research initiative to advance CPU-intensive applications, part of a series of projects including real-time ray tracing and 3D display walls. The main contributors to the project included a number of optimization experts in Intel Russia, as well as Intel's Performance Library Team. In the early days of OpenCV, the goals of the project were described as:

- Advance vision research by providing not only open but also optimized code for basic vision infrastructure. No more reinventing the wheel.
- Disseminate vision knowledge by providing a common infrastructure that developers could build on, so that code would be more readily readable and transferable.
- Advance vision-based commercial applications by making portable, performance-optimized code available for free – with a license that did not require code to be open or free itself.

The first alpha version of OpenCV was released to the public at the IEEE Conference on Computer Vision and Pattern Recognition in 2000, and five betas were released between 2001 and 2005. The first 1.0 version was released in 2006. A version 1.1 "pre-release" was released in October 2008.

The second major release of the OpenCV was in October 2009. OpenCV 2 includes major changes to the C++ interface, aiming at easier, more type-safe patterns, new functions, and better implementations for existing ones in terms of performance (especially on multi-core systems). Official releases now occur every six months and development is now done by an independent Russian team supported by commercial corporations.

In August 2012, support for OpenCV was taken over by a non-profit foundation OpenCV.org,

Applications:

OpenCV's application areas include:

- 2D and 3D feature toolkits

- Egomotion estimation
- Facial recognition system
- Gesture recognition
- Human–computer interaction (HCI)
- Mobile robotics
- Motion understanding
- Object identification
- Segmentation and recognition
- Stereopsis stereo vision: depth perception from 2 cameras
- Structure from motion (SFM)
- Motion tracking
- Augmented reality

To support some of the above areas, OpenCV includes a statistical machine learning library that contains:

- Boosting
- Decision tree learning
- Gradient boosting trees
- Expectation-maximization algorithm
- k-nearest neighbor algorithm
- Naive Bayes classifier
- Artificial neural networks
- Random forest
- Support vector machine (SVM)
- Deep neural networks (DNN)

Programming language

OpenCV is written in C++ and its primary interface is in C++, but it still retains a less comprehensive though extensive older C interface. There are bindings in Python, Java and MATLAB/OCTAVE. The API for these interfaces can be found in the online documentation. Wrappers in other languages such as C#, Perl, Ch, Haskell, and Ruby have been developed to encourage adoption by a wider audience. Since version 3.4, **OpenCV.js** is a JavaScript binding for selected subset of OpenCV functions for the web platform. All of the new developments and algorithms in OpenCV are now developed in the C++ interface.

Hardware acceleration:

If the library finds Intel's Integrated Performance Primitives on the system, it will use these proprietary optimized routines to accelerate itself.

A CUDA-based GPU interface has been in progress since September 2010.

An OpenCL-based GPU interface has been in progress since October 2012, documentation for version 2.4.13.3 can be found at docs.opencv.org.

OS support:

OpenCV runs on the following desktop operating systems: Windows, Linux, macOS, FreeBSD, NetBSD, OpenBSD. OpenCV runs on the following mobile operating systems: Android, iOS, Maemo, BlackBerry 10. The user can get official releases from SourceForge or take the latest sources from GitHub. OpenCV uses CMake.

CHAPTER 6

SYSTEM TESTING

6.1 TESTING OBJECTIVES

Testing is a set of activities that can be planned in advance and conducted systematically. For this reason a template for software testing, a set of steps into which we can place specific test case design techniques and testing methods should be defined for software process. Testing often accounts for more effort than any other software engineering activity. If it is conducted haphazardly, time is wasted, unnecessary effort is expanded, and even worse, errors sneak through undetected. It would therefore seem reasonable to establish a systematic strategy for testing software.

6.1.1 Type of Testing

There are two type of testing according their behaviors

1. Unconventional Testing

2. Conventional Testing

6.1.1.1Unconventional Testing

Unconventional testing is a process of verification which is doing by SQA (Software Quality Assurance) team. It is a prevention technique which is performing from begging to ending of the project development. In this process SQA team verifies project development activities and insuring that developing project is fulfilling the requirement of the client or not.

In this testing the SQA team follows these methods:

1. Peer review

2. Code walk and throw

3. Inspection

4. Document Verification

6.1.1.2 Conventional Testing

Conventional Testing is a process of finding the bugs and validating the project. Testing team involves in this testing process and validating that developed project is according to client requirement or not. This process is a correction technique where testing team find bugs and reporting to the development team for correction on developed project built.

