Decision Suitable Route on Restoration Process for 14 Bus System of Myanmar Power System with PI Controller

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Abstract: When the bulk transmission system is subjected to large disturbances there is the possibility of a system wide blackout due to cascading outages. After a partial blackout or system breakdown condition, restoring power system is needed and then power needs to be restored as quickly, stability and reliability as possible and consequently. How to efficiently manage power systems and restore the systems from faults is a challenging research issue in power engineering. In this paper, the most suitable power system restoration transmission lines route is analyzed for in Myanmar Power System with using MATLAB/SIMULINK and PI Controller.

Key Words: restoration process, blackout, restoration transmission lines route, PI Controller.

1. INTRODUCTION:

The restoration of a transmission power system from a blackout is a complex real-time control problem. Operators in control centers are, fortunately, not faced with this situation very often because power systems are designed to prevent a total system collapse (e.g., protection devices which isolate a faulted transmission line, shed load, or isolate thermal units). However, a disturbance may cause some cascade events which result in a degradation of frequency and / or voltage conditions in the power system. As the transmission power system is meshed, the consequences of this degradation are spread all over the system. Usually, the system is divided into islands (by protection devices) in order to preserve at least some parts of the system. However, if there is no balance between production and consumption in the islands, they are likely to be blacked-out.

During blackout or system breakdown condition, the operators in control centers provide information about the actual state of different system variables. In Myanmar's electric power system, numerous wide outage experiences occur, including complete blackout cases by line fault, lightning strikes, equipment failure and so on. Consequently, MEPE's (Myanmar Electric Power Enterprise) system operators have been trained well to handle wide blackouts.

The operator's task is to discover the disturbances in the system's operation [8]. An important aid in this task is given by the visualization of all the elements of the system and their operating status (on/off), as well as by the information about the main system variables (voltage level, load level, branch charge, network configuration etc.).The operators can analyze the actual system state and defined restoration strategy, the operators make step-by-step decisions on restoration actions [1], [7], [10].

After a major disturbance in the power system, communication devices are usually overloaded because of client calls which interfere with the communication between the control centers and the substations and the generation sites. Then, some information may not be available to the EMS, but could be communicated from another control centre by telephone [7]. This step-by-step action must be done belatedly.

Therefore, scientific analysis is required to meet the requirements of fast and reliable system restoration. And then, in this paper, the most suitable power system restoration route is analyzed with PI controller and MATLAB/SIMULINK and then it will support to do restoration process as quickly and stability.

