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Stability Simulation of 150 kV Malang Power Grid

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Abstract

In general, the electric power system is fully operational for 24 hours, where energy will be provided through power generation commitments. Operationally, the system will withstand various load changes or disturbances, both of which are dynamic. These dynamic conditions will have an impact on system stability, as discussed in this work which concentrates on generator performance. Stability can be in the steady state range or transient stability, which is directly related to the presence of oscillations. Therefore the control of oscillations in the power system becomes very important, which can be done by replacing the traditional automatic voltage regulators for excitation control in addition to multi-engine power systems. In this study, the design builds on a robust balance and adaptive critique technique used to reduce the oscillation time for each generator. This evaluation is applied to the Malang Grid which uses an abused voltage of 150 kV that connects the existing backbone system. The evaluation results show that the generator experiences oscillations in the generator system, both voltage, and power. In addition, to support this, large disturbances will have an impact on various power and voltage levels, which affect generator performance.

Keywords

Power, System, Stability, Oscillation

INTRODUCTION

The network that constitutes the power system is made up of the generating, distribution, and transmission systems. The energy source (such as coal and diesel) is converted into electrical energy in this process. All of the connected parts of the system, including the cable, motor, transformer, and synchronous generator, make up the power system. The study of the power system is made up of a lot of electrical engineering research and analysis. A power system's response to diverse events across time is also investigated using a group of studies collectively referred to as electric power system research. An electric power system is a collection of electrical components used to generate, distribute, and utilize electric power. The ultimate goals of power system studies are to have a power system for an energy system or facility that is reliable, efficient, and safe in both normal and abnormal situations [1], [2]. It makes it possible for power to be produced by generators, voltage levels to be changed by transformers, energy to be transported from one location to another via transmission lines, energy to be distributed among numerous transmission lines and power transformers via buses, and for consumers to use energy (loads). Circuit breakers and related switches are utilized during this procedure to connect or switch the components of the power system in a variety of different configurations. Large-scale nonlinear systems include generator-based power systems. The Single Machine Infinitive Bus SMIB power system model and linear control theory are used to design the standard excitation controllers for the generators. This might happen in an emergency involving the restoration of the power system or the partitioning of the power system into smaller islanding systems. Regardless of where the load changes, all generating units acting as frequency regulators in big, linked power networks will contribute to the total shift in a generation [3], [4]. The device must keep the system frequency constant when running a small, isolated load. This is important because the requirements for a unit that is connected to a powerful system differ from those for a reliable system. This will enable you to understand how the generator responds to various loading circumstances.

Power system engineering is a significant and crucial component of electrical engineering research. Its main emphasis is on the production of electrical power and its requirements-compliant transfer from the sending end to the receiving end with the least amount of losses. The electricity fluctuates a lot when there are disturbances or variations in the load. These reasons make the idea of power system stability essential in this context. It is used to define a system's ability to quickly return to regular operation after experiencing any transience or interruption. All important power generating facilities throughout the world have relied on the AC system as their main power source since the turn of the 20th century and up until the present. Nonlinear control theory-based power system control has attracted renewed interest in recent years, particularly for improving the transient stability of the system. Nonlinear models are used, and nonlinear feedback linearization techniques are implemented for the generator models,

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minimizing the operating point-dependent aspect of the linear designs, as opposed to approximation linear models, as in the design of the typical power system stabilizer. Generator transient stability can be considerably improved by using nonlinear controls. In comparison to linear controllers, nonlinear controllers are more complex structurally and need more installation work. A stability system refers to a power system's ability to sustain an operating equilibrium under ordinary operating conditions and to quickly return to an acceptable equilibrium after a disturbance [5], [6]. For the power system to remain stable, the dynamics of the system under disturbances must be studied. Stability is the capacity of a power system to return to normal or steady performance after exposure to disruptions. Stable-state behavior is related to how a synchronous machine reacts to a continuously increasing load. It is largely concerned with determining the highest level of machine loading that may be achieved while maintaining synchronism. A system's capacity to react to minute disturbances that lead to oscillations is known as dynamic stability. The system is deemed to be dynamically stable if these oscillations don't exceed a certain amplitude and vanish right away. When these oscillations' amplitudes keep rising, the system becomes dynamically unstable. Transient stability is the capacity to respond to large disturbances, which may cause noticeable changes in rotor speeds, power angles, and power transfers. Transient stability is a rapid phenomenon that usually manifests itself within a short period.

