

Simulation of Static Synchronous Compensator (STATCOM) for Voltage Profile Improvement

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Abstract
Voltage profile improvement is a very important aspect of power quality and system stability. Flexible A.C Transmission System (FACTS) devices have been developed to provide system stability thereby enhancing controllability and increasing the power transfer capability. Static Synchronous Compensator (STATCOM) is a member of FACTS devices used for voltage profile improvement as well as power quality improvement of the net system. In this paper, a STATCOM is simulated in Simpower Simulink of MATLAB environment for voltage regulation in a nominal π medium transmission line. The simulation results show that a STATCOM without droop is a perfect voltage regulator and follows exactly the reference voltage. When the results are compared to one with droop regulator, it was found that the sooner performs better than the later. However, the droop extends the linear operating range of the STATCOM.
Keywords—STATCOM, FACTS, power quality, voltage regulation, grid

1. Introduction

Power quality is significant to both utility operators and consumers at all level of usage especially to non-linear loads and sensitive devices placed in both industrial and domestic environment (Krishna & Reddy 2013). Power quality refers to the proper characteristics of supply voltage and also a reliable and effective process for delivering electrical energy to consumers. In other words, it is the power that enables equipment to work properly (Srinivas & Reddy 2011). The measure of power quality depends on the nature and type of equipment. Thus, power quality that is considered good for one equipment may not be good for another equipment. Hence, power quality can be directly related to maintaining a smooth sinusoidal waveform of bus voltages at rated frequency and also to be free from noise and harmonic distortion (Kumba & Sumanthi 2012). Therefore, any deviation of magnitude, frequency or purity from the ideal sinusoidal voltage waveform can be considered as power quality issue (Earnest & Wizelius 2011).

Binding standards and regulations are currently being imposed on suppliers and consumers, the obligations to maintain the required power quality parameters at the point of interconnection, POI (Hiren et al 2010). These obligations become necessary due to the widespread use of power electronics equipments that are sensitive in nature such as computers, converters, programmable logic controllers and energy efficient lightning (Mohod & Aware 2011). These loads are very sensitive, hence, can lead to power quality disturbances such as voltage dip, voltage swell, voltage flicker, voltage transient, and harmonic distortion. Among such disturbances, voltage dip is the most dangerous one because it can leads to equipment failure, industrial shut down and tripping of protection devices (Omar & AbdRahim 2008).

However, when good power quality is required, some kinds of compensation devices are necessary to overcome the power quality disturbances (Kanaujia & Srivastava 2013). Thus, to restore the required power quality, FACTS devices have been introduced (Das & Moharana 2012). Among such devices, STATCOM is the latest development in that regard capable of interfacing between the utility and the consumer with the aim of providing voltage profile improvement by compensating the reactive and harmonic power generated or absorbed by the load (Khadem & Basu 2010). Thus, FACTS controllers provides an avenue for the regulation of transmission of alternating current thereby increasing or diminishing the power flow in specific lines and providing a quick response to stability problems (Mohanty and Barik 2014).

2. Static Synchronous Compensator (STATCOM)

Static synchronous compensator, popularly known as STATCOM is a shunt connected reactive power compensation device used on alternating current electricity transmission network. It is capable of generating and or absorbing reactive power and its output can be varied to control certain power parameters. It is a power electronic based voltage source converter (VSC) that can act as either a source or a sink of reactive power in an a.c power system.

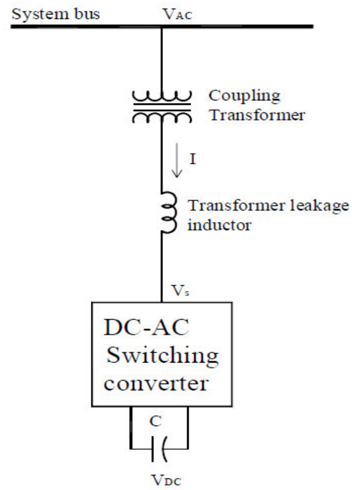

Figure 1. Basic Configuration of a STATCOM

STATCOM is a member of FACTS devices used for voltage profile improvement. It makes use of VSC to inject a compensation current of variable magnitude and frequency into the system at the bus PCC. It is thus a three phase VSC with capacitance on its d.c link. STATCOM is thus a solid-state switching converter capable of generating or absorbing independently controllable real and reactive power at its output when it is fed from an energy source or energy storage device as its input terminal. The d.c voltage can be provided by a battery or an energy-storage capacitor. The output of a STATCOM is a set of three phase voltage, each in phase and coupled to the corresponding a.c system voltage through a small reactance. The reactance can be provided by a leakage inductance of the coupling transformer or by an interface reactor. STATCOM is a very fast acting device that is analogous to an ideal synchronous machine, which generates a balanced set of three sinusoidal voltages at the fundamental frequency, with controllable amplitude and phase angle. It is based on VSC topology that utilizes either Gate-Turn-off Thyristor (GTO), or Insulated Gate Bipolar Transistor (IGBT) devices. Thus, a STATCOM is a VSC that converts a d.c input voltage into an a.c output voltage for active and reactive power compensation (Kamarposhti & Alinezhad 2010).

