International Journal of Science and Engineering Applications
Volume 7–Issue 07,125-129, 2018, ISSN:-2319–7560

Modelling and Control of Quadrotor Control System using MATLAB/Simulink

Wai Mar Thet
Department of Electronics Engineering
Technological University Thanlyin, Myanmar

Myo Myint
Department of Electronics Engineering
Technological University Thanlyin, Myanmar

Ei Ei Khin
Department of Electronics Engineering
Technological University Thanlyin, Myanmar

Abstract: Generally, Quadrotor type Unmanned Aerial Vehicles are unstable in nature, so to stabilize it, the controller is used. This paper observes the PD controller that make use of UAV to control the adjust of quadrotor UAV even as in the air. The gain parameters of the PD controller, the proportional gain K_p and the derivative gain K_d are apply to be stable and good performance. Unmanned aerial vehicles (UAV) are becoming increasingly common and span a huge range of size and shape. After integrating PD controllers into the systems, quadcopter settling time of roll, pitch and yaw system. Simulations result and comparison of X, Yand Yaw control techniques are presented at the end of this paper. This controller monitors the controlled process variable, and compares it with the reference or set point. The difference between actual and desired value of the process variable, called the error signal. Error is applied as feedback to generate a control action to bring the controlled process variable to the same value as the set point. Control action in which the output is proportional to a linear combination of the input and the time rate of change of input.

Keywords: stabilization; integrating; simulations result and comparison; error signal; control action

1. INTRODUCTION

UAVs or ‘Unmanned Aerial Vehicles’ are defined as aircrafts without the onboard presence of pilot. Research and development of unmanned aerial vehicle (UAV) are getting high encouragement nowadays, since the application of UAV can apply to variety of area such as rescue mission, military, film making, agriculture and others. For search and rescue mission, UAV that attached with infrared cameras assist the mission to search the target. Quadcopter or quadrotor aircraft is one of the UAV that is major focuses of active researches in recent years. Quadcopter operated by thrust that produce by four motors that attached to it body. It has four input force and six output states (x, y, z, θ, ψ, ω) and it is an under-actuated system, Quadcopter has the advantages over the conventional helicopter where the mechanical design is simpler. UAVs are usually used for activities which are deemed to be either too dull, dirty or dangerous for humans, and as a result, eliminates the risk of loss of human life for certain applications [1]. UAVs can be remotely controlled or flown autonomously based on pre-programmed flight plans. Hence, plenty of research has been done with regards to control techniques for the trajectory tracking of the flight plans. Quadrotors are now widely available, both as commercial products and as open-source projects. Usually UAV systems are unstable and stabilization control plays a very important role in it. It automatically stabilizes the attitude of the vehicle and prevents the vehicle from flopping and also maintains the desired orientation during flight. The Quadrotor UAV stabilization is depend upon the appropriate controlling of their four motor speed. A stable flight is necessary for safety and for better flight experience and to achieve a successful mission. The four rotors are used in controlling the vehicle. Each rotor produces moments as well as vertical forces. These moments have been experimentally observed. The flight movement of quad-rotor UAV is controlled by varying the speed of each propeller and the attitude stabilization can be achieved by controlling the required speed of each motor. UAVs can be remotely controlled or flown autonomously based on pre-programmed flight plans. Hence, plenty of research has been done with regards to control techniques for the trajectory tracking of the flight plans. Nowadays, one of the most popular UAV type is the rotary fixed-wing UAV. They are highly lauded due to the advantages they have, such as; vertical take-off and landing ability, portability, good mobility, ability to carry payload, and also the ability to operate in constraint spaces. The main contribution of this paper is to introduce a new based PD control algorithm for attitude stabilization of Quad-rotor UAV. It is worth to mention that the proposed algorithm was implemented and tested on developed Quadrotor UAV system and compared with conventional PD Controller.

2. MODELLING OF A QUADROTOR

2.1 Aerodynamics Forces and Torques

Quadrotor needs a mechanism for generating forces and torques that are required to control its horizontal and vertical movements. There are four main forces that exert on a quadrotor: gravity, lift, thrust and drag. Gravity is a force that pulls the quadrotor down because of its mass. Lift and thrust are the upward reaction forces acting on quadrotor due to the propellers. Finally, drag is the backward force on the quadrotor due to air. Quadrotor mechanism is mainly based on its rotors and propellers that generate thrust perpendicular to its rotor. The main thrust is generated along Z axis that creates vertical movement. The horizontal movements along X and Y axes are resulted from directing the force or thrust vector in the appropriate direction. Therefore, quadrotor can be characterized by one main control force T b uF, collective lift u is the sum of the thrust generated by the four propellers.