MULTY SYSTEM

A disturbance of the electric power grid is invariably followed by instability. These disturbances include, for instance, load changes or network interruptions (transients). Fast and frequent fluctuations in load are difficult for the generator to handle, which can jeopardize the dynamic stability of the system [7]. As a result, frequency oscillations occur in the generator. A poor reply can result in lengthy frequency oscillations. As a result, there will be a reduction in the easily available power transfer power. The generator must run at the same frequency since a multi-machine power system employs unison operation across all machines. Any interruptions will thus have a direct impact on how electrical power varies. Changes in electrical power will also affect mechanical power. The difference in response times between a quick electrical power response and a longer mechanical power response will cause instability. These differences cause the system to fluctuate. System stability is less affected by the gain enhancement of the excitation circuit. The overall stability of the power supply depends on the dynamic behavior of the generators in a power system. [8]. The synchronous generator converts mechanical power into electrical power at a specific voltage and frequency. Diesel engines, steam turbines, and water turbines are examples of prime movers or objects that produce mechanical power. Its essential requirement must be the ability to maintain a nearly constant speed regardless of the amount of power used or the source. The mechanical characteristics of the machines are included in the research of any power system to evaluate its transient stability since the machines must adjust the angle of their rotors after any disturbance to satisfy the requirements of power transfer imposed [9]. Compared to hydrodynamics, electric dynamics have a very small time constant and can be disregarded.

The well-known mechanical equations for a rotating machine are built upon the swing equation of rotating inertia. The control analysis procedure characterizes the generating unit by utilizing linear differential equations to describe how they respond to minor perturbations [10]. A machine's shaft speed remains constant when the electrical and mechanical torques for braking are balanced. A torque imbalance will cause the machine to accelerate or slow down following the laws of motion for rotating bodies. For stability study, synchronous machines have been simulated using a variety of models, some of which account for damper windings and transient flux linkages and others that do not. a two-axis model with one damper winding on the d-axis (direct axis) and two on the q-axis, as well as the machine's transient and sub-transient characteristics (quadrature axis). This method, which transforms machine variables into a frame of reference based on a common rotor using Park's transformation, will be described. The direct (d-axis), quadrature (q-axis), and third axes associated with the zero sequence component current are transformed from a reference frame fixed with the stator to a revolving reference frame fixed concerning the rotor (0-axis). The zero sequence current is equal to zero for a balanced system, hence the latter is eventually removed from the model.

A device that is linked to a power system and uses active or reactive power is referred to as a load. In terms of quality, load modeling differs from generator modeling. Modeling any common load component, such as lights, heaters, and freezers, is not too difficult. The specific composition of the load is frequently very difficult to estimate, therefore this is only a minor portion of the issue. The makeup of the load is constantly changing to suit customer usage trends for various appliances and gadgets. It is influenced by the climate, consumer lifestyle, and numerous other variables. It would be impracticable to represent each load component, even if the load composition was precisely understood.

