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RESEARCH ARTICLE

Addressing the Security risk of a Massive Deployment of Photovoltaic Power for Electric Power Systems

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Abstract

Future electric power systems will incorporate a high percentage of Photovoltaic (PV) power generation as a means of mitigating environmental issues including global warming and energy depletion. The author observes that if the increase in uncertainties brought about by the PV penetration cannot be prevented, then it will be difficult to carry out the N-1 security level. To ensure the N-1 security requirement is met despite the uncertainties, paper has suggested a new notion of "robust power system security" along with many conditions to be met. In this research, and offer a model of uncertainties caused by PV generation, and use robust power system security to guide our choice of parameters. Next, simulate the system to learn more about, how PV and load disconnections affect stability, and how Fault Ride Through (FRT) and Dynamic Voltage Support (DVS) influence stability. Finally, it is demonstrated that the massive penetration of PV would significantly raise the complexity of burden jobs in future power system operation planning and real-time operation.

Keywords: Photovoltaic; PV; Solar Energy; DVS; Power System Security; Security Issues

Introduction

Global warming and energy depletion are only two of the many issues that have received attention in recent years. In an effort to address a wide range of environmental issues, the spotlight is now on renewable energy. There will likely be a significant increase in the number of intermittent renewable energy sources integrated into grids in the coming years. In particular, the quantity of photovoltaic (PV) power introduced in 2020 will be multiplied by 20, and will climb to 40 times (about 53 GW) by 2030. The future speedy installation of solar panels is a goal that has been established. Growth is anticipated to continue (1). But when solar radiation levels are high, a lot of PV is added to the grid, and its output varies a lot. the distribution system's voltage regulation and management to dampen output variations It has been noted that there are issues, such as insufficient power and frequency variations (2). in this sense However, the authors believe it is an issue that has not been well explored. Consequently, huge variations in PV production as a result of variations in solar radiation conditions, that is, prediction Increasing unpredictability makes it impossible to guarantee a constant supply of goods and services. Furthermore, the standard N1 confidence scale Create a new log and a system to track how the standard can be kept even in the face of uncertainty. explained their idea of "bust reliability" (5).

This will be effective in the future as uncertainty grows. This is expected to provide guidance for measures to sustain reliability. Following that, it will take a bird's-eye view of the complete system in a more realistic setting. The behaviour of load and PV during system disruption is interesting from several perspectives. Consider how it will impact the system. (1) Consider how load and PV dropouts affect stability. (2) Assuming that PV will be widely adopted in the future, the FRT function will be used to endure low voltage and continue operation, and the Dynamic Voltage Support (DVS) function will be used to maintain voltage. Consider the effect of Then the PV's presence or absence. Summarise the aspects of shedding. (3) load and PV desorption; power system faults may develop as a result of power outages or weather-related PV power generating conditions. The paper present that the complexity of the integration process grows by pointing out that the failure point leading to step-out can change when it occurs. In addition, the future supply and demand outlook is presented in this paper. Regarding future energy policy, however, it is necessary to review existing plans. There are numerous discussions occurring, including situational discussions. In all cases, however, the quantity of PV installed is expected to grow faster than anticipated. enigmatic uncertainty problems and confidence maintenance in uncertain environments In particular, the issue of stability affects not only India but also worldwide.

Future system reliability

Conventional system operation is based on annual, monthly, weekly, and daily time schedules. After securing reliability while gradually increasing accuracy with bread. The resulting load p(t) on the demand side is changes are almost patterned, and the uncertainties that are difficult to predict are not much to consider. Mathematically, this can be expressed as p(t) is the variation parameter value at time t, and the predicted lead time.

The estimation problem for δt can be expressed as follows.

$$p(t) = \hat{p}\,(t|t - \delta t) + \Delta(\delta t) \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

The first term on the right side of equation (1) is the value of p(t) estimated at time t-δt.

is the predicted value, and the second term is the prediction error. The prediction error is at time t-δt is unavoidable uncertainty in tend to increase on the other hand, in the future, a large amount of PV Under the conditions of introduction, the amount of power generated in a specific area is affected by the weather.