2. OPERATIONAL STATE OF POWER SYSTEM:

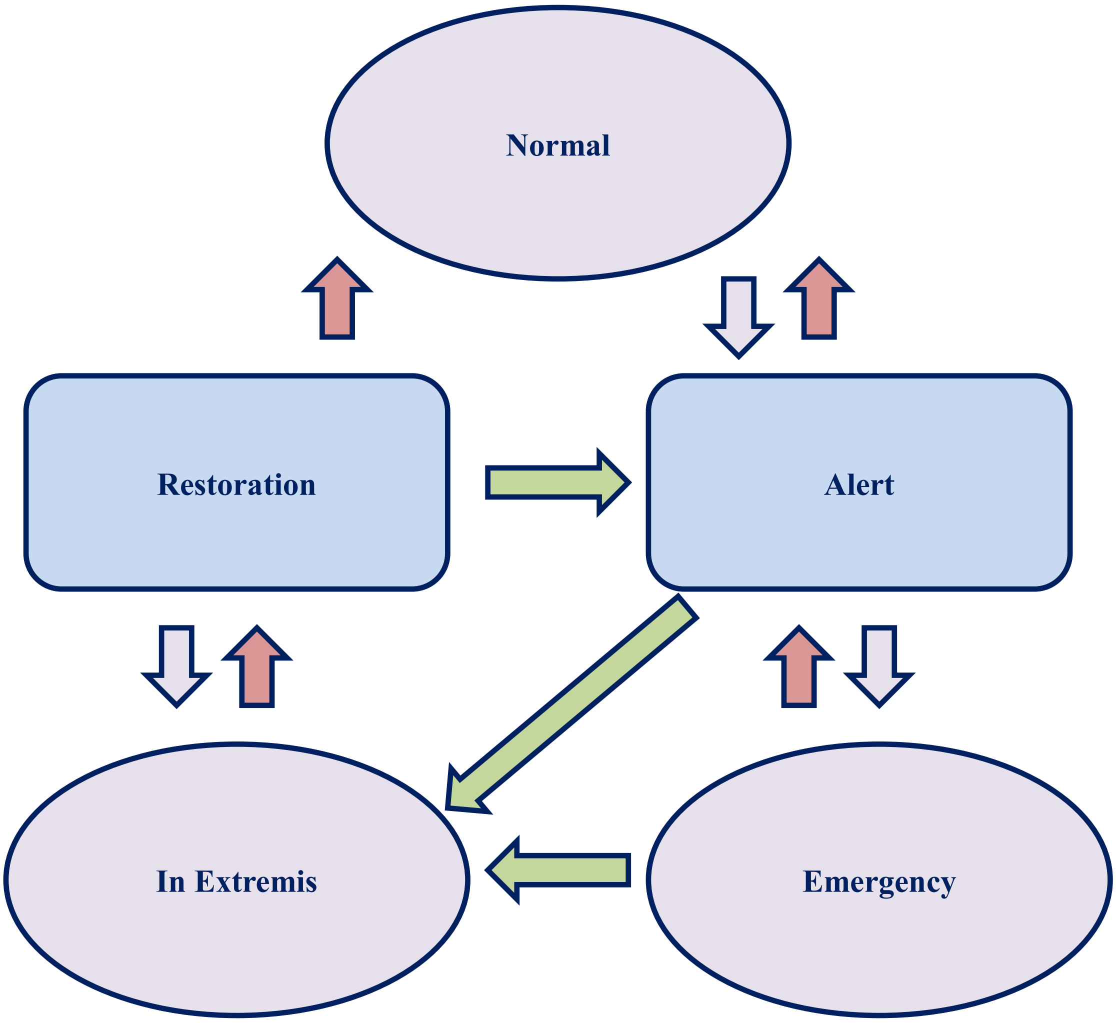


Fig.1 Operational State of Power System

In operational state of power system, there are five states and as shown in Figure.1. **Normal State**: No system component is being overloaded. All the system variables are in the normal range and the system operates in a secure state and is able to withstand a contingency without violating any constraints.

Alert state: The system enters the alert state when the system condition is degraded. In this state, all the system variables are still within the acceptable range and no constraints have been violated. However, the system components may be overload when an N-1 contingency occurs and leads the system into an emergency state. The system may also directly transit from the alert state to the in extremis state if the disturbance is severe enough.

Emergency state: When the system is in the alert state, a sufficiently large contingency event may bring the system to the emergency state, where system voltages at many buses go below the normal range and the one or more system components may experience overloading. In this state, the system may be restored back to the alert state by initiating corrective control strategies such as transmission system reconfiguration (TSR), generation rescheduling (GR), and load shedding (LS).

In Extremis: The system enters the in extremis state if the appropriate corrective controls are not applied or are ineffective when the system is in the emergency state. Corrective control strategies in this state include load shedding (LS) and system islanding (SI). These controls are intended to prevent total system blackout and preserve as much of the system as possible.

Restorative State: This state depicts a condition where control strategies are being deployed to reconnect all system components and to restore system load. Depending on the system condition, the system may transfer to the alert state, or directly transit back to the normal state [1],[2].

3. POWER SYSTEM RESTORATION PROCESS:

A power system cannot possibly be free from various problems such as line faults, and so on. An essential task in the operation of power systems is restoration after a blackout. The restoration process returns the system back to normal operation after any combination of system components have been lost as a result of an outage. Although a power system is designed and operated in the best circumstances, it still impossible to prevent all contingencies which could cause blackouts. Then the blackout duration is equally important while the physical extent of the blackout is a concern. So, detailed and suitable restoration process with its numerous independent entities is required to ensure that the system [2]. Power system restoration process includes such as: (i) Assessment of the system status and initial cranking sources, which means that preparation (ii) Identification and preparation of restoration paths (route) to build subsystems, network which include generation, transmission and distribution, (iii) Resynchronization of subsystems and restoration of loads (iv) and then restoration process will be completed [5], [6]. The power system restoration process is as shown in Figure.2.