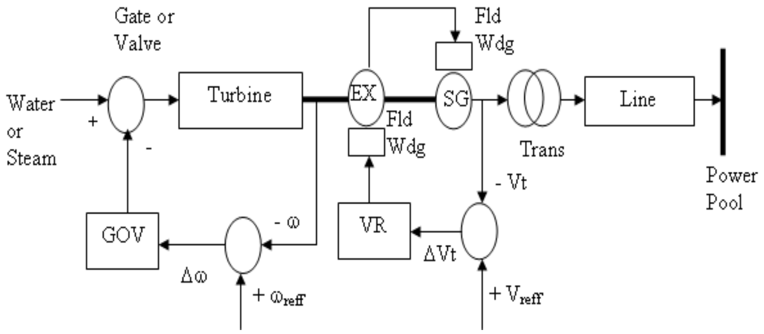


Figure 1. Power system connection model

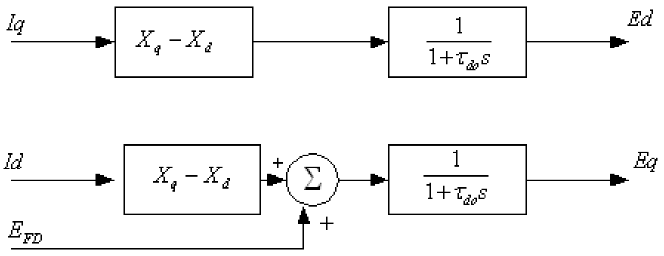


Figure 2. Generating unit function model

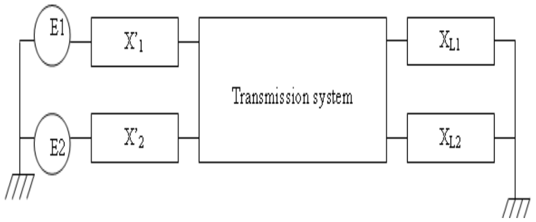


Figure 3. Interacting multi machines model

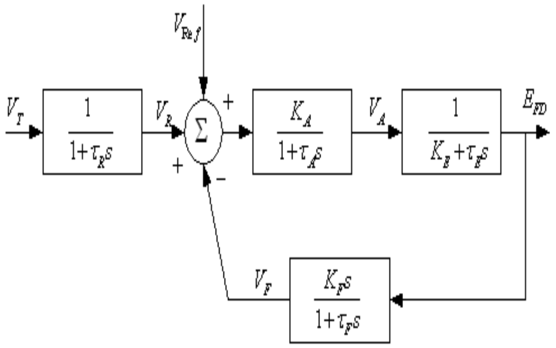


Figure 4. Excitation system model

It is standard procedure to characterize the composite load characteristic as seen from bulk power delivery points when analyzing power system stability. Each load class that is created from the aggregated load is represented by a specific load component. Static and dynamic load characteristics are traditionally separated into two groups [11]. For the system generators, two different kinds of exciters (AVRs) were employed. A basic gain exciter was used on the machines without ESSs. The control equation for this model is denoted by the letters EFD. the simple gain model's parameters The IEEE ST1 Type exciter is used with machines that have an ESS.

TECHNICAL APPROACH

A simulation was used to evaluate the 150 kV system that is currently in place in Malang while using a blackout as the major disruption. It could be accomplished by branching off of Kebon Agung's south tail, which is not related to Tulung Agung or Blitar. To open the interconnection to Pasuruan, a branch journey in Lawang was given on the north side. Malang's power system is connected to PLN Region 4 in Pasuruan, and it also exports power to Tulung Agung via Blitar. The simulation was performed using the load condition on a 150 kV power line, with Madura's peak load being 109,11 MW and 42,9 Mvar, Bali's peak load being 336,3 MW, and 118,8 Mvar, and East Java's peak load being 2.732,6 MW and 1.001,741 Mvar. Malang's power system was thought to be at 150 kV because it lacked a 500 kV power line system, and by supplying power at 70 kV with its lower voltage system instead of at 150 kV while taking into account all of the interconnecting systems. Peak loads were 16,800 MW and 7,000 Mvar in Lawang, 115,000 MW and 60,000 Mvar in Kebon Agung, 30,500 MW and 16,900 Mvar in Pakis, 58,700 MW and 34,200 Mvar in Sengkaling, and 58,900 MW and 38,500 Mvar in Wlingi.