Where l is distance from the propellers to the center of mass of the quadrotor and Q is the fan torques due to air.

The collective lift u is the sum of the thrust generated by the four propellers.

$$\alpha = \sum_{i=1}^{4} f_i \quad (1)$$

Torque produced by each axis is resulted from

$$\gamma_{\theta} = b(f_2 - f_4) \quad (2)$$

$$\gamma_{\emptyset} = b(f_3 - f_1) \quad (3)$$

$$\gamma_{\varphi} = Q_1 + Q_2 + Q_3 + Q_4 \quad (4)$$

Where b is distance from the propellers to the center of mass of the quadrotor and Q is the fan torques due to air drag.

θ°_{roll}, θ°_{pitch} and θ°_{yaw} are the roll, pitch and yaw angular velocity that can be received from gyro sensor. The error values will be

$$e_{roll} = \theta^{\circ}_{rollde} - \theta^{\circ}_{roll} \quad (5)$$

$$e_{pitch} = \theta^{\circ}_{pitchde} - \theta^{\circ}_{pitch} \quad (6)$$

$$e_{yaw} = \theta^{\circ}_{yawde} - \theta^{\circ}_{yaw} \quad (7)$$

where rollde θ°_{rollde}, pitchde $\theta^{\circ}_{pitchde}$ and yawde θ°_{yawde} represent desired angular velocity. Using these error values in PD equation, it can be gained

$$\mu_{roll} = k_p e_{roll} + k_d \frac{de_{roll}}{dt} \quad (8)$$

$$\mu_{pitch} = k_p e_{pitch} + k_d \frac{de_{pitch}}{dt} \quad (9)$$

$$\mu_{yaw} = k_p e_{yaw} + k_d \frac{de_{yaw}}{dt} \quad (10)$$

2.2 Quadrotor Configuration

Quadrotor UAV can be assigned to two different configurations; plus, and cross configuration. In this case, four brushless DC motors are mounted on quadrotor UAV in cross configuration. One pair of motors (1, 3) rotates in counter clockwise direction while the other pair of motors (2, 4) rotates in clockwise direction as shown in fig. The motion of quadrotor is achieved by varying the motor speed. Thus, increasing or decreasing the four motor's speeds together generates vertical motion. Increasing motor (1, 2) speed or motor (3, 4) speed produces roll rotation that results quadrotor to bend left or bend right. The same method is used for pitch control. Varying motors (1,4) and motors (2,3) speed conversely produce pitch rotation that results quadrotor to go forward or backward. Yaw rotation can be done by the difference in the counter-torque between each pair of motors.

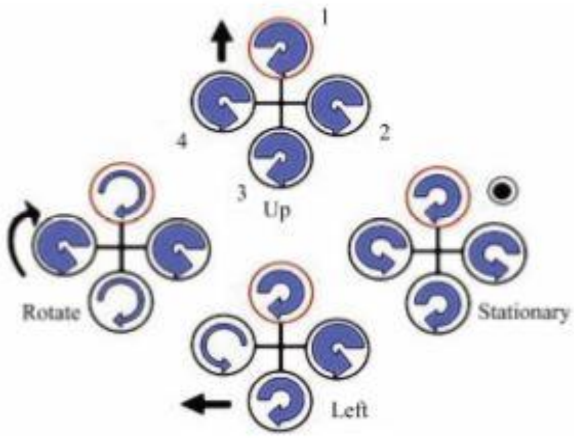

Figure 1. Quadrotor concept motions description

3. CONVENTIONAL PD CONTROLLER

Proportional-plus-derivative(PD) controllers are widely used in the industry [2,3]. The main reason is its relatively simple structure, which can be easily understood and implemented in practice [4]. The widespread use of PD-type controllers in industries has affected efforts in the design and tuning of conventional PD controllers so as to achieve an optimal performance for the control system [5] The quadrotor in nature is very unstable. In order to stabilize the quadrotor, PD controller is needed to be developed within the system. PD controller is the most widely used controller because of its simplicity and robustness. The mathematical equivalent of PD control algorithm can be expressed as

$$\mu = k_p e + k_d \frac{de}{dt} \quad (11)$$

Where k_p and k_d are the proportional, and derivative gains respectively. To achieve stabilization, three PD controllers are implemented for three different axes: roll, pitch and yaw respectively. For a sensor feedback, we use gyro sensor which is three axes angular rate sensor.