Uncertainties corresponding to mispredictions in supply and demand management, such as sudden changes in supply and demand are likely to increase significantly. In statistical planning, system operation planning, and real-time operation, the prediction considerable amount of difficult uncertainty Δ should be considered in analysis and control. In order to express this mathematically, in this paper, Eq. (1)

Based on the above, the existence region Rp(t) of p(t) is defined as follows.

$$Rp(t) = \{p|p = \hat{p}(t) + \Delta, \text{ for all } \Delta \in R\Delta(\delta t)\} \cdots\cdots \quad (2)$$

Equation (2) above is called the parameter variation region, and the frequency of the predicted value p0(t) is allow an uncertainty Δ in A conceptual diagram of this is shown in Fig. 1.

where the region RΔ of Δ represents the spread as a function of δt, and multiple system states exist at the same time cross-section. means that it is equivalent to in this paper, the Uncertainty is defined as the difference in PV generation at the demand end (regional weather forecast).

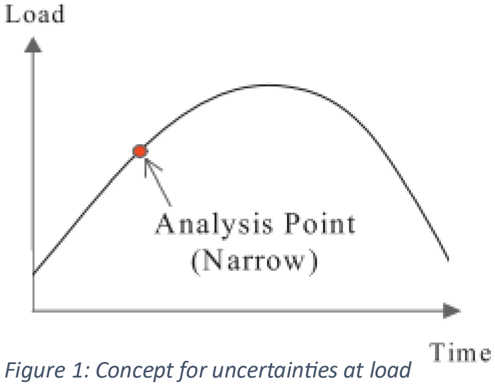

Figure 1: Concept for uncertainties at load

Applying the conventional N-1 reliability criterion in such an uncertain environment i.e., the number of analyses required to identify the most severe accident point. However, there is a risk that it will be difficult to apply due to reasons such as a significant increase. Therefore, system maintain the N-1 reliability criterion in an uncertain environment. Here, organized the conditions for what is suggested. Robust reliability refers to system planning and system operation. At some time before, maintaining the N-1 confidence criterion taking uncertainty into account.

Robust reliability is defined as follows. First, the conventional Control variables such as generator output to satisfy N-1 reliability criteria. The region of u is the static security region (SS region) is defined as follows:

$$\left.\begin{aligned} &u \in SS(p) = SS_0(p) \cap SS_1(p) \cap \cdots \cap SS_N(p) \\ &SS_n(p) = \{u \mid u_{min} \le u \le u_{max},\ f_n = 0,\ g_n \le 0\} \qquad (3) \\ &\qquad\qquad n = 0, \ldots N \end{aligned}\right\}$$

where $f_n = 0$, $g_n \le 0$ is n^{th} system constraint, and $SS_n(p)$ is given by the deterministic parameter p in the region u can take while satisfying this constraint. As a system constraint, overloading of lines, etc., is considered against contingency failures. load, voltage value, voltage stability, and transient stability. It mean the intersection area for each of these constraints. The Robust Static Security region (RSS region) is by introducing uncertainties such as PV output, the parameters of Eq. (2). It is defined by the following equation as the intersection area of the SS area for the fluctuation.

Modeling of Future Grids

In this section, it is presenting a model of the 50-Hz system assuming a cross-section in 2035. Simulations using a multi-layer system confirmed the calculations shown in the previous section. In the following, the system used for the study and the desorption of load and PV are described.

Model System Used for the Study

The system is divided into three parts: demand forecast, generation mix, and power system model. The details of each are described below:

Demand Forecast “Long-term Energy Supply and Demand Outlook”

Natural Resources and Energy Agency) (6) shows power generation in 2030 in the current fixed case. For a capacity of 1,359,000 GWh, a case that introduces maximum energy conservation. The power demand reduction rate is calculated from the power generation amount of 964,000 GWh.

29% (= 1 − 96.4/135.9)

On the other hand, the “power demand Long-term Perspective” (Research Committee for Natural Resources and Energy) (7), 2000 Extending the average annual growth rate of 1.35% from 2020 to 2025. The maximum power demand in 2030 without considering energy conservation is 263.9 GW. The reduction rate of power demand of 29% mentioned above is taken into consideration. The maximum nationwide demand in 2030, when energy conservation is introduced to the maximum extent, is 187.4 GW can be assumed. Similarly, the maximum demand of the 50 Hz system is based on the 50 Hz national demand ratio (58.3%), this is the maximum demand of the 50 Hz system model used in the paper is 107.8 GW.