6.2 TEST CASE DESIGN

6.2.1 Unit Testing

The primary goal of unit testing is to take the smallest piece of testable software in the application, isolate it from the remainder of the code, and determine whether it behaves exactly as you expect. Each unit is tested separately before integrating them into modules to test the interfaces between modules. Unit testing has proven its value in that a large percentage of defects are identified during its use. In the company as well as seeker registration form, the zero length username and password are given and checked. Also the duplicate username is given and checked. In the job and question entry, the button will send data to the server only if the client side validations are made. The dates are entered in wrong manner and checked. Wrong email-id and web site URL (Universal Resource Locator) is given and checked.

6.2.2 Integration Testing

Testing is done for each module. After testing all the modules, the modules are integrated and testing of the final system is done with the test data, specially designed to show that the system will operate successfully in all its aspects conditions. Thus the system testing is a confirmation that all is correct and an opportunity to show the user that the system works.

6.2.3 Validation Testing

The final step involves Validation testing, which determines whether the software function as the user expected. The end-user rather than the system developer conduct this test most software developers as a process called “Alpha and Beta Testing” to uncover that only the end user seems able to find. The compilation of the entire project is based on the full satisfaction of the end users. In the project, validation testing is made in various forms. In question entry form, the correct answer only will be accepted in the answer box. The answers other than the four given choices will not be accepted.

6.3 TESTING STRATEGIES

A number of software testing strategies have been proposed in the literature. All provide the software developer with a template for testing and all have the following generic characteristics:

1. Testing begins at the component level and works “outward” toward the integration of the entire computer-based system.
2. Different testing techniques are appropriate at different points in time.
3. The developer of the s/w conducts testing and for large projects, independent test group.
4. Testing and debugging are different activities, but debugging must be accommodated in any testing strategy.

6.3.1 Integration Testing:

The strategies for integrating software components into a functioning product include the bottom-up strategy, the top-down strategy and to ensure that modules will be available for integration into the evolving software product when needed. The integration strategy dictates the order in which modules must be available and thus exerts a strong influence on the order in which modules are written, debugged and unit tested.

6.3.2 White Box Testing:

It is just the vice versa of the Black Box testing. There we do not watch the internal variables during testing. This gives clear idea about what is going on during execution of the system. The point at which the bug occurs were all clear and were removed.

6.3.3 Black Box Testing:

In this testing we give input to the system and test the output. Here we do not go for watching the internal file in the system and what are the changes made on them for the required output.

6.3.4 Interface Testing

The Interface Testing is performed to verify the interfaces between sub modules while performing integration of sub modules aiding master module recursively.

6.3.5 Module Testing

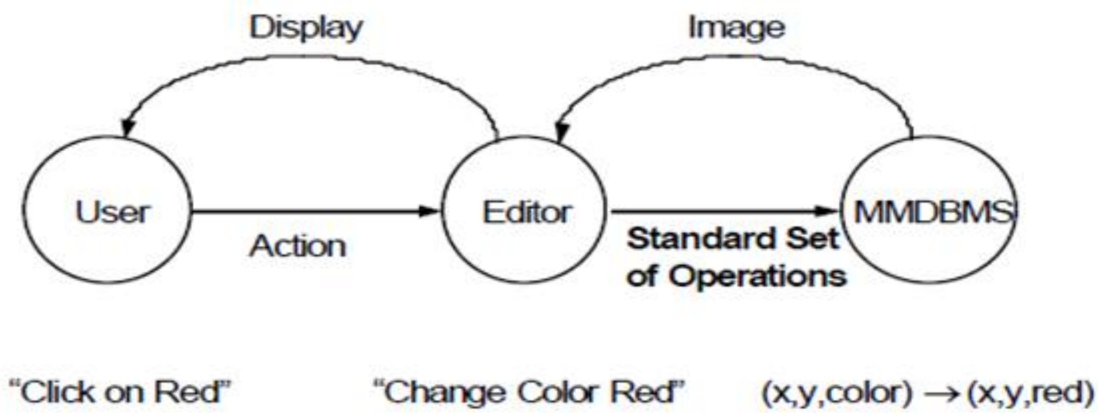
Module Testing is a process of testing the system, module by module. It includes the various inputs given, outputs produced and their correctness. By testing in this method we would be very clear of all the bugs that have occurred.