4. IMPLEMENTATION OF SIMULINK

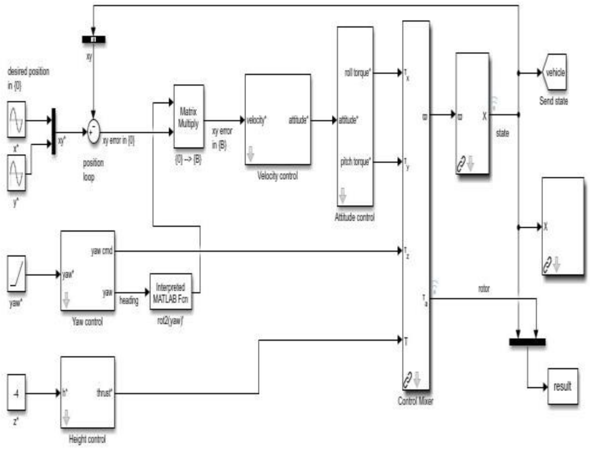

Figure 2. Block Diagram of Simulation

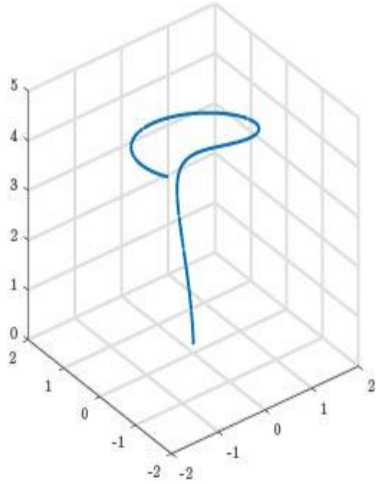

Figure 3. The trajectory of UAV without changing P

This figure contains yaw control, high control, velocity control, attitude control. Firstly, the velocity control of proportional gain is 0.1 and derivative gain is 2. The High control of proportional gain is 4 and derivative gain is 1. The altitude control of proportional gain is 100 and derivative gain is 1. The yaw control of proportional gain is 20 and derivative gain is 2. The simulation result of desired value and actual value as shown in figure 4. The error value x, y and yaw as shown in figure 5. And then, this velocity, high, altitude and yaw control with proportional gain is changing and the derivative is not changing this result of desired and actual value as shown in figure 7, and the error value of x, y and yaw as shown in figure 8.

5. SIMULATION RESULT

The simulation result is the compared of desired and actual value and error without changing P and with changing P. The changing of P is high the error is high. The greater the value of P, the higher the error becomes. This paper states the result of this desired and actual error of X, Y and Yaw.

Table 1. PD gain values for without changing P

Type	k_p	k_d
Velocity Control	0.1	2
High Control	4	1
Altitude Control	100	1
Yaw Control	20	2