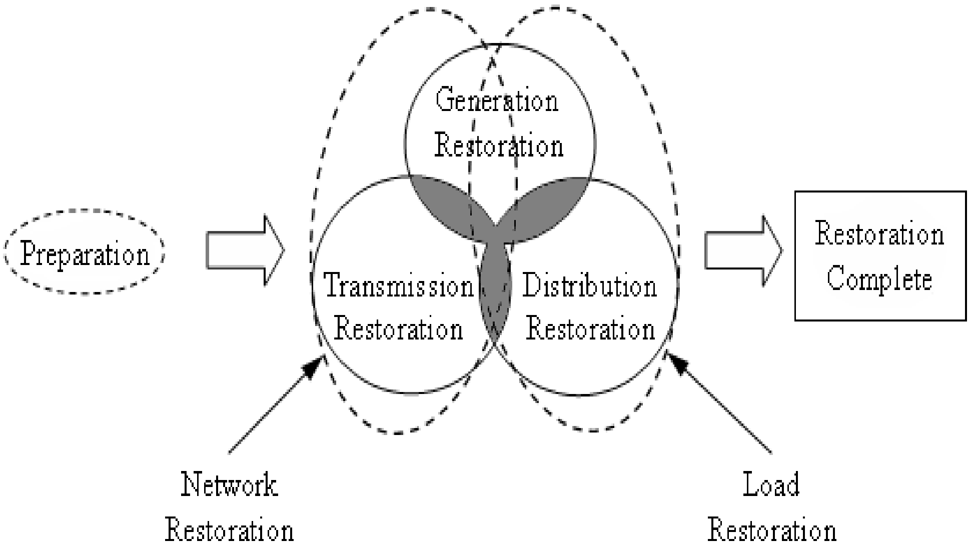


Fig.2 Power System Restoration Process

4. PRESENT MYANMAR POWER SYSTEM:

In Myanmar, for its transmission system, 230kV, 132kV and 66kV are employed as transmission network and then 33kV, 11kV and 6.6kV for its distribution system.

The present power systems can be divided into two parts. While the 132kV system covers the central regions around the Tharzi substation and all northern regions, the 230kV system runs from the Tharzi substation south towards the Yangon area. These two different voltage systems operate geographically independent of each other. There is a possibility of system blackout or facility overloading when some facilities are in outage. In many cases, when a high voltage transmission line trips, the Myanmar grid divides into two islands (Yangon and outside Yangon). This results in significant power imbalance in each island. The power imbalance induces a severe frequency and voltage fluctuation that causes power supply interruption.

A. *Proposed System based on Myanmar Power System*

In this system, there are six generation plants and among them Shwedaung is Gas type and others are Hydro types, then its single line diagram shows in Figure.3. Its parameters are as shown in Table 1 and Table 2. And then, all of voltage ranges are 230KV as assumed.

