Modelling Sri Lankan Power sytem

To Study the Effect on Dynamic Stability with Large Scale Wind Power Integration

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Introduction

To meet the increasing demand for electrical energy, the estimated need of new generating capacity to the Sri Lankan power system is over 4400 MW in next 15 years [1, 2]. Studies have revealed that wind is the most promising option of the available renewable sources for grid connected power generation in Sri Lanka other than the conventional larger generating stations. Wind energy resource assessment study carried out in 2002 has confirmed the availability of 20,000 MW of wind resources in north-western coastal region from Kalpitiya Peninsular to Mannar Island, Jafna Peninsular and the Central Highlands.

However not enough studies are available to assess the transmission grid accessibility of these wind resources. And also no system studies are carried out on routine basis for transmission connection proposal for non-dispatchable power including the large scale integration of wind power. However the studies associated with large scale integration of wind power are less complication than that of the distributed power generation. Yet dynamic stability is the concerning issue due to the intermittency of the wind power availability and also due to the limitations of supporting the fault current by wind generators.

Methodology

The Sri Lankan transmission system is initially modeled using IPSA software, with data sufficient for steady state analysis. The best option would be to build the model from the beginning using the database, which will accommodate the easy maneuverability of the model for different applications and users. It also helps the gradual upgrading of the database with real data when available. The model thus developed was run for steady state analysis and the computed values were compared with actual measured values for different loading conditions.

In the next step, the generator data required for transient studies was inserted in to the database. In first attempt, no typical data was used in place

of missing data. This allows the system to run on IPSA default values. Dynamic stability of the system was then studied to demonstrate the stability model of the IPSA. Then in second attempt, the default damping factor (which was zero in IPSA) was slightly adjusted together with minimum required transient data using typical values. This was done for machines, which were not had sufficient data. These values were stored in a different database thus leaving the database with real data untouched.

The following Stability criterion is used. The system shall remain stable during and after a system disturbance for three phase faults at any O/H line cleared by the protection with successful and unsuccessful auto re-closing including a possible loss of generation and load transformer. Few marginal dynamic stability cases were identified for this study through the experience on the recent faults events in the CEB system and by considering the three phase fault levels at all the bus bars.

In present Sri Lankan power system stability issues are more vulnerable during the periods of more concentrated heavy hydro generation. These periods are generally occurred in July-August and November-December, for normally anticipated weather patterns. Therefore within this paper the stability analysis was limited to system peak loading occurred at 19:30 hrs on 7th August 2006. The considered peak had 50% concentrated hydro 30% concentrated thermal and 20% dispersed mixed generation.[3] All loads were modeled as fixed load as it represent worst case. In other words the motor loads generally supports towards greater stability than the fixed loads.

Finally, the impact on the dynamic stability of the Sri Lankan power system on integrating moderately large wind power to the system at identified Grids, were studied for the selected marginal stability cases. Study within this paper was limited to 100 MW wind integration at Puttlam Grid Substation for a night peak loading condition

Results

Following bus bars are more vulnerable for dynamic instability when three phase fault occurs at the line with heaviest current, closest to the bus bar. Measured and calculated voltages and load flow are listed in the Tables 1, 2 and 3. [3]

Table 1. Comparison of voltage results

Bus Bar	Voltage measured (kV)	Voltage calculated (kV)
Kotmale_220	225.0	223.3
Victoria_220	230.0	226.2
Kalnya_132	130.0	129.4
Fort_132	128.0	129.2
SapGS_132	132.0	129.8
LaxNew_132	132.0	133.9

Table 2. High fault level 220 kV busbars & heavily loaded lines with load flow comparison

Bus Bar	Symmetri. fault level (pu MVA)	Heavily Loaded Line / Generator	Calcula. Load (MW)	Measur. Load (MW)
Biygma_220	46.601	Kotmale_220	141.83	140
Kps_220	44.228	Kps_CCG	104.99	105
Kotmale_220	40.948	Biygma_220	141.83	140
Panni_220	39.409	Biygma_220	58.63	60
Ktgoda_220	37.226	Biygma_220	81.33	80
Victoria_220	36.167	Kotmale_220	91.25	90

Table 3. High fault level 132 kV busbars & heavily loaded lines with load flow comparison