In general, STATCOM can be operated to perform the following objectives:

- Voltage regulation
- Power factor correction
- Load balancing
- Harmonic compensation

3. Components of a STATCOM

STATCOM is basically comprised of four major components, namely

- Voltage source converter (VSC)
- Coupling transformer
- Controller
- DC energy storage

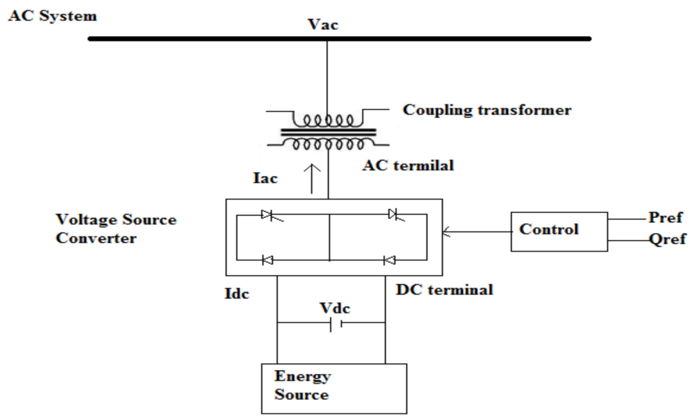

Figure 2. Basic Components of a STATCOM

3.1 Voltage Source Converter (VSC)

VSC is a power electronic device capable of generating a sinusoidal voltage of desired frequency, magnitude and phase angle. It converts the d.c voltage across the storage device into a set of three phase a.c output voltages (Sivakoti et al 2013). The voltages are in phase and coupled with the a.c system through the reactance of the coupling transformer. The function of VSC as an integral part of STATCOM is to contribute in mitigating power quality disturbances either by completely replacing the voltage or by injecting the missing voltage. The missing voltage in this case is the difference between nominal and actual voltage. The VSC is usually based on some kind of energy storage that will supply the d.c voltage. The desired voltage can then be obtained by switching the solid state electronic devices in the converter circuit.

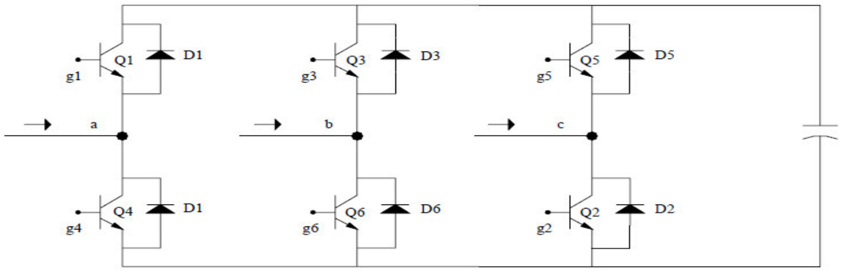

Figure 3. A three phase Voltage Source Converter

3.2 Coupling Transformer

Coupling Transformer is required to step down the system voltage to match that of the utility grid. A coupling reactor is usually incorporated in order to filter out the current harmonic components that are generated by pulsating output voltage of the VSC. The AC voltage difference across the leakage reactance produces reactive power exchange between the STATCOM and the power system, in such a way that the AC voltage at the bus bar can be regulated to improve the voltage profile of the power system, which is the primary duty of the STATCOM. Alternatively, a secondary damping function can be added into the STATCOM to enhance power system oscillation stability.

3.3 Controller

The controller performs feedback control and outputs a set of switching signals to drive the main semiconductor switches of the power converter. It generates switching signal for the STATCOM to enable the STATCOM injects a reactive current into the grid to behave as an over-excited synchronous generator (or capacitor) thereby supporting the grid voltage or absorbs reactive current and behave like an under-excited synchronous generator (or inductor) and tends to decrease the grid voltage. The STATCOM compensator is varied according to the control strategy (Tajavoth et al 2013).

The main function of the controller is to maintain the voltage magnitude constant at the point where sensitive load is connected, under system disturbances. It does this by measuring and comparing the r.m.s voltage at the load point with the reference voltage. The difference between the two values is the error signal which serves as input to the controller. The output is the power angle δ which is provided to the PWM signal generator. Thus, the processed error signal generates the required power angle, δ, that will drive the error to zero, thereby restoring the r.m.s value of the load voltage to the reference voltage value.

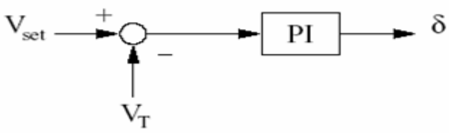

Figure 4. Block Diagram of a STATCOM Controller

3.4 DC Energy Source

The d.c voltage source can be provided by a capacitor connected on the d.c side of the VSC or by a battery energy storage system (BESS). The dc energy source is connected in parallel with the d.c capacitor. It carries the input ripple current of the converter. The capacitor can be charged by the VSC or by BESS. The function of the BESS is to support the real power source under power fluctuating condition. Thus, in order to achieve the required voltage regulation, the BESS is connected in parallel to the d.c capacitor of the STATCOM thereby making it as energy storage element. The BESS will then inject or absorbs the reactive power required to stabilize the grid system while maintaining the d.c capacitor voltage constant. In other words, it charges and discharges to improve the voltage profile. Thus, the d.c energy storage is responsible for supplying and absorbing the real power that is being exchanged by the transmission system at its d.c terminals (Malarvizhi &

Baskaran 2010).

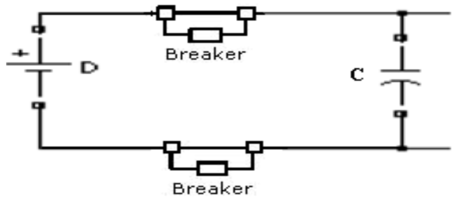

Figure 5. DC Energy Source

4. STATCOM Topology for Voltage Profile Improvement

STATCOM generates a set of balanced three phase sinusoidal voltages at the fundamental frequency, with rapidly controllable amplitude and phase angle (Appala-Naranya et al 2013). In other words, the VSC in the STATCOM generates a controllable AC voltage source behind the leakage reactance. This voltage is compared with the AC bus voltage of the system; if the voltage magnitudes are equal, the reactive power exchange is zero. If the VSC voltage magnitude is higher than that of the AC bus voltage magnitude, the AC system sees the STATCOM as a capacitance connected to its terminals. Conversely if the VSC voltage magnitude is lower than that of the AC bus, the A.C system sees the STATCOM as an inductance connected to its terminals (Usha & Kumar 2013).