6.3.6 Maintenance

The objectives of this maintenance work are to make sure that the system gets into work all time without any bug. Provision must be for environmental changes which may affect the computer or software system. This is called the maintenance of the system. Nowadays there is the rapid change in the software world. Due to this rapid change, the system should be capable of adapting these changes. In our project the process can be added without affecting other parts of the system. Maintenance plays a vital role. The system will able to accept any modification after its implementation. This system has been designed to favour all new changes. Doing this will not affect the system’s performance or its accuracy. This is the final step in system life cycle. Here we implement the tested error-free system into real-life environment and make necessary changes, which runs in an online fashion.

6.4 Testing the sample LM

For an image LM to be complete, it must be able to perform each of the eight low level image operations needed by the algorithm described in section 4. In this section, we will show that the sample LM described in section 5 can perform each of the eight operations.



6.4.1 Image Operation List:

The algorithm given above uses eight image operations. In step 1, a pixel is either added to or removed from an image. In step 2.1, a tuple is either added to or removed from a pixel. In step 2.2.1, the x variable of a tuple is modified. In step 2.2.2, the y variable of a tuple is modified. In step 2.2.3, the c variable of a tuple is modified. In step 2.2.4, the v variable of a tuple is modified.

To demonstrate the technique for testing for completeness of an image LM, we will use the LM proposed in which contains six operations. These operations are called merge, define, mutate, modify, combine, and apply function.

6.4.2 Merge

The merge operation combines a base image, A, with a new image, B. The result is the union of the pixels in the two images. This operation is flexible enough to be either opaque or transparent. If it is transparent, whenever images A and B have pixels at the same coordinates, the value of the pixels in A will be used. In the same situations, if it is opaque, the values of the pixels in B will be used. Formally, let A be the base image where A = {P1, P2, ... , Pm} with m ^{3} 0, and B be an image {Q1, Q2, ... , Qn} with n ^{3} 0. Recall from section 3 that a pixel is defined as a set of 4-tuples {<x, y, c, v>} where all of the values of x are equal, and all of the values of y are equal. The result of merging A with B returns the union of their pixels based on the x and y coordinates, meaning that if there is a pixel Pi in A where Pi = {<xi, yi, ci1, vi1>, <xi, yi, ci2, vi2>, ... , <xi, yi, cik, vik>}, and there is a pixel Qj in B where Qj = {<xj, yj, cj1, vj1>, <xj, yj, cj2, vj2>, ... , <xj, yj, cjh, vjh>}, such that xi = xj and yi = yj, then we will include only one of the pixels in the resultant union.

6.4.3 Define

The define operation selects a subset of an image. This operation is frequently referred to as cropping. Formally, let A be an image where A = {P1, P2, ... , Pm} with m ^{3} 0. Performing the define operation on A will create a new image {P1, P2, ... , Pr} with m ^{3} r.

6.4.4 Mutate

The mutate operation changes the position of pixels in an image. This means that it assigns new values to the x and y coordinates of some of the pixels. In terms of our image definition, this operation will assign new values to the x and y variables of the tuples in a pixel. Since the
result of this operation must be an image, there cannot be another pixel in the resulting image with the same x and y coordinates.

6.4.5 Modify

The modify operation affects the values of the channels of an image. It will change the color of some of the pixels in an image to a new color. In terms of our image definition, this corresponds to changing the value of the v variable in a tuple.

6.4.6 Combine

The combine operation is similar to the modify operation in that is also changes the colors of an image. The difference is that it computes the new color of a pixel by using the colors of adjacent pixels. As with the modify operation, this corresponds to changing the value of the v variable in a tuple in terms of our image definition.

6.4.7 Function prtform

Finally, the apply function operation manipulates the channels used by an image. Unlike the modify and combine operations, it edits the channels themselves, not their values. Among the functions this operation performs is adding a channel, removing a channel, and replacing a channel. In terms of our image definition, it affects the values of the c variables in the tuples.

CHAPTER 7
CONCLUSION

Enhancing education system could be done not only by targeting the process of education itself, but also by providing the most possible comfort for student and parents to increase their interest in school. The idea of this project was to target this issue, in which a tracking system for the school bus.This system provides a mean for the parents to track their kids. The system is totally managed by the school which puts less cost and more information security. It allows the school to know about the absence of a student and hence the driver of the bus can avoid passing by his place if this will help him to avoid road congestion. A possible improvement that could be added to the application is to use notifications rather than sending SMS since it is cheaper. Adding an Camera to the application from the bus side to remind driver when he gets beside students home is another good idea to be added.