Simulation

In this study, the computer simulations are used to show how unfavourable weather circumstances might be avoided. The impact of determinism on system stability is investigated. First, in this scenario, look at Patterns down:

❖ **Pattern 0:** When both PV and load remain constant. The influence on stability is then considered when the PV or load drops. As a result, the research is organised into three patterns.
❖ **Pattern 1:** Only PV declines
❖ **Pattern 2:** Only when the load lowers
❖ **Pattern 3:** When both the PV and the load fail

In the rest of this paper will discuss the simulation and present the results.

Conditions for Simulation

The study was carried out under the following prerequisites conditions:
✓ Power flow between regions is assumed to be (assuming interconnected lines). It is set at 1 to 3 GW, similar to the power system.
✓ The subsystem distributes the PV installation area.
✓ The starting voltage of each node must be within 1 0.05 pu.
✓ Eight fault spots on the 500-kV main line.
✓ Assume a 3-L-G-O (fault clearance time of 0.077 seconds) accident in the starting power flow cross-section of the peak cross section.

✓ The generator's operating condition is governor-free operation.

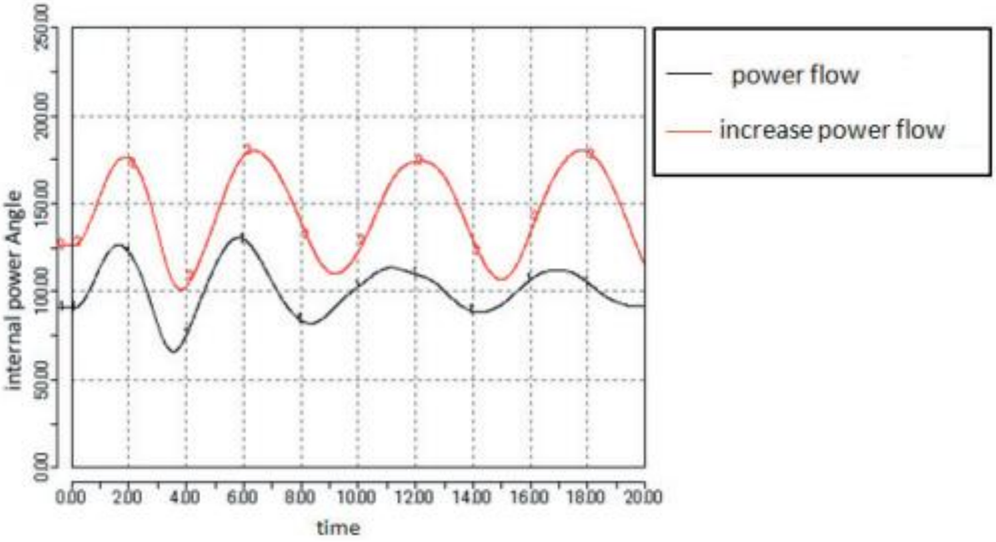

Figure 2:Swing curve at Fault Point with Pattern 0

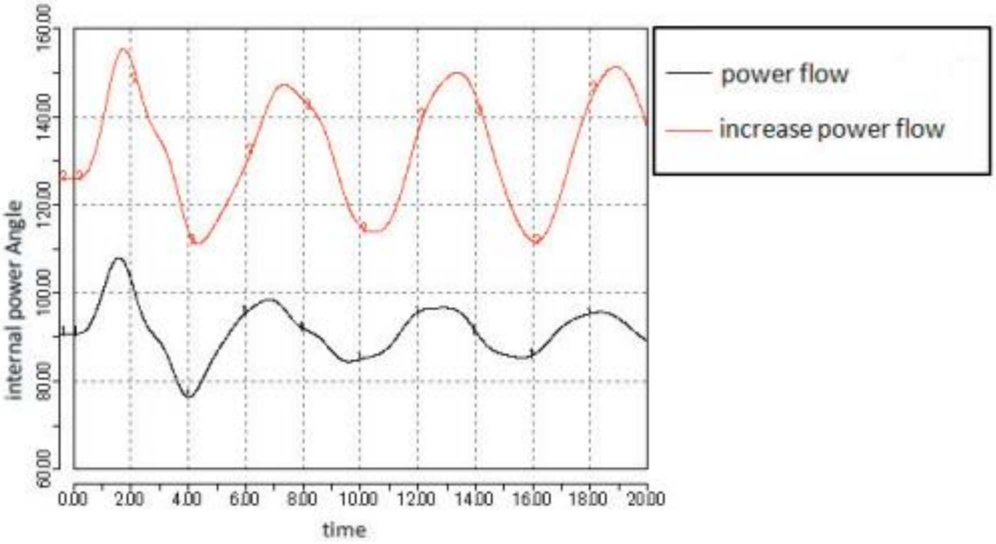

Figure 3: Swing Curve at Fault Point with Pattern 1

Following that, Pattern 1 (PV dropout), the most severe and somewhat severe Pattern 1, is analysed, followed by Pattern 2 (load loss). Pattern 1 (PV dropout) is the most severe because existing power sources, such as thermal internal phase difference angle increases and generator acceleration owing to a system fault, are exacerbated. This is due to the fact that the synchronization force concerning the reference generator is assumed, and there is figure 2,3,4,5 depicts the simulation results discussed above. Pattern 2 (load loss) is less severe because the load is smaller. Because the supply capacity becomes insufficient as a result of the dropping of the group of generators, the output will decline, and finally, the internal phase with the reference generator will be reduced.