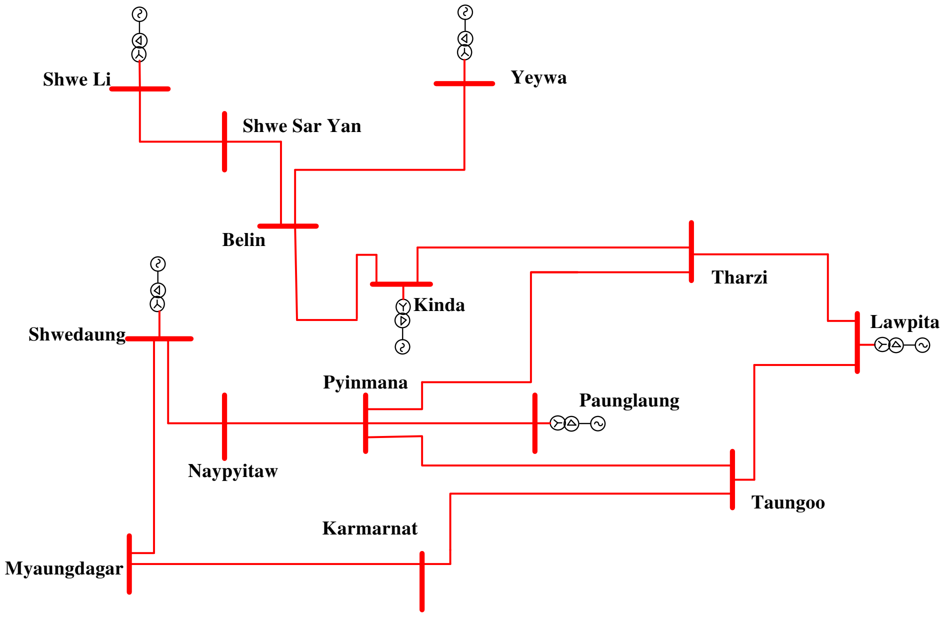


Fig.3 Single Line Diagram of Transmission Lines for Proposed System

Table.1. Generation Data for Proposed System

No	Station	Type	Installed Capacity (MW)	No; of Machine	Total (MW)
1	Lawpita	Hydro	14 28 26	4 2 2	248
2	Kinda	Hydro	28	2	56
3	Yeywa	Hydro	198	4	790
4	Shweli	Hydro	100	4	400
5	Paunglaung	Hydro	70	4	280
6	Shwedaung	Gas	18	3	55

Table.2. Branch Data for Proposed System

No	From Bus	To Bus	Voltage Rating (kv)	Resis-tance (Ω/km)	Reac-tance (H/km)	Suspt-ance (F/km)	Length (km)
1	LPT	TZI	230	0.036	0.301	0.012	235.79
2	TZI	KDA	230	0.036	0.301	0.012	73.06
3	KDA	BLN	230	0.036	0.302	0.012	67.34
4	BLN	YWA	230	0.036	0.302	0.012	39.16
5	BLN	SSY	230	0.036	0.302	0.012	27.58
6	SSY	SLI	230	0.048	0.301	0.012	289.97
7	LPT	TGO	230	0.072	0.424	0.009	154.06
8	TGO	PMN	230	0.055	0.331	0.011	100.8
9	PMN	NPT	230	0.047	0.318	0.012	20.54
10	PMN	PLG	230	0.048	0.304	0.008	13.36
11	PMN	TZI	230	0.072	0.429	0.011	134.71
12	NPT	SD	230	0.047	0.318	0.011	218.09
13	SD	MDG	230	0.047	0.318	0.011	205.54
14	MDG	KMN	230	0.048	0.319	0.011	64.33
15	TGO	KMN	230	0.048	0.318	0.012	190.7

B. Requirement for black-Start

- The generator can run with self-power as soon as possible.
- The generator has to secure enough energy sources to supply power regardless of weather conditions or external causes.
- The generator can supply reactive power to 80% of the capacity.
- Terminal voltage of black-start generators is within the available range from 0.9 pu to 1.0 pu [3], [9].

As the black-start generators, Yeywa and Shweli which have the largest generation capacity are selected. But after simulation, black-start of Yeywa is best condition to restore path transmission line. If so, Generation Yeywa will be selected as Black-start source.

C. Requirements for restoration lines

- Reactive power to cover the charging capacity of the primary restoration line on load or no-load can be supplied.
- Substation voltage is under 1.1 pu in the 132kV system and 1.05 pu in the 230kV system.
- There is no problem against transient phenomenon by switching and ferro-resonance of the transformer [4], [8].

5. SIMULATION FOR PROPOSED SYSTEM:

MATLAB/SIMULINK is the most suitable to build model for proposed system and then power system stability can be observed according to simulation results.

In Myanmar, hydro generators or gas turbines which can start by themselves. Therefore, it is not possible to select primary restorative transmission lines in general to supply cranking power for large generation plants and then, this paper reports selecting restorative transmission lines (route).

The simulation model of Proposed System is shown in Figure.4. Results of voltage and frequency for all three cases are carried out by using MATLAB/ SIMULINK. In Myanmar system, marked limit voltage oscillation is within 0.6pu and 1.2pu, and then frequency deviation is 48Hz and 51Hz. The cases for restoration of transmission lines routes are listed below, in Table 3.