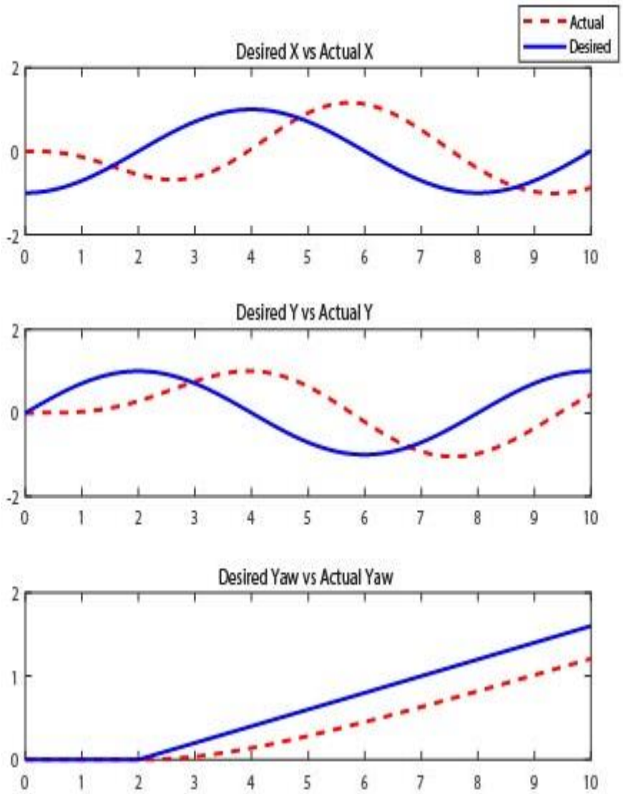

Figure 4. Plot of desired & actual value of X, Y & Yaw

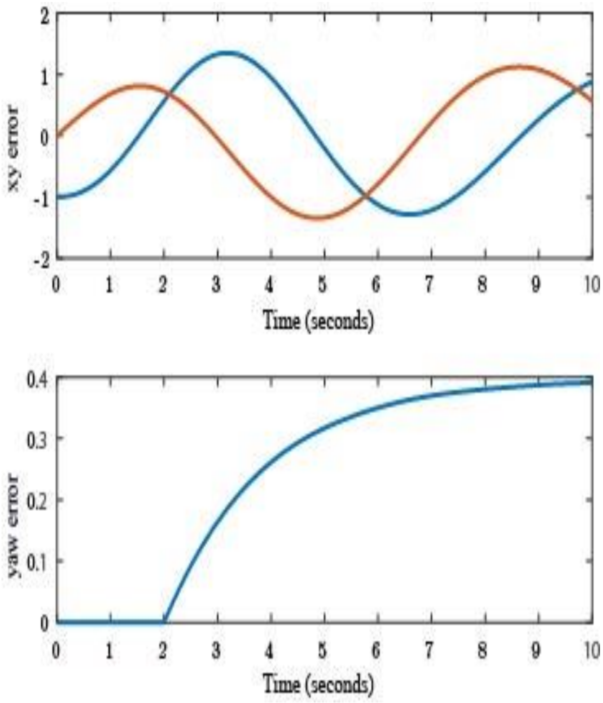

Figure 5. Plot of error in X, Y & Yaw without changing P

Table 2. PD gain values for with changing P

Type	k_p	k_d
Velocity Control	0.2	2
High Control	8	1
Altitude Control	200	1
Yaw Control	40	2