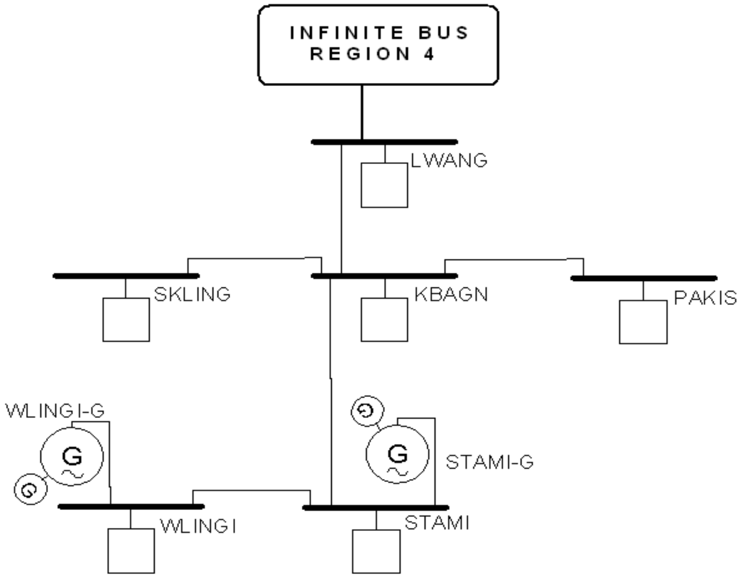


Figure 5. Malang power grid model

RESULT

To prepare the system data for a stability assessment, load flow studies were conducted. These studies outline the critical operating point for solving nonlinear differential equations with linear systems. A power flow program or load flow establishes the steady-state voltage and angle at each bus for a specific system. Conventional nodal or loop analysis is inappropriate for power flow investigations since input data for loads are often provided in terms of power. In addition, rather than serving as sources of voltage or current, generators are thought of as power sources. The power flow problem is expressed as a collection of non-linear algebraic equations, making it computer-solvable.

The outcomes of power flow studies are essential for monitoring the system's current state, assessing the viability of alternative strategies, such as adding new generator sites, addressing rising load demands, and locating new transmission sites, as well as laying the groundwork for stability studies. This technique finds solutions for variables like voltage magnitudes and angles at all buses using the Newton Raphson approach. The knowledge of the flow on each power line supplying demand and voltage on each bus resulted from the analysis of load flow or power flow using Newton-Raphson. The highest voltage loss in the power system occurred in the Lawang load flow, which was 1,71 percent. And with losses totaling 1.252,4 KW, the Lawang unending bus incurred the greatest losses.

Simulations that employ uniform representations for all system components determine the operating security limits. If the ESS is extremely complex, the benefits may not be accurately reflected by operating security limits since it will have to be approximated in the simulations. Every power plant will respond to a disruption when it arises, as was the case in this case when a branch tripped on a feeder and both the hydropower facilities Sutami and Wlingi were impacted.