Consider the following Figure:

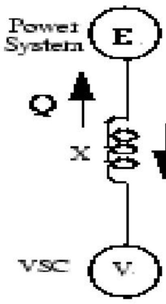

Figure 6. Single line diagram of a STATCOM

Where
E = System voltage (Line voltage of the transmission line)
V = Voltage generated by the VSC
X = Equivalent reactance of the coupling transformer
δ = Phase angle of E with respect to V
P = Active power dissipated in the system
Q = Reactive power generated or absorbed by the STATCOM

The active power, P and reactive power, Q, can be expressed in terms of the system voltage, converter voltage and the reactance of the coupling transformer (Nazrul-Islam & Kazushige 2013):

$$P = \frac{EV}{X} sin\delta \qquad (1)$$

$$Q = \frac{E^2}{X} cos\delta \qquad (2)$$

While the phase angle, δ is given as:

$$\delta = \frac{R}{X}\frac{(V-E)}{E} \qquad (3)$$

The STATCOM based current controlled VSC injects compensation current into the grid thereby making the source current harmonic free with a corresponding shift in the phase angle with respect to the source voltage to a desired value. The injected current will then cancel out the reactive and harmonic parts of the load and induction generator current, thereby improving the voltage profile. Thus, the impedance of the shunt controller, which is connected to the line voltage, causes a variable current flow, and hence, represents an injection of current into the line. If the STATCOM has a DC source such as BESS or an energy storage device like capacitor on its DC side, it can supply real power to the power system. This can be achieved by adjusting two parameters, namely; the phase angle of the STATCOM terminals (or VSC) and the phase angle of the AC power system. If the phase angle of the AC power system lags that of the VSC, the STATCOM supplies real power to the AC system. Conversely, if the phase angle of the AC power system leads the VSC phase angle, the STATCOM absorbs real

power from the AC system. The main function of the BESS is to serve as an energy storage element purposely for voltage regulation and to keep the d.c capacitor voltage constant.
The STATCOM can be operated in two modes of operation as under

- In voltage regulation mode (the STATCOM voltage is maintained within specified limits)
- In VAR control mode (the STATCOM reactive power , Q is maintained at a fixed value)

In voltage regulation mode, the STATCOM implements the following V-I characteristic:

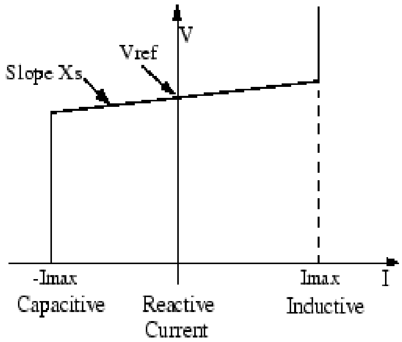

Figure 7: V-I Characteristics of a STATCOM in Voltage Regulation Mode

The voltage is said to be regulated at the reference value,Vref, provided the compensation current, I stays within the minimum and minimum current values (-Imax, Imax) imposed by the converter rating. However, in order to extend the linear operating range of the STATCOM, a voltage droop is normally used (usually between 1% and 4% at maximum reactive power output), and the V-I characteristic has the slope depicted in Figure 10. In the voltage regulation mode, the V-I characteristic is described by the following equation:

$$V = V_{ref} + X_s I \qquad (4)$$

Where V = Positive sequence voltage (pu)
I = Compensation current (pu/P_c)
X_s= Slope or droop reactance
P_c = Three phase power of the converter

STATCOM has no moving parts; hence, it generates or absorbs reactive power at a faster rate than other FACTS devices. It is capable of generating as well as absorbing reactive power thereby regulating the voltage profile of the bus to which it is connected.

5. Simulation Results and Discussion

The entire system is simulated in Simpower Simulink of MATLAB environment. It consists of a 100MVA STATCOM located at the centre of a nominal π medium transmission line. The control parameters of the STATCOM were first set to voltage regulation mode without any droop. The system reference voltage (i.e the p.u voltage used by the regulator) was initially set to 1p.u and decreased to 0.98pu at t = 0.3s. It is further increased to 1.02pu at t = 0.6s and finally brought back to 1p.u at t = 0.9s.

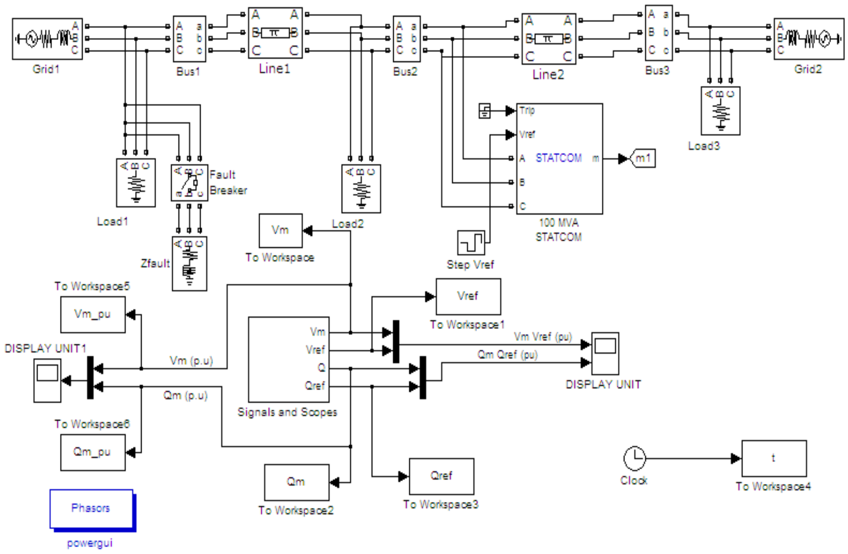

Figure 8: Simulink Diagram of a STATCOM for Voltage Regulation

5.1 Null Droop Condition

It can be seen from Figure 9a that under null droop condition, the STATCOM measured voltage, Vm follows the reference value, Vref. This implies that STATCOM is a very good voltage regulator. Figure 9b shows the reactive power absorbed/generated by the STATCOM, Qm together with the reference one, Qref. Positive value of Qm represents the reactive power absorbed by the STATCOM while negative value indicates the reactive power generated. The two Figures certify that the STATCOM absorbs reactive power when the A.C system voltage rises and generates reactive power when the A.C system voltage falls.