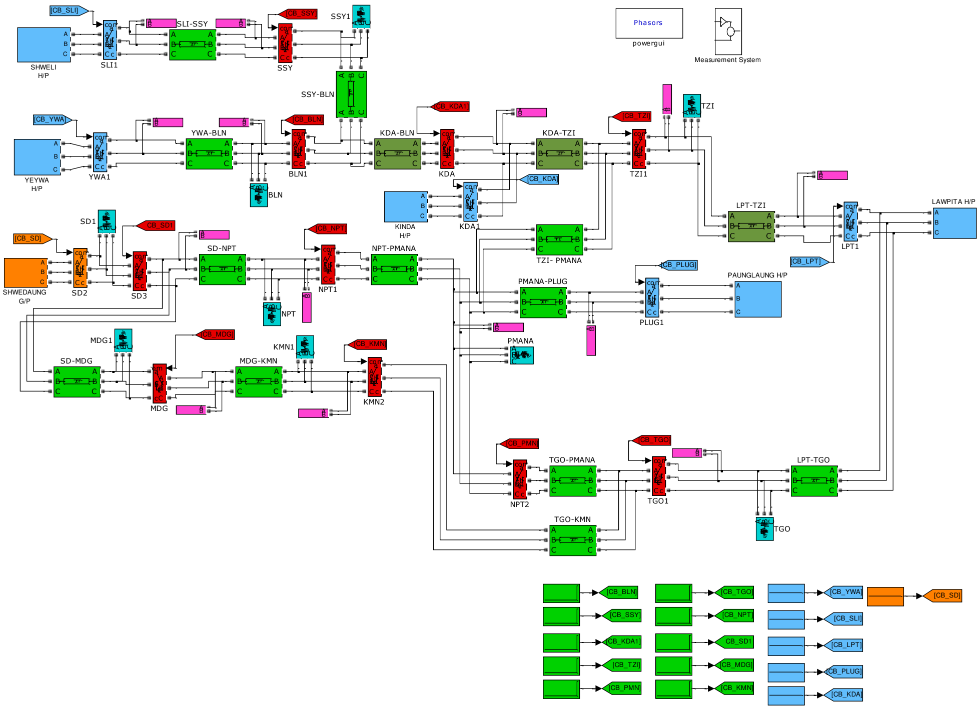
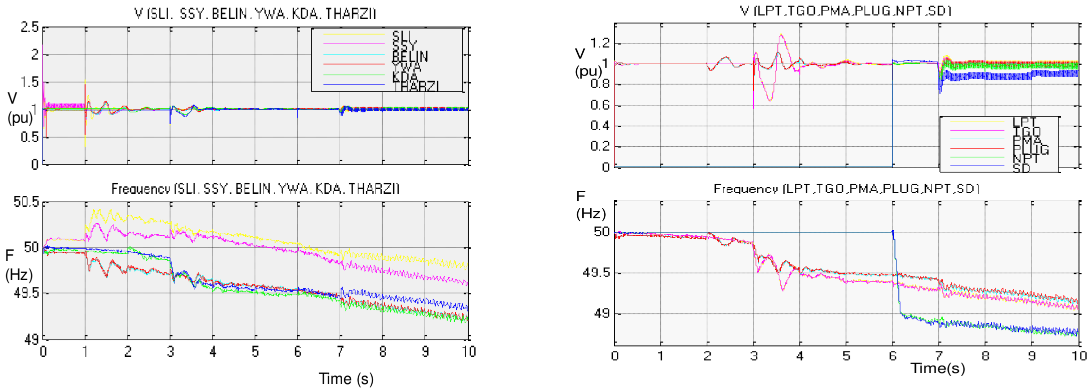


Fig.4 Simulation Model for Proposed System

Table.3 The Cases for Transmission Lines Routes

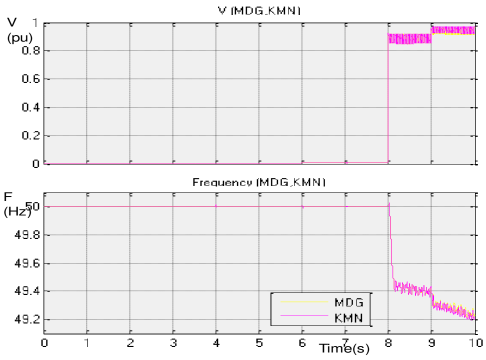
Case No	Route Lines
Case 1	Yeywa (G) → BLN(CB) → SSY(CB) → KDA (CB) → TZI (CB) → PMN (CB) → TGO (CB) → NPT (CB) → SD (CB) → MDG (CB) → KMN (CB)
Case 2	Yeywa (G) → BLN(CB) → KDA(CB) → TZI(CB) → PMN(CB) → NPT(CB) → SD(CB) → MDG(CB) → KMN(CB) → TGO(CB) → SSY(CB)
Case 3	Shweli (G) → SSY(CB) → BLN(CB) → TZI(CB) → KDA(CB) → TGO(CB) → KMN(CB) → PMN(CB) →MDG9CB) → NPT(CB) → SD(CB)

D. *Simulation for Case 1*



(a) (b)

In Figure.5 (a), simulation result is clearly seen that, voltage oscillation of Shweli and Yeywa are nearly 1.3pu within one second. After that these two of lines and other lines are normally limited between 0.6pu and 1.2pu. Frequency oscillation of simulation result is also limited along the time (0-10)s.