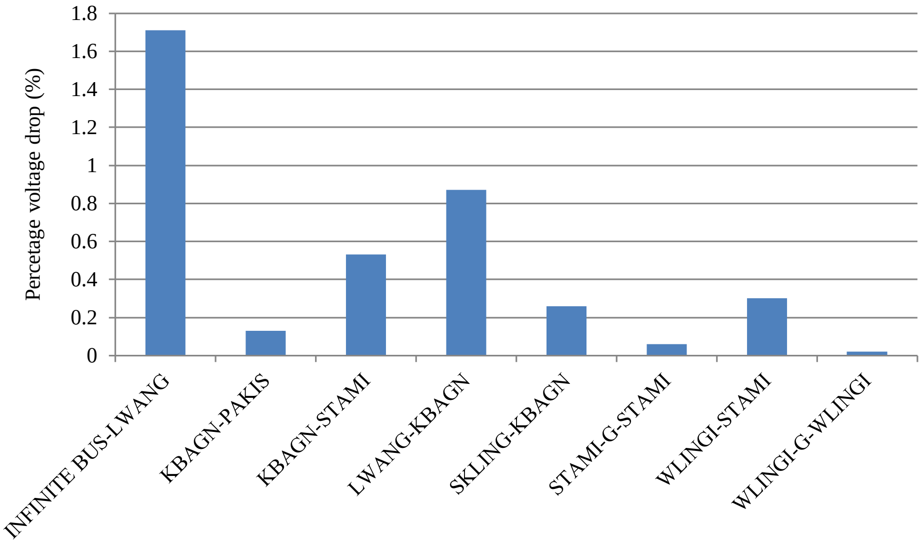


Figure 6. Voltage drop of each line

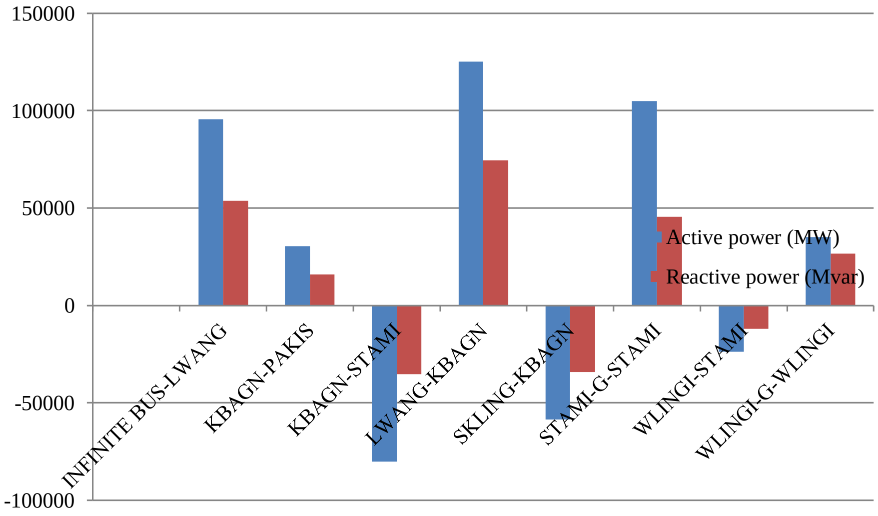


Figure 7. Power delivery in conductors

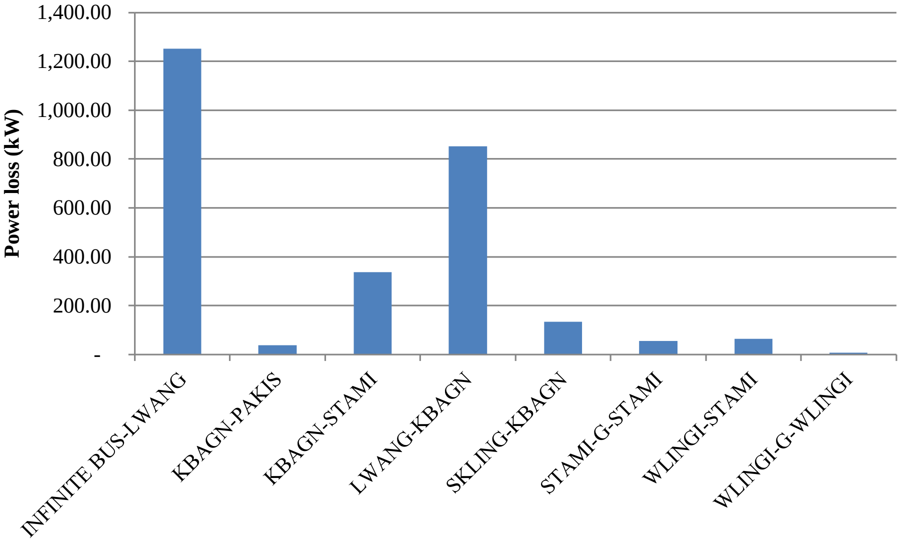
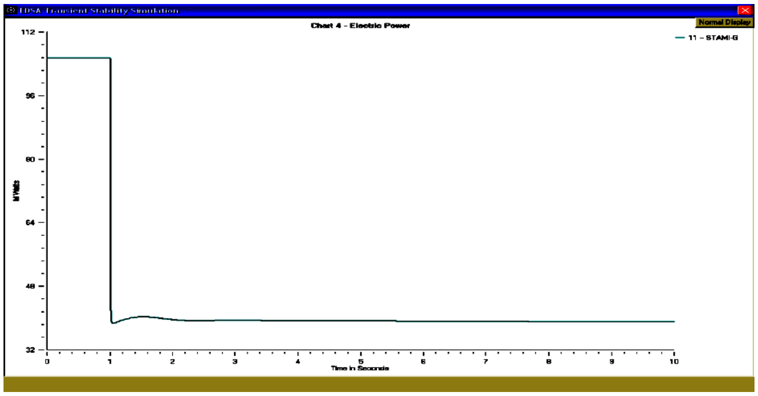
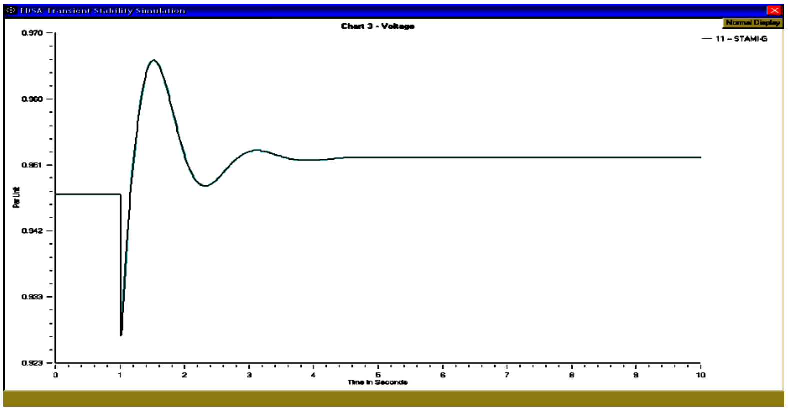