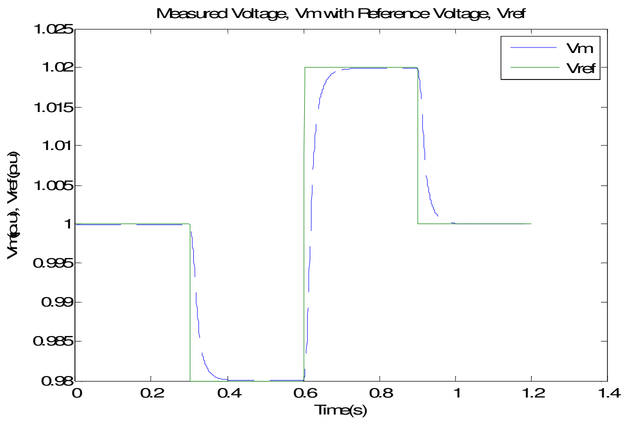

Figure 9a. STATCOM Measured and Reference Voltage under Null Droop Condition

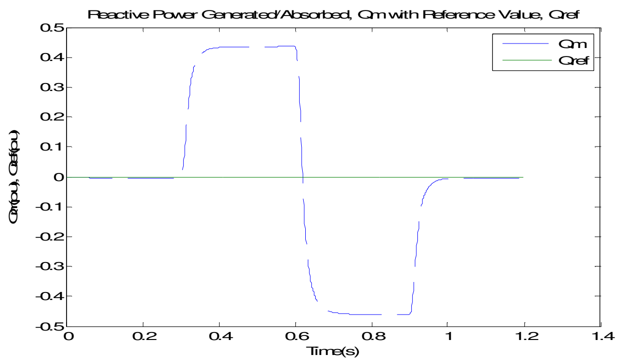

Figure. 9b. Reactive Power Absorbed/Generated by the STATCOM with Reference Value under Null Droop Condition

5.2 Droop Condition

Figure 10a shows the STATCOM measured and reference voltage (Vm and Vref) under droop condition.

Specifically, a droop of 2% was set. The corresponding reactive power, Qm absorbed/generated by the STATCOM is shown in Figure 10b. It can be seen from Figure 10a that, because of the droop, the STATCOM measured voltage, Vm does not follow the reference value, Vref perfectly.

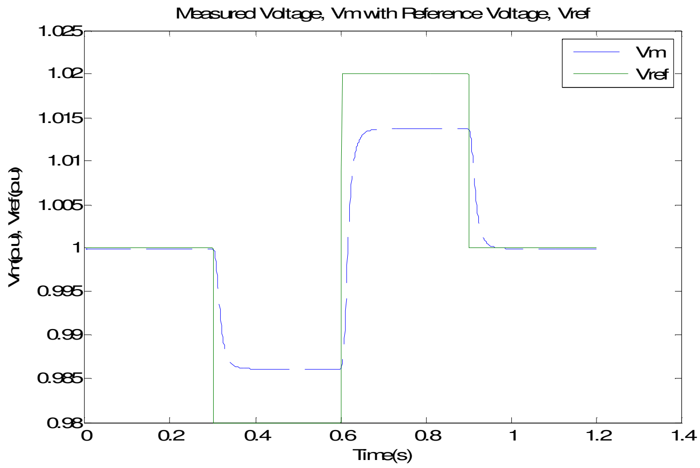

Figure 10a. STATCOM Measured and Reference Voltage under Droop Condition

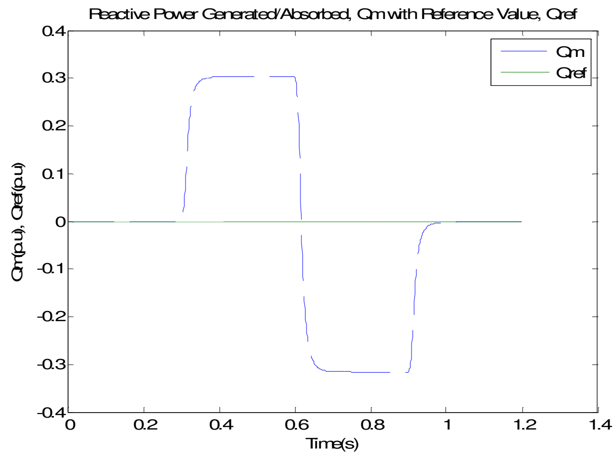

Figure 10b. Reactive Power Absorbed/Generated by the STATCOM with Reference Value under Droop Condition

5.3 During Fault Condition

Figure 11 shows the measured voltage and the reactive power generated by the STATCOM when a remote fault is applied. It can be seen from the Figure that the STATCOM generates reactive power in order to provide voltage support to the system during the fault period.