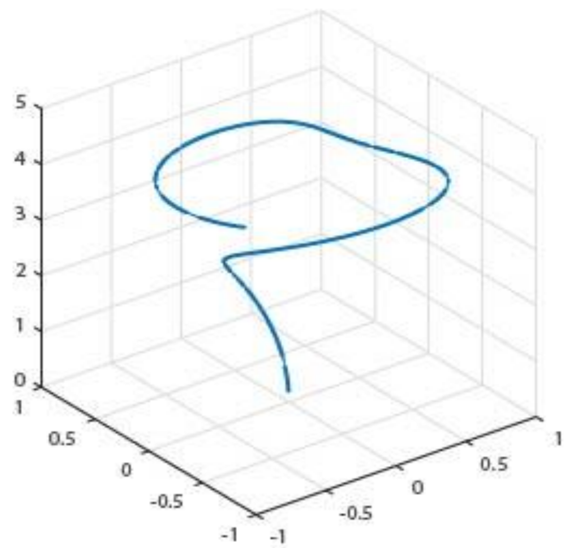

Figure 6. The trajectory of UAV with changing P

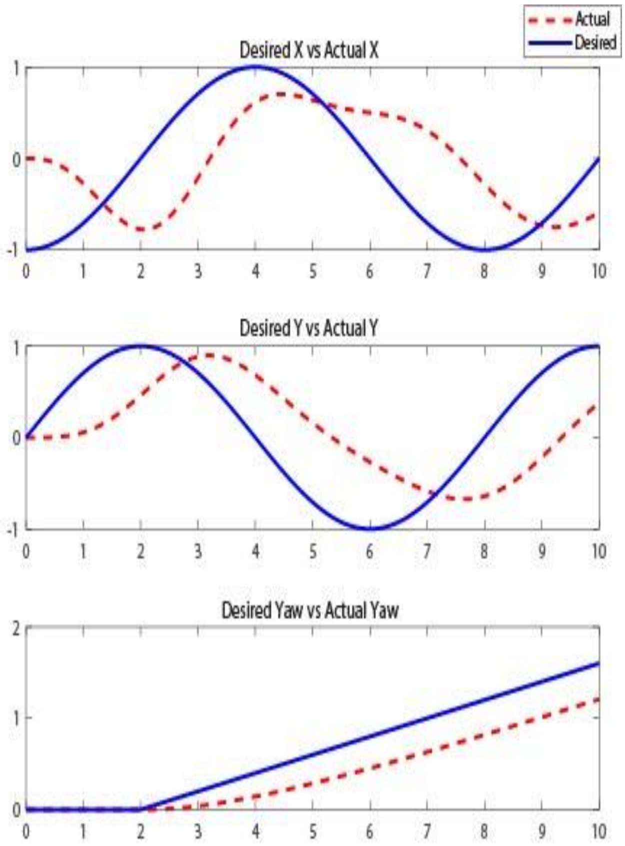

Figure 7. Plot of desired & actual value of X, Y & Yaw

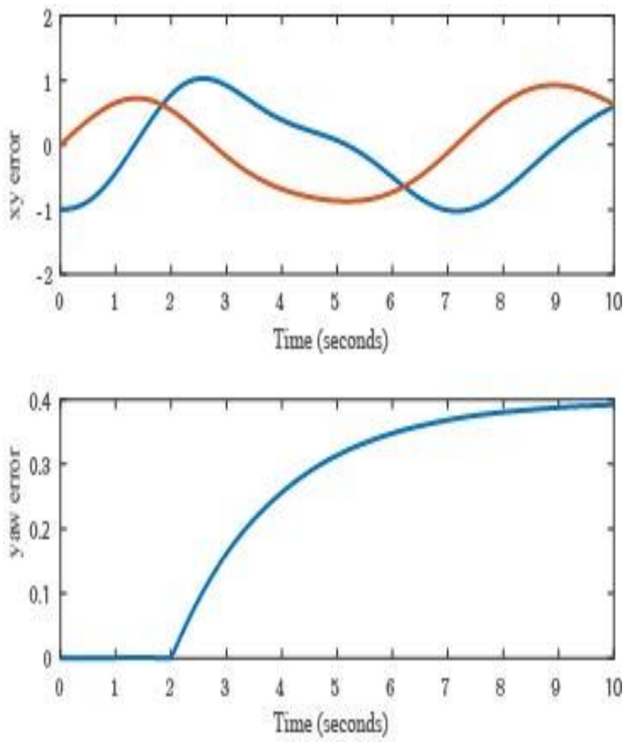

Figure 8. Plot of error in X, Y & Yaw with changing P

6. CONCLUSION

Unmanned aerial vehicles (UAV) can provide a critical support for search and rescue operations. However, in order to achieve their full potential, it is necessary to properly account for all the parameters that can affect the flight of the UAVs such as quality of sensory operations (that can depend on the position of the UAVs for instance), energy constraints, environmental hazards or data sharing constraints between UAVs and rescue teams.

This paper presented the design of a PD controller algorithm to control the quadrotor system. The simulation result of the desired value and actual value of X,Y and Yaw compared without changing PD and with changing PD controller .Also the compared of this result can be improved by using others features.

7. ACKNOWLEDGMENTS

I greatly appreciate to all teachers from the Department of Electronics Engineering, Technological University (Thanlyin) who work in Research.

I would like to give great thanks to Research Department of Electronics Engineering, Technological University (Thanlyin) for kind permission to study related on-going research projects.

8. REFERENCES

[1] Comparison of Backstepping, Fuzzy-PID, and PID Control Techniques using X8 model in relation to A* Path Planning Yi Zhou Singapore Institute of Technology , Singapore.

[2] K. J. Astrom and T. Hagglund, "Automatic Tuning of Regulators with Specifications on Phase and Am- plitude Margins," Journal of Automatica, Vol. 20, No. 5, 1984, pp. 645-651. doi:10.1016/0005-1098(84)90014-1.

[3] W. K. Ho, O. P. Gan, E. B Tay and E. L. Ang, "Perform- ance and Gain and Phase Margins of Well-Known PID Tuning Formulas," IEEE Transactions on Control System Technology.

[4] Q. G. Wang, T. H. Lee, H. W. Fung, Q. Bi and Y. Zhang, "PID Tuning for Improved Performance," IEEE Transac- tions on Control Systems Technology.