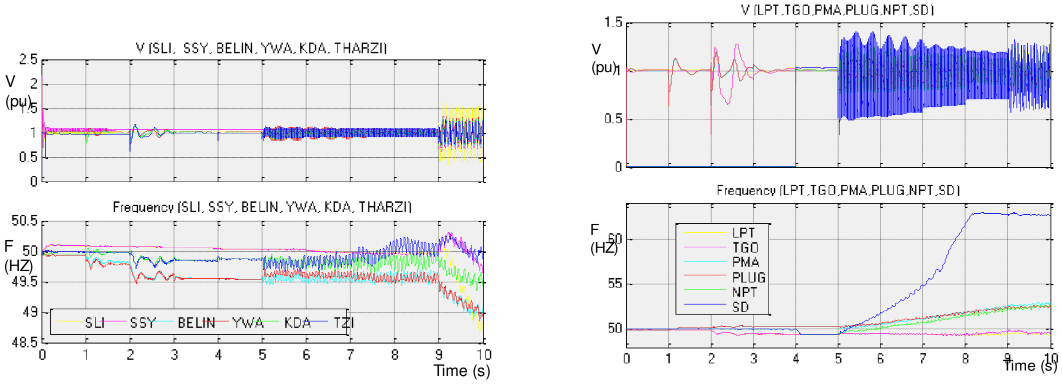
(c)

Fig. 5 Simulation result for case 1

In Figure.5 (b), simulation result of voltage, Lawpita and Taungoo lines closely reach 1.3pu between three and four second. But, after reached that condition, all of lines are normal. Frequency flow down during three second and seven second and then continue within limitation.

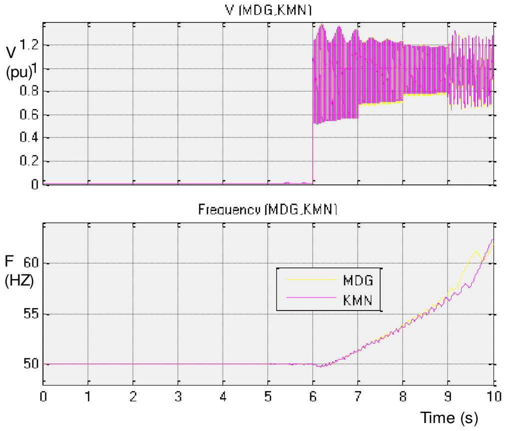
Simulation result is clearly seen in Figure.5 (c), it was seen voltage and frequency were within limitation.

E. Simulation for Case 2



(a) (b)

In Figure.5 (a), at nine second, when Taungoo circuit breaker was on, the voltage of Shweli line suddenly leap about 1.5pu. Frequency fluctuation is also limited along the time (0-10) s.



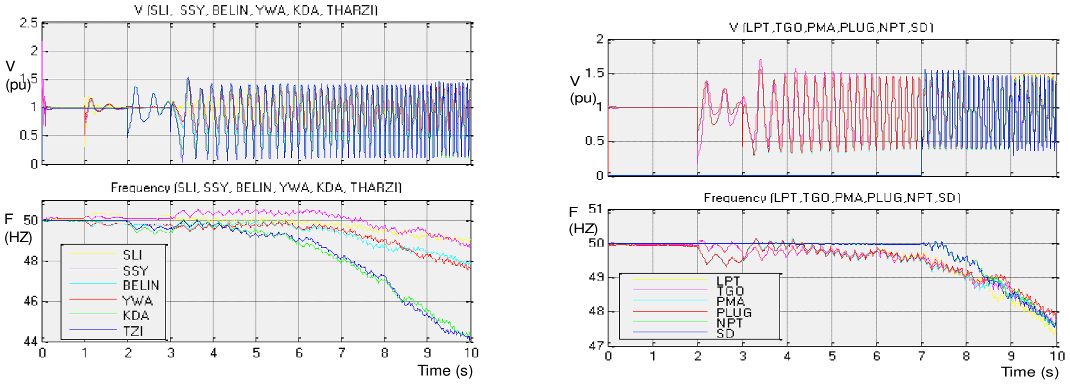
(c)