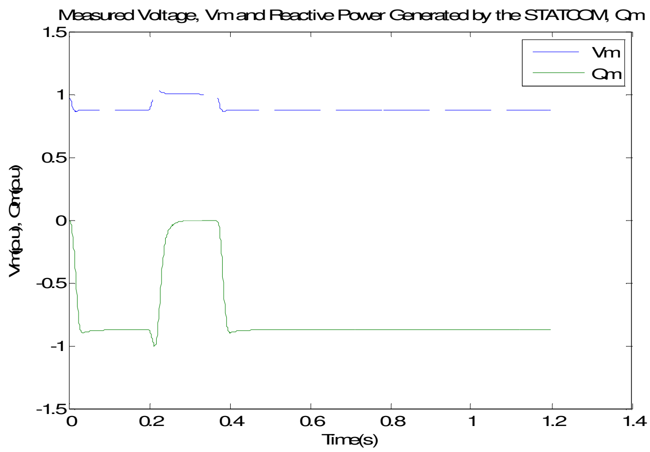

Figure 11. Measured Voltage and Reactive Power Generated by the STATCOM

5. Conclusion

The paper has presented a technological review of STATCOM for voltage profile improvement. Its basic structure, configuration, component parts and topology were also presented. Simulation results reveal that STATCOM is an excellent voltage regulator especially when operated without droop. It can provide both capacitive and inductive compensation. It has the capability of controlling output current over the rated maximum capacitive or inductive range independent of the a.c system voltage and it has increased transient rating in both capacitive and inductive operating regions as well as maintaining full compensating current at depressed line voltage.

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Design of a 4-Junction Road Intersection Intelligent Traffic Controller System in Ado-Ekiti, Ekiti State, Nigeria

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Abstract
Most roads in Nigeria cities are usually congested, some throughout the day, others during rush hours. Larger part of this problem is as a result of congestion at road-intersections. However, traffic-light systems have long been invented to control this problem. Most of these traffic light control systems are imported thereby making them expensive to acquire and adapted to the local circumstances that most time depend on the attitude and the way of life of the people. Traditional traffic light control systems are designed to function at only a particular type of traffic intersection. For example, a control system that was designed for a cross-junction may not serve at T-junction.This paper presents a design with a microcontroller-based traffic light control system that has the ability to control any type of 4-junction and cross traffic intersections based on traffic density, in an attempt at curbing traffic offences. It is indigenous as well as versatile in its control functions and has the effect of drastically reducing the design cost.
Keywords: Congestion, Road-intersection, Traffic-light, Cross-Junction, T-Junction, Microcontroller

1 Introduction
In Nigeria today, most especially in the city of Ado-Ekiti, the capital of Ekiti State, many cases of road crashes and fatal accidents are recorded on daily basis. These are as a result of increase in vehicular movements accompany with traffic congestions most especially at the junctions where vehicles from different directions struggle for space to access next route within a very short time. However, the tendency to outsmart the incoming vehicles in opposite or adjacent routes often result into road crashes, accidents, gridlocks and loss of productive hours (Tzafestas, A. et al., 2000). The infrastructure only provides limited resources which cannot handle the current traffic problems. This has called for urgent attentions for a more efficient techniques to solving traffic problems. There is a need for an improved strategy with greataccuracy to providing lasting solution to the traffic problem. This paper aims at designing a 4-junction intelligent and cross- traffic light control system which can be deployed at road intersections for traffic control with the overall objectives which include the study ofthe traffic control, design, possible implementation of the 4-junctioin road intersection intelligent traffic controller and subsequent evaluation of the functionality.This intelligent traffic light control system is intended to control a wide range of 4-junction and cross-road intersections such as automobile/automobile cross-junction and automobile/pedestrian cross-junction.Conventional methods for traffic signal controls have failed to deal efficiently with the complex and varying traffic situations. They are based on the pre-set cycle time to change the signal status without any analysis of traffic situation. Due to the fixed cycle time, such systems do not consider which intersection has more load of traffic, so should keep green light on or should terminate earlier rather than complete cycle time. In case of intersections, conventional control systems only consider waiting time of signals on different directions but not the vehicle directions.In this paper, the micro-coded ROM-based method is used. This enabled us to develop instruction codes (program) using a Top-Down design approach to determine the functionality of the entire system embedded in a microprocessor device. This design method provides us with a lot of flexibilities which enables us to incorporate control for many types of traffic intersections as well as give enough room for further modifications. More sub-programs can be developed to represent more tasks that may be added to the system at any time.

2 Background Information
Traffic lights, which may also be known as stoplights, traffic lamps, traffic signals, stop-and-go lights, are signalling devices positioned at road intersections, pedestrian crossings and other locations to control competing flows of traffic. Traffic lights have been installed in most cities around the world. They assign the right of way to road users by the use of lights in standard colours (Red-Amber-Green), using a universal colour code (and a precise sequence, for those who are colour blind) (Ram, B. 2008).The most common traffic lights consist of a set of three lights: red, amber, and green. When illuminated, the red light indicates for vehicles facing the light to stop, the amber indicates caution, either because lights are about to turn green or because lights are about to turn red and the green light is to proceed

3 Traffic Light Technologies
There are several technologies associated with traffic light control systems. They are of two perspectives: Optics

and Lighting, and the control module technologies.

3.1 Optics and Lightning

3.1.1 Light-Emitting Diodes (LEDs)

In the mid1990s, cost-effective traffic light lamps using light-emitting diodes (LEDs) were developed; prior to this traffic lights were designed using incandescent or halogen light bulbs. Unlike the incandescent-based lamps, which used a single large bulb, the LED-based lamps consist of an array of LED elements, arranged in various patterns. When viewed from a distance, the array appears as a continuous light source.LED-based lamps have numerous advantages over incandescent lamps, among them are, much greater energy efficiency, much longer lifetime between replacements, measured in years rather than months. Part of the longer lifetime is due to the fact that some light is still displayed even if some of the LEDs in the array are dead, brighter illumination and less ‘phantom light’ resulting from reflection of direct sunlight, the ability to display multiple patterns from the same lamp.Individual LED elements can be enabled or disabled, much faster switching, instead of sudden burn-out like incandescent-based lights, LEDs start to gradually dim when they wear out, warning transportation maintenance departments well in advance as when to change the light.