[5] Y. C. Cheng and C. Hwang, "Stabilization of Unstable First-Order Time-Delay," Journal of the Chinese Institute of Engineers.

[6] D. Vrancic, S. Strmcnik, J. Kocijan and P. B. M. Oliveira, "Improving Disturbance Rejection of PID Controllers by Means of the Magnitude Optimum Method," ISA Trans- actions.

International Journal of Science and Engineering Applications
Volume 7–Issue07, 130-132, 2018, ISSN:-2319–7560

Internet of Thing Technology Concentration for Reliable and Smart Power System

Hnin Yi Aye
IT Department,
West Yangon Technological University,
Myanmar

Ohn Zin Lin
Electrical Power Department,
Yangon Technological University,
Myanmar

Abstract: Internet of Thing becomes a advanced technology in transforming many areas of mod-ern age including power system. Electricity is also a backbone of the country's economy and it is important to get the reliable supply at all time. Using IoT technology, the switching time and restoration of the system can be reduced and consequently the reliability can be improved. In this paper, how to concern the IoT technology in power system is described. Moreover, the reliability improvement by IoT technology is also conducted with the reliability indices analysis. According to the results, the amount of energy not supply, ENS and system average interruption duration is reduced by the IoT technology. The reliability test system of RBTS bus 2 is used as the test system.

Keywords: I0T, Power system, Reliability improvement, Energy not supply, SAIDI, Smart Grid

1. INTRODUCTION

The Internet of Things (IoT) refers to the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. IoT is expected to spread rapidly over the coming years and this convergence will unleash a new dimension of services that improve the quality of life of consumers and productivity of enterprises, unlocking an opportunity. For consumers, the IoT has the potential to deliver solutions that dramatically improve energy efficiency, security, health, education and many other aspects of daily life. For enterprises, IoT can under-pin solutions that improve decision-making and productivity in manufacturing, retail, agriculture and other sectors [1].

.The major area where IoT deals with energy management systems is the smart grid. IOT extends the benefits of smart grid be-yond the automation, distribution and monitoring being done by the utilities [2]. The task of the IoT in the field of electrical energy includes

(1) Advanced Metering Infrastructure (AMI)

(2) SCADA (Supervisory Control and Data Acquisition)

(3) Smart Inverters

(4) Remote control operation of energy consuming devices

By using conventional switch gears in distribution systems, it takes too much time to know fault locations and to disconnect the faulted lines. By using Distribution Automation System (DAS), the problem can be solved in short time. . Therefore, it is necessary to use automated protections devices controlled by SCADA system to improve the reliability of the system. And IOT technology is used in SCADA system.

In SCADA system, Remote Telemetry Unit (RTU) is a device that collects and transmits the data to Mater Terminal Unit (MTU). RTUs are equipped with input chan-nels for sensing or metering, output channels for control. A block diagram of RTU is shown in Fig.1. The working principle of each protection devices such as disconnector and circuit breaker (CB) are monitored by programmable logic controller (PLC)[3].

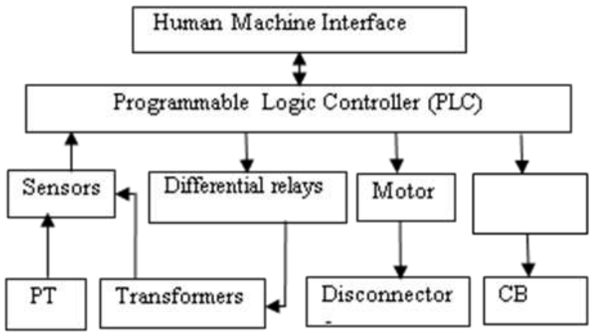

Fig. 1 Block Diagram of RTU

2. METHODOLOGY

Distribution system is responsible for transferring electrical energy to the end users. The outage in the distribution system has a localized effect compared with generation and transmission sectors. However, analysis of the customer failure statistics indicates that the distribution system has the greatest contribution to the unavailability of supply to a customer.

In this paper, to analyze the impact of protection system on reliability, following reliability indices are used: system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI), customer average interruption duration index (CAIDI), energy not supplied index (ENS) and average energy not supplied index (AENS) The equations of reliability indices are equation (1)-(5) [4].