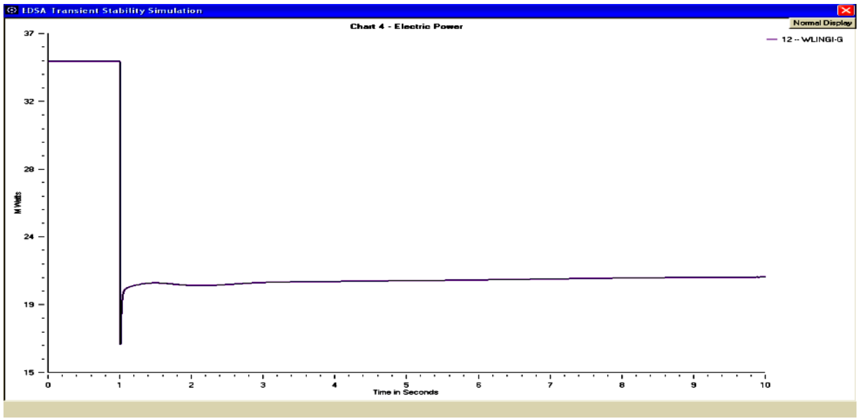
Figure 8. Power loss



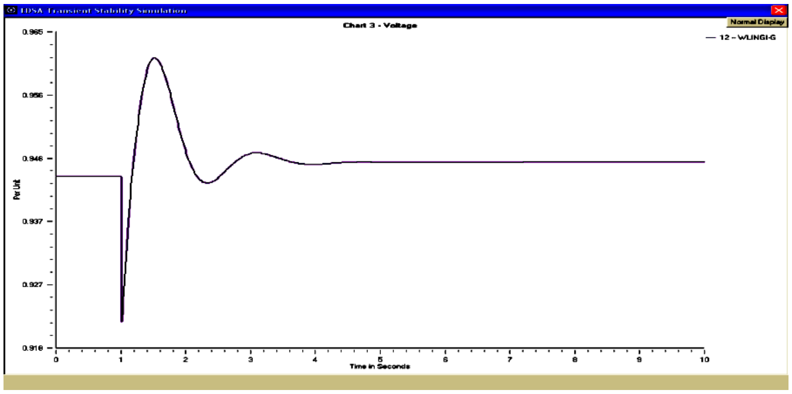
a. Power respond



b. Voltage respond
Figure 6. Power station Sutami's respond



a. Power respond



b. Voltage respond

Figure 10. Power station Wlingi’s respond

The Sutami power station's generator response during a blackout is shown in figures 9 and 10. It saw that the generator was fluctuating in terms of voltage and electric current, so it altered its method of supplying electricity. Branch tripping failure caused a voltage overshoot of 0,968 pu at 0.8 seconds; as a result of the load loss, the voltage increased by 0,948 pu to 0,952 pu on 150 kV. However, in the Wlingi Power Station, only 0,944 pu increased to 0,946 pu, with an overshoot of 0,962 at the 0.53-second mark following a malfunctioning blackout.

CONCLUSION

In cases where the operating security limitations may not accurately represent any benefits, operating security limits are created using simulations that use uniform representations for all system components. When a disturbance occurs somewhere in the system, all of the power plants will respond to it, as in this case when a branch tripped on a feeder and both the hydropower plants Sutami and Wlingi were affected. The system will need to be approximated in the simulations. The voltage drop on the Lawang bus, according to the results, was 1,71 percent. The blackout state and the largest losses 1.252,4 KW on the feeder infinite Bus to the Lawang Bus would affect each power plant's oscillation response. Every power plant has an unstable state that can lead to a new point.

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