3.1.2 Programmable Visibility Signals

Signals such as the 3M High Visibility Signal and McCain “Programmable Visibility” signal, utilize light diffusing optics and a powerful Fresnel lens to create the signal indication. Lit via a powerful 150W PAR46 sealed-beam lamp, the light from the lamp in these “programmable visibility” signals passes through a set of two glass lenses at the back of the signal. The first lens, a frosted glass diffusing lens, diffuses the light into a uniform ball of light around five inches in diameter. The light then passes through a nearly identical lens known as an optical limiter (3M’s definition of the lens itself), also known as a “programming lens”, five inches in diameter as well.

3.1.3 Conventional Lighting Systems

Conventional traffic signal lighting, still common in some areas, utilizes a standard light bulb. Typically, a 67 watt, 69 watt, or 115 watt medium base light bulb provides the illuminationlight then bounces off a mirrored glass or polished aluminium reflector bowl, and out through a polycarbonate plastic or glass signal lens (Zvonko, S. B.2005). In some signals, these lenses were cut to include a specific refracting pattern.

3.2 Control Module

There are several technologies that can be used to process Boolean algebra which is the brain behind the control logic which now in turn controls the sequencing operation of the lighting system. These are as follows:

3.2.1 Standard-Cell

Numerous chips are available that realize some commonly used logic circuits. They usually conform to an agreed-upon standard in terms of functionality and physical configuration (Albagul. A, et al, 2006). Each standard chip contains a small amount of circuitry (usually involving fewer than 100 transistors) and performs a simple function. To build a logic circuit, the designer chooses the chips that perform whatever functions are needed and then defines how these chips should be interconnected to realize a larger logic circuit.

3.2.2 Programmable Logic Devices.

In contrast to standard chips that have fixed functionality, it is possible to construct chips that contain circuitry that can be configured by the user to implement a wide range of different logic circuits. These chips have a very general structure and include a collection of programmable switches that allow the internal circuitry in the chip to be configured in many different ways. The designer can implement whatever functions needed for a particular application by choosing an appropriate configuration of the switches. The switches are programmed by the end user, rather than when the chip is manufactured. Such chips are known as programmable logic devices (PLDs).

3.2.3 Micro-Code ROM-Based Devices

Another set of devices in use are the micro-instruction coded ROM-based microprocessor devices. The microprocessor is a digital integrated circuit that can be programmed with a series of instructions to perform various operations on data. A microprocessor serves as the central processing unit (CPU) of many devices such as the computer (Watkinson, J. 2002). It can do arithmetic operations, move data from one place to another, and make decisions based on certain conditions. The microprocessor and its derivatives are highly used in embedded systems. Basically, a microprocessor consists of an arithmetic logic unit (ALU), instruction decoder, a register array, and a control unit (Sun,W., et al 2000).

4. Limitations of Existing Traffic Light Control System

Most of the existing traffic light control systems are faced with several limitations such asflexibility issue due to their hardware nature which cannot be changed as desired when such need arises to meet with traffic trend demand (Marcovitz, A. B.2002), high cost because they are imported and thus attract some duty, most of traffic light control systems are junction specific, there are no traffic light trainers available to handle them.At present in the city of Ado-Ekiti, the traffic situation with the present control system is quite worrisome and unbearable.

The following data were collected to corroborate our observations and findings.

5. Materials and Methods

People were employed for the purpose of data collection. Each person was stationed at each arm of the two major intersections in Ado-Ekiti. The following data were collected for the two intersections:

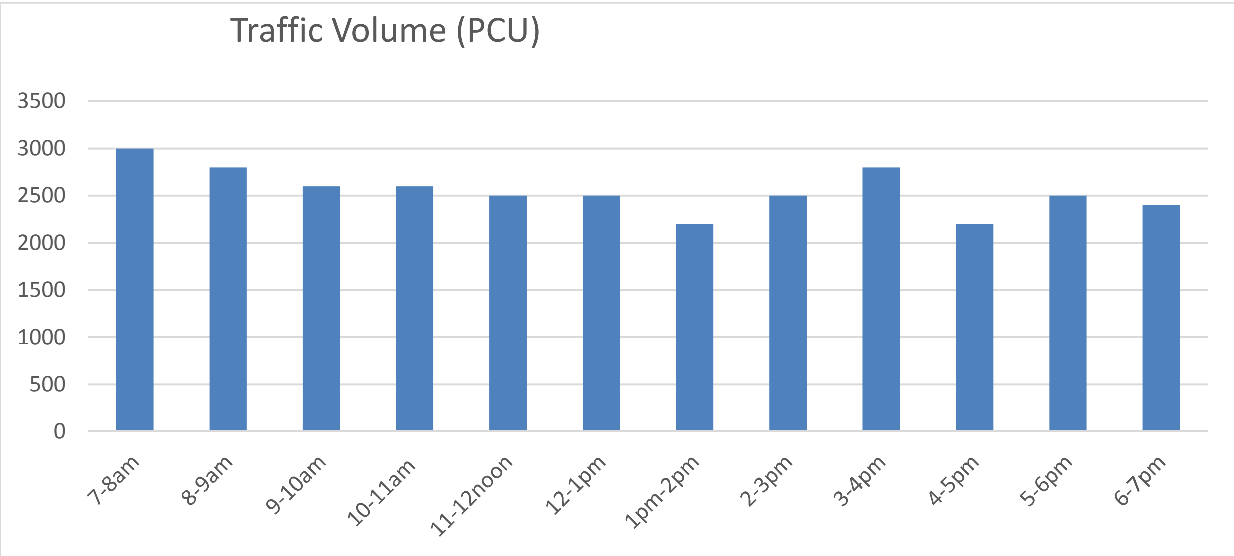
i. The number of vehicles entering the intersections every hour, from each approach, for a period of 12 hours.
ii. The number of vehicle entering the intersections every 5 minutes, from each approach, for the peak period in the morning and in the afternoon and the average thus found.
iii. Vehicle volumes for each traffic movement from each approach, classified by vehicle type i.e. motorcycles, light trucks, medium trucks and heavy trucks during traffic movement at the intersections.