Reliability indices are typically computed by utilities at the end of each year by using historical outage data recorded in distribution outage reports. This is important because utilities know how their systems are performing. However, it is less useful when the specific impact of various design improvement options wish to be quantified and compared. To make such comparisons, a model must be developed which is capable of predicting.

$$SAIFI = \frac{\text{total number of customer interruptions}}{\text{total number of customer sserved}}$$

$$= \frac{\sum \lambda_i N_i}{\sum N_i} \quad \text{per/ year} \qquad (1)$$

$$\text{SAIDI} = \frac{\text{sum of customer interruption duration}}{\text{total number of customer}}$$

$$= \frac{\sum U_i N_i}{\sum N_i} \quad \text{hr/year} \qquad (2)$$

$$\text{CAIDI} = \frac{\text{sum of customer interruption duration}}{\text{total number of customer interruptions}}$$

$$= \frac{\sum U_i N_i}{\lambda_i N_i} \quad \text{hr/year} \qquad (3)$$

$$\text{ENS} = \sum L_{a(i)} U_i \quad \text{MWh/yr} \qquad (4)$$

$$\text{AENS} = \frac{\text{total energy not supplied}}{\text{total number of customers served}}$$

$$= \frac{\sum L_{a(i)} U_i}{\sum N_i} \quad \text{MWh/yr} \qquad (5)$$

Where $\mathbf{L_{a(i)}}$ is average load demand at load point **i** and $\mathbf{U_i}$ is outage time at load point **i**.

Reliability indices are useful for determining what a customer can expect in terms of interruption frequencies and durations [4].

3. TEST SYSTEM AND DATA

The test system used in this paper is RBTS Bus 2 system shown in Figure 2 [5]. The single 11 kV supply point for RBTS Bus 2 system is justified by the 20 MW load. The feeders are operated as radial feeders alt-hough they can be connected as a mesh through normally open sectionalizing points.

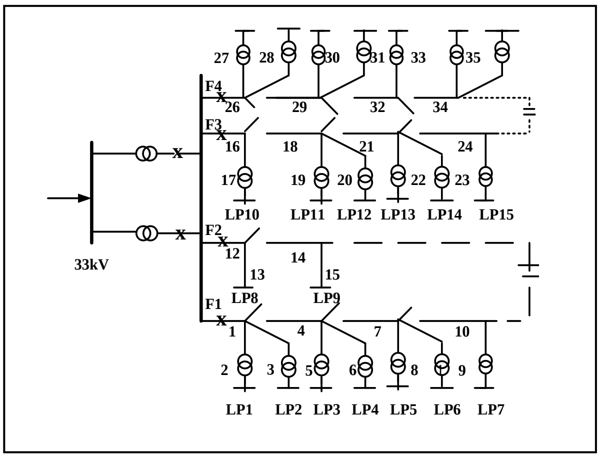

Fig. 2 Distribution system for RBTS bus 2

Table 1 Feeder types and lengths

Feeder Type	Length (km)	Feeder section numbers
1	0.6	2,6,10,14,17,21,28,30,34
2	0.75	1,4,7,9,12,16,19,22,24,27,29,32 ,35
3	0.8	3,5,8,11,13,15,18,20,23,26,31, 33,36

Table 2 Loading data

Feeder	Average Load (MW)	Peak Load (MW)	Numbers of customers
1	3.645	5.934	652
2	2.15	3.5	2
3	3.106	5.057	632
4	3.39	5.509	622
Total	12.291	20	1908

The test system has four feeders and thirty six feeder sections. Feeder types and lengths are mentioned in Table 1. For calculation of indices, the failure of breaker and bus bar can be neglected because the failure ration is so small. The tie line effect is also neglected. The load data and system reliability data is shown in Table 2 and 3.

Table 3 Reliability and system data

Component	λ	r	r_p	s
33/11 Transformer	0.015	200	15	1
11/0.4 Transformer	0.015	200	10	1
11kv Lines	0.065	5		1

The $\boldsymbol{\lambda}$ is failure rate per year per kilometer for lines and failure rate per year for transformers. The **r** is repair time in hour. The $\mathbf{r_p}$ is replacement time by a spare in hour. The **s** is switching time in hour.