Fig.6 Simulation result for case 2

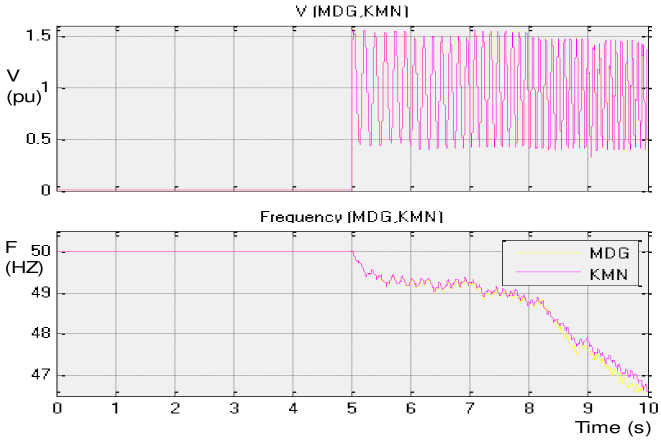
But, in Figure.5 (b), voltage oscillates two to three seconds and then when Naypyitaw circuit breaker was on at five seconds, only of Shwedaung line voltage away from limitation until the edge of the time. Frequency also leaps at five seconds.

In Figure.5(c) shows that, Myaungdaga and Karmarnat lines' voltage and frequency fluctuation simulation result. During in six seconds condition, these two lines of voltage and frequency are out of limitation.

F. Simulation for Case 3



(a) (b)



(c)

Fig.7 Simulation result for case 3

In this Figure 7, clearly seen that both voltage and frequency of all lines out within limitation.

6. ANALYSIS FOR THREE CASES OF RESTORATION ROUTE:

All of three cases are simulated with MATLAB/SIMULINK but without PI controller and results are shown in figure .5, 6 and 7. Then, analysis result for these three cases is as shown in Table 4.

Table.4 Analysis Result for three Cases

Case No	Min Frequency Deviation (Hz)	Max Frequency Deviation (Hz)	Min Voltage Oscillation (pu)	Max Voltage Oscillation (pu)
Case 1	48.7(-2.6%)	50.4 (0.8%)	0.6(-40%)	1.2(20%)
Case 2	48.7(-2.6%)	65(30%)	0.5(-50%)	1.5(50%)
Case 3	44(-12%)	50.2(0.4%)	0.2(-80%)	1.6(60%)

As the result of simulation, case 1 has maximum frequency deviation 0.4Hz and maximum voltage oscillation 1.2pu, within limitation. But both of frequency and voltage's limitation are out in case 2 and 3. Therefore, power needs to be restored as quickly, stability and reliability as possible and consequently, restoration route case 1 is recommended.