5.1 Traffic volume data analysis

The hour count from 7.00am to 7.00pm was collected and analysed. The analysis is shown below.

Time (hours)	Traffic Volume (PCU)
7-8am	3000
8-9am	2800
9-10am	2600
10-11am	2600
11-12noon	2500
12-1pm	2500
1pm-2pm	2200
2-3pm	2500
3-4pm	2800
4-5pm	2200
5-6pm	2500
6-7pm	2400

Table 1: 12-hours traffic volume at Ejigbo/Federal Poly intersection

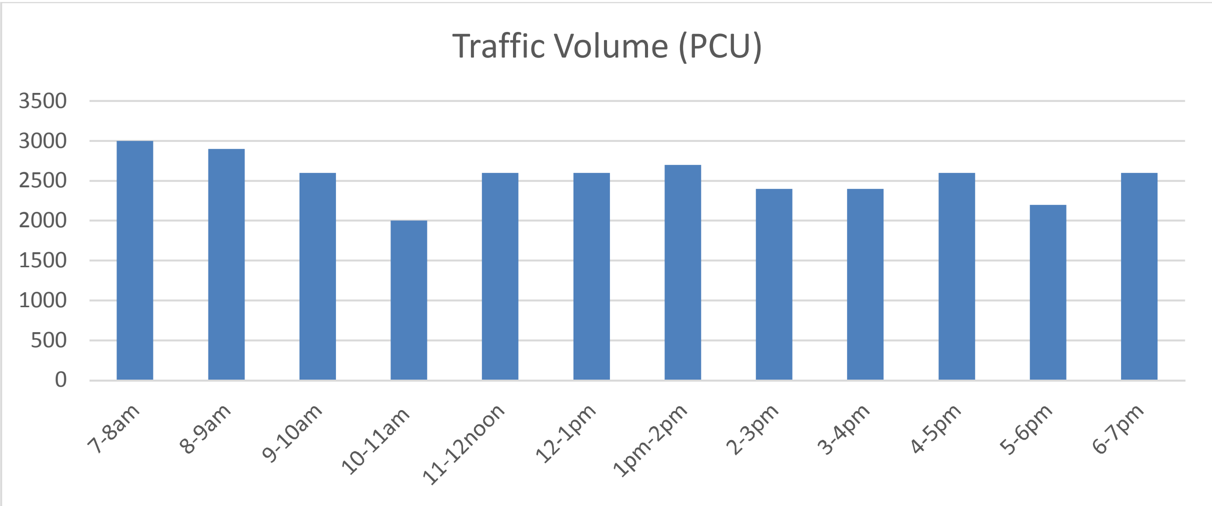


Time (hours)

Figure 1: 12-hours traffic volume at Ejigbo/Federal Poly intersection

Time(hours)	traffic volume (pcu)
7-8am	3000
8-9am	2900
9-10am	2600
10-11am	2000
11-12noon	2600
12-1pm	2600
1pm-2pm	2700
2-3pm	2400
3-4pm	2400
4-5pm	2600
5-6pm	2200
6-7pm	2600

Table 2: 12-hours traffic volume at Bashiri/Adebayo/Fajuyi Roundabout Intersection



Time (hours)

Figure 2: 12-hours traffic volume at Bashiri/Adebayo/Fajuyi Roundabout Intersection

5.2 Average Daily Traffic (ADT) of the Intersections

The average daily traffic is the number of vehicles that pass a particular point on a roadway during a period of 24hours consecutive hours average over a period of 356 days. The volume collected for 12 hours (V_{12}) in Passenger Car Unit (PCU)is made use as shownin table 3.

Ijigbo/Federal Poly Road Intersection	Bshiri/Adebayo/Fajuyi Intersection
V_{12}=29,545 But V_{12}=80% ADT The average volume for 24 hours is thus V_{24}=ADT=V_{12}/0.8=29,545/0.8 ADT=36,931 vehicle/day	V_{12}=30,943 But V_{12}=80% ADT The average volume for 24 hours is thus V_{24}=ADT=V_{12}/0.8=30,943/0.8 ADT=38,678 vehicle/day

Table 3: Table shows the average daily traffic (ADT) of the intersection

5.3 Results and Discussions

From the analysis above, the two major intersections operates at a low level of control. Therefore a better control scheme is necessary for better performance.

6 The Design of 4-Junction Road Intersection Intelligent Traffic Controller

The design of the Intelligent Traffic Light Control System will enable the following;

- It can be configured to serve at the following types of traffic intersection, 4-junction with left turn, automobile pedestrian crossing, 4-Junction with LED display and 4-junction with lamps (when interfaced). Just by selecting the right control input, the control system is meant to behave as a control for the selected road intersection (Dan, E., et al 2003).

- This control system/training kit can serve as training equipment for all types of road users. It can be used in schools, driving schools and even at home to educate road users on traffic behaviour and rules governing traffic flow at road intersections and pedestrian crossings.
- It is meant to replace the imported traffic light heads, this being indigenous.The traffic control will have advanced technology, ranging from auto-sensing and control to dynamic time slot allotment. Traditionally, traffic light timings are fixed in nature. This can cause a lot of time waste and delay making some busy lanes wait almost indefinitely while the less busy lanes enjoy free flow since all lanes are assigned equal time intervals both for wait-and-go phases (Tanenbaum, A.S. 2006).