4. SIMULATION RESULTS

In automation system, the switching time is decreased 1hr to 1 minutes. Repaired time is also decreased 5 hours to 0.5hour [3]. Assume that transformer replacing time is reduced 10 hours to 5 hours. By changing these data, reliability condition is analyzed in two cases as follows:

Case I : Conventional System

Case II: System with IoT Technology

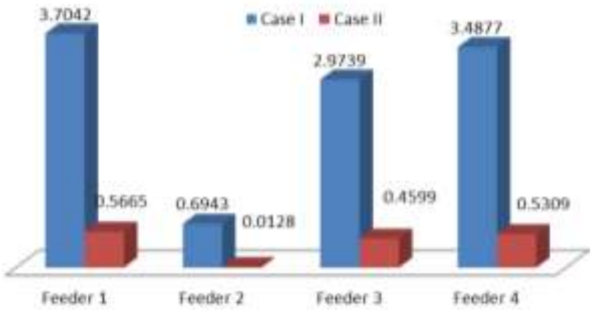

Fig.3 Comparison of ENS in two cases

The comparison of energy not supply is shown in Fig.3 and the amount of ENS is compared in two cases for four feeders. according to results, the amount of ENS is reduced using IoT technology. For example, ENS is decreased from 3.7042 MW to 0.5665 MW per year.

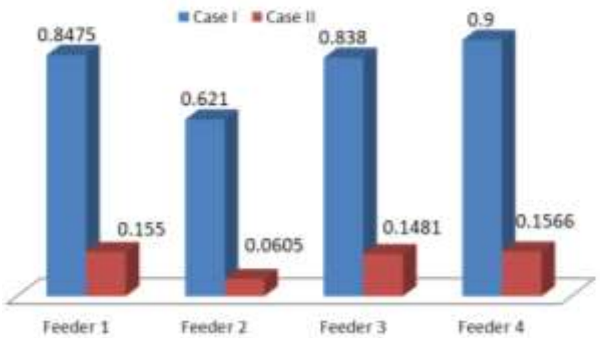

Fig.4 Comparison of SAIDI in two cases

In Fig.3, the c system average interruption duration index is compared for four feeders. As we can see in the result, the duration of interruption is decreased in case II. For feeder 1, the customer will be interrupted 0.8475 hours in one year if the system is the conventional system. After installation of IoT, the interruption time is reduced to 0.155 hour. This analysis is only for small test system and there will be a huge impact for a large

5. CONCLUSION

Or thanks to the experts who have contributed towards development of the template. According to the analytical results in this paper, the concentration of IoT can make the power system reliability better. of Things is improving efficiency to assist the smart grid system. By collecting and analyzing data, utilities are able to provide more reliable and efficient power to users. As the use of IoT technology becomes more prevalent, we can expect a greener and more efficient electricity delivery system.

6. ACKNOWLEDGMENTS

We are deeply grateful to Ministry of Education, Myanmar for giving a chance for motivating to submit the research papers.

7. REFERENCES

[1] GSM Association. (2014). Understanding the internet of thing (IoT). https://www.gsma.com/iot/wp-content/uploads/2014/08/cl_iot_wp_07_14.pdf

[2] Electric Technology (2016). Internet of things and its application in electrical power industry

http://www.electricaltechnology.org/20 16/07/internet-of-things-iot-and-its-applications-in-electrical-power-industry.html

[3] Ohn Zin Lin and Hajime Miyauchi(2014). DG Potential in Myanmar and Proposed Method to Improve Distribution System Reliability by DGs and SCADA Based Distribution Automation System. Paper presented at *the international conference of electrical engineering, 20145: HongKong*

[4] Roy Billition and Ronald Allan (1984).“Reliability Evaluation of Power System”, *New York*,.

[5] Ronald Allan, Roy Billinton, I Sijarief, L.Goel and K.S.So (1991). A Reliability Test System for Educational Purpose-Basic Distribution System data and results. *IEEE Trans. Power Syst, vol.6, no.2, pp.813-820, May 1991*.

[6] U.S Department of Energy (2012). Reliability Improvements from the Application of Distribution Automation Technologies-Initial Result.

[7] Ohn Zin Lin, Hajime Miyauchi.(2017) "Reliability Forecasting in Distribution System Considering Variable Failure Rate: Combination of Equipment Inspection Method and Weibull Analysis", International Review of Electrical Engineering (IREE)

[8] Ohn Zin Lin, Hajime Miyauchi.(2017) "Optimal Replacement Time of Electrical Components Based on Constant-Interval Replacement Model: Equipment Inspection Method and Weibull Analysis", Energy and Power Engineering, 2017