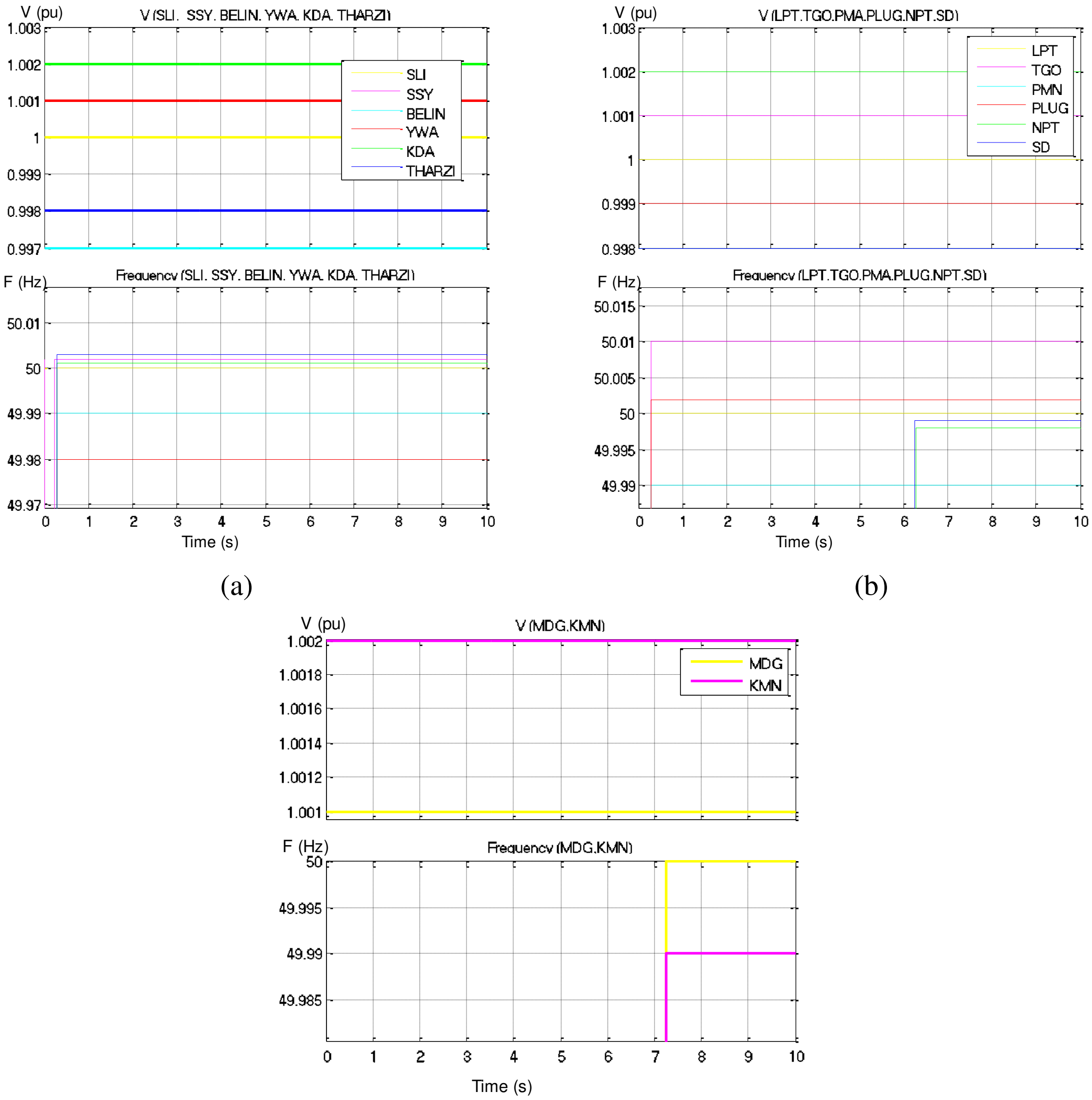
In this simulation cases, there is no controllers to control voltage and frequency oscillation. Therefore, the PI controllers must be added to control voltage and frequency for stabilization for recommended case 1.

7. SIMULATION FOR RECOMMENDED CASE 1 WITH PI CONTROLLER

We can see that an integral controller (K_i) decreases the rise time, increases both the overshoot and the settling time, and eliminates the steady-state error. For the proposed system, the closed-loop transfer function with a PI control is:

$$\frac{X(S)}{F(S)} = \frac{K_pS + K_i}{S^2 + 10S + (20 + K_p)S + K_i}$$

Let's reduce the K_p to 30, and let K_i equals to 70



(a) (b)

(c)

Fig.8 Simulation result for recommended case 1with PI controller

8. CONCLUSION:

In this study, the PI controller has been investigated for voltage and frequency control of the proposed power system. The comparison of the proposed power system with and without PI controller is developed in MATLAB as shown above figures. The simulation result is shown that the control system gives smooth performance. Modeling and simulation analysis of proposed power system which parts of Myanmar Power system are clearly described in this study.

9. RECOMMENDATION:

For the reliable power system, restoration process is necessary and restoration path optimization transmission line is also essential. This paper presents, the most suitable power system restoration path optimization is analyzed for power transmission lines with using MATLAB/SIMULINK and PI controller.

According to simulation results, output values in all three cases are presented at above. Among them, case1 has the best output value for restoration path optimization and it route was simulated with PI control as shown in above Figure.8. We can be clearly seen that, the result values of voltage and frequency are within in limitation. Therefore, power needs to be restored as quickly, stability and reliability as possible and consequently, restoration path case1 is recommended.

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