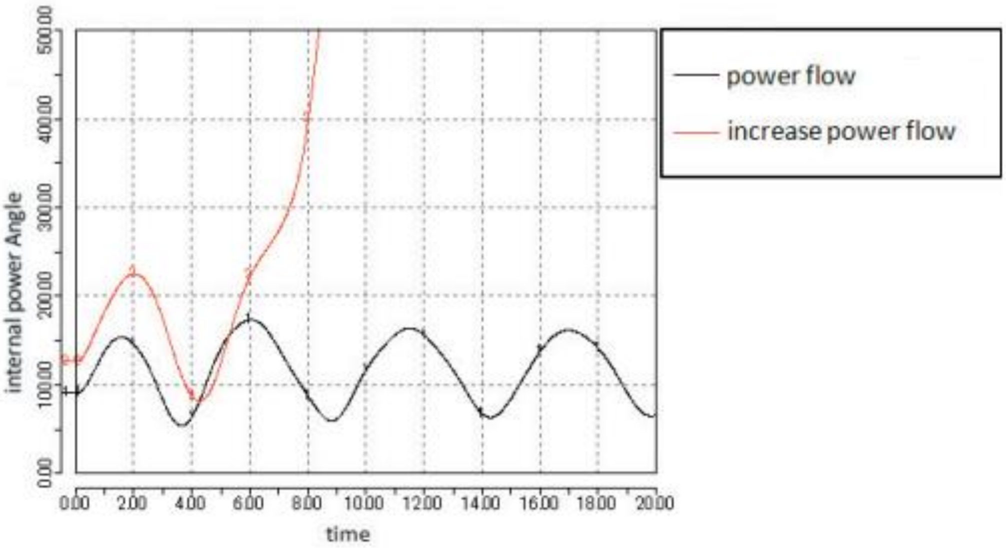

Figure 4: Swing Curve at Fault Point with Pattern 2

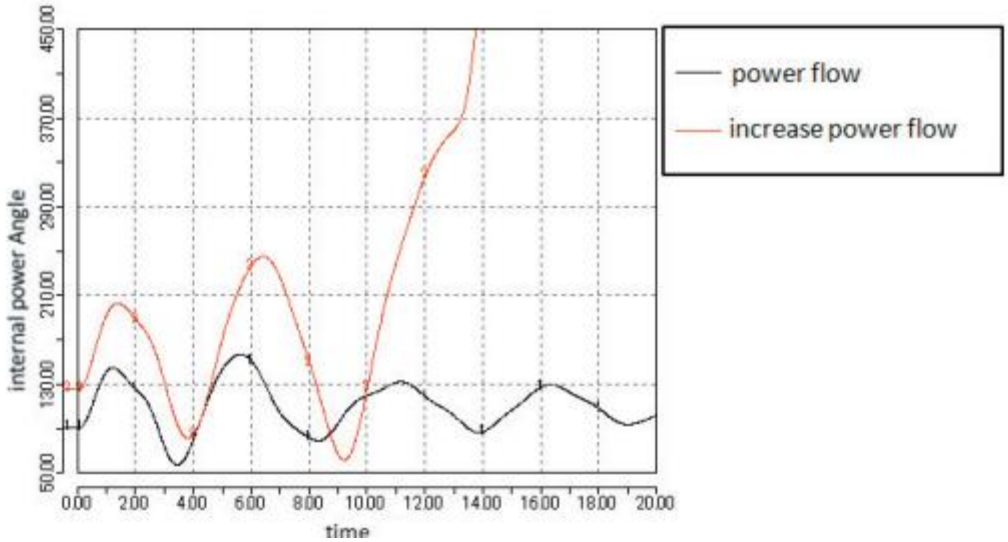

Figure 5: Swing Curve at Fault Point with Pattern 3

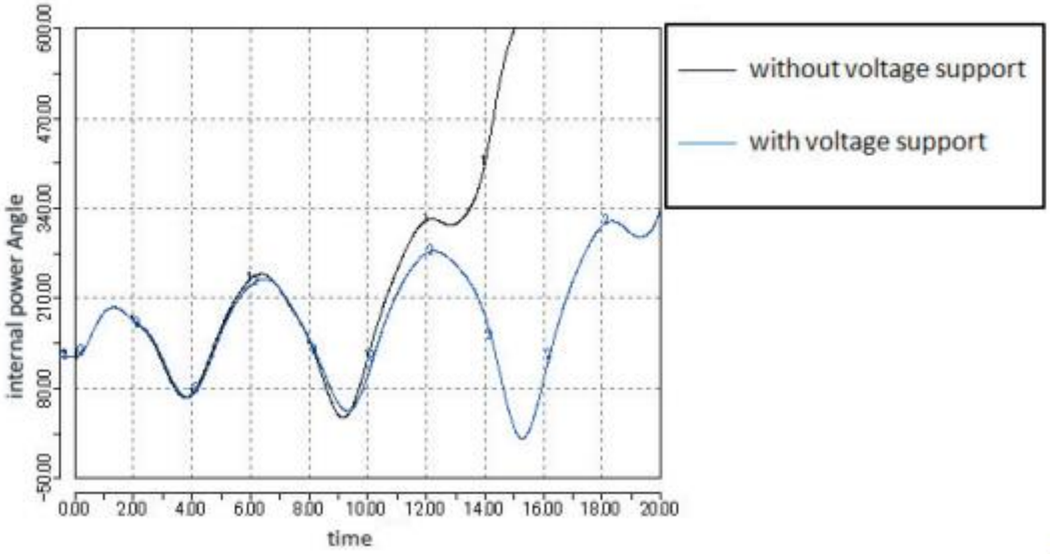

Figure 6: Comparison of Transient Stability with or without DVS

This is assumed to be since it acts in the direction of reducing the differential angle. From the results in Figure 6, it is clear that the PV does not have a DVS function. Even in cases where it becomes stable, it is stable with the DVS function. It can be seen that it contributes in a situation where PV is generating full power in all regions, and the stability is unstable. It has improved from a stable state to a stable state. this is an especially long distance. In the case of a comb system, the voltage drops at the intermediate point due to a system fault is supported by the DVS function of PV, that is, the so-called halftone phase. It is considered that this indicates that the effect is appearing. The power conditioning subsystem of PV is FRT Equipped with a function to continue operation without dropping out in the event of a system disturbance. It is being established technically as far as possible.

Conclusion

The research modeled the uncertainty of PV and proposed a suitable parameter selection strategy based on the concept of robust reliability. This is expected to provide suggestions for effective strategies to sustain reliability. The Effects of Load and PV Dropouts on Oscillatory Divergence Stability In terms of impact, took a bird's-eye view of the complete system in a condition similar to the actual system. Considering future large-scale PV deployment DVS is equipped with functions for constant voltage adjustment and stability maintenance, in addition to the FRT function, which withstands voltage sag and maintains operating.

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