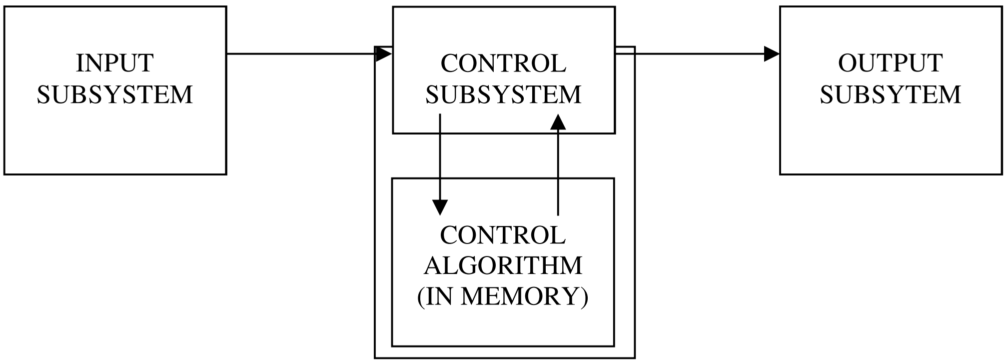


Figure 3: Block Diagram Overview

As indicated in Figure 3 above, the input subsystem comprises a switch panel that passes input signals to the control system which in turn invokes control algorithm from the system's memory for its control operations.The input signal is used to configure the system to behave as a particular type of traffic junction controller. The user can select one out of the four types of junction controls at the time of configuration prior to installation of the panel. When used as a trainer, selection is also made in a similar manner.The timing signals are used to control the sequencing of light. The light change cycles through GREEN, AMBER and RED in response to the timing requirements of the system.

6.1 Timing Requirements of the System

The period of time in which only green LED is on and other LEDs are off on a traffic light head is T1 = 100 seconds. This applies for red only on time.The amber-green as well as amber-red on period is T2 = 20 seconds. At this time, the red LEDs to mean stop is also on for the lanes without the right of way.The pedestal 'go' time is T3 = 80 seconds. We see that the 'go' and 'stop' exclusive period is 20s while the 'getready-to-go' and 'get-ready-to-stop' time is 19 seconds. At the pedestrian 'go' time all the lanes show red LEDs on.

6.2 Flexibility Factor

The system will be flexible in that it can be modified to accommodate new functions. To make this possible, a reprogrammable microcontroller is used. Programs will be modularized so that more modules can be added when more functionality is required. An unwanted function can be removed from the system by simply removing the program module responsible for it.

6.3 The Software Subsystem

The various road junctions to be controlled in this work are software driven and thus require a software program to be written and embedded in the system's memory. The language of choice for this problem is Assembly language. The approach adopted is a modular structure in which different types of junction controls are designed as small program modules which now combine into a fairly complex program.

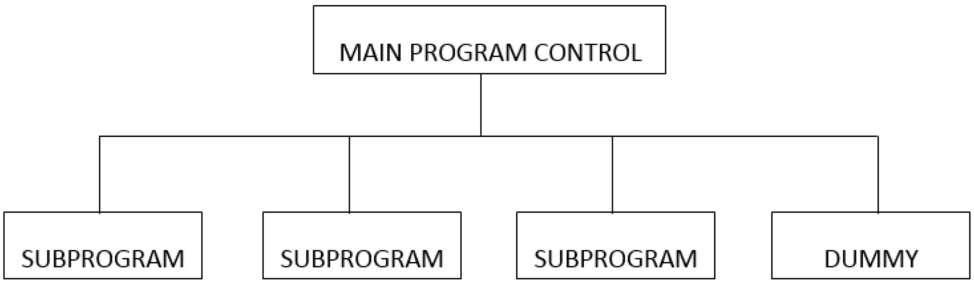


Figure. 4 Software control modules

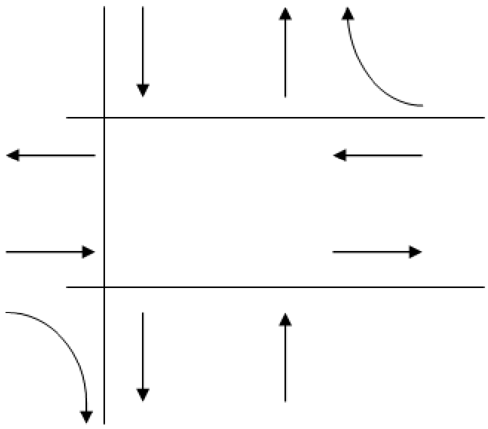


Figure 5 Cross-junction traffic flow with no left turn

6.4 Software Subsystem Implementation

The entire software driving the traffic light control system is Assembly language coding. The source code was developed in an integrated development environment (IDE) and compiled using an Assembler to generate Intel Hex file.

Figure 6 Log In And Log Out Interface

Figure 7: This Display the Features Present Inside The Software

Figure 8: *Map of Fajuyi Pack*

Figure 9: Traffic Offence Report View

Figure 10: Traffic Offence Report When Login

Figure 11: A View of The Data Saved

Figure 12: Vehicle Traffic Control Systems

7 Conclusion

This control system can be deployed to any road junction for traffic controls.Like every research and practical work, diverse kinds of problems are often encountered. The problems encountered in this work and how they were solved and manoeuvred were quite challenging. Based on our analysis of the present traffic control system, the following assumption became necessary in order to develop a feasible system, the system will only work for four-way junction with traffic coming from the four cardinal directions with left turn and traffic only move in one direction at a time.In the course of developing this prototype, the real challenging problems encountered were the analysis of road junctions and the design of control algorithm. However these problems were combated by careful analysis and design having in mind some factors such as traffic application design, availability of component and research material, efficiency, compatibility, portability, and also durability.Apart from using the system as an intersection controller, it could be adopted to traffic volume measurement, using the same basic design, it can also be expanded for the traffic control of wide area network (WAN) for the traffic control of any number of intersection and approaches. These offer the feature of centrally controlling the traffic movement within the city, this prototype can be adopted for real life usage by using state switching devices such as relay, silicon Controlled Rectifier (SCR) to actuate the traffic lights.

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