Bus Bar	Symmetric. fault level (pu MVA)	Heavily Loaded Line / Generator	Calcula Load (MW)	Measur. Load (MW)
Kalnya_132	40.845	SapGS_132	49.17	50
Fort_132	40.518	Kps_132	69.88	70
SapGS_132	37.822	Biygma_132	69.78	70
Polpitiya_132	37.450	Kotmale_132	61.76	60
LaxNew_132	37.025	Polpitiya_132	50.50	50
Kollon_132	44.173	Mrdna_132	63.57	65

The stability studies were done on the modeled Sri Lankan power system network. This was done for successful three phase re-closure after 300 ms and also for unsuccessful re-closure. The fault clearing time was assumed as 100 ms. Four cases were studied in simulation and their waveforms are shown in Figure 1, 2, 3 and 4.

Case 1: Fault at Kps_220 bus bar cleared through bus bar protection

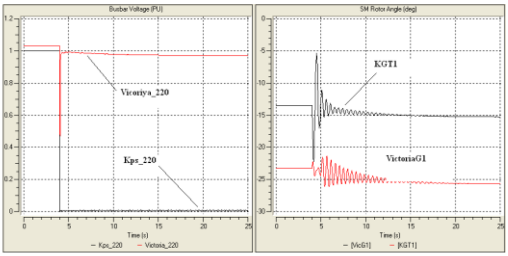

Figure 1(a): Bus voltages Figure 1(b): SM rotor angle

In Figure 1(a), around 165 MW generation is loss from the system when clearing the Kps 220 bus bar for a bus bar fault. In Figure 1(b), KGT1 is a machine closer to the affected bus bar and Victoriya G1 is a machine far away to the affected bus bar. Both machines are remaining in stability after the bus bar fault.

Case 2: Double Faults on Biyagama Kotmale 220 kV Lines at Biyagama end

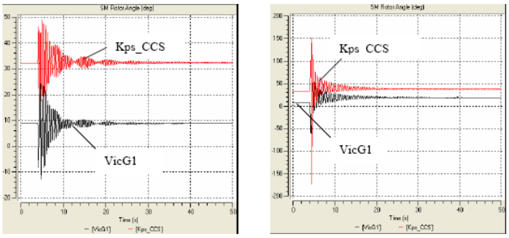

Figure 2(a): with re-closing, Figure 2(b): without re-closing

Biyagma 220 and Kotmale 220 are buses with heavy fault level and experiences system collapse during double faults under certain loading conditions. Kps CCS closer to the affected bus is critically stable on unsuccessful re-closing.

Case 3: ApuraNew line at Kotmale without re-closing 300 ms clearing delay

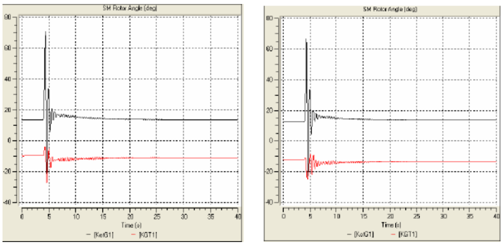

Figure 3(a): No wind Figure 3(b): with wind

This demonstrates the modeling capability of IPSA to study dynamic stability issues. It was checked with 400 ms clearing time and with longer clearing time without re-closing it shows the reaching critical stability on the Kotmale machine closer to the fault

Discussion

The database approach is the most appropriate for power system model development in IPSA. The initial steady state and security analysis was done through the partly populated database. Studying of the large power system was done in highly structured manner in the order of steady state load flow analysis, rate exception handling and contingency analysis. The dynamic stability of power system was studied only after solving and / or identifying the unsolved issues in the order mentioned. In the process, the model is validated by comparing to the measured load data and also to the known instability issues. Finally the model was used to forecast the system stability for large scale wind integration at the most promising site at Puttlam, where the base load coal power plant is also anticipated. In large scale wind integration of wind, it is assumed that the wind is connected through a representative synchronous generator. During a disturbance wind generation will back off from the system without supporting the fault current, in worst case scenario.

Conclusions

Calculated load data through steady state load flow analysis is tallied with measured data. Instabilities shown in the system for unsuccessful auto re-closing at Biyagama Kotmale 220 kV double circuits for simultaneous faults, is a known issue in the system, which was instrumental on blackout of the system as well. Also few selected marginal cases of instability were not worsened due to the introduction of 100 MW wind at Puttlam. This was evident from the case of three phase fault on ApuraNew line at Kotmale bus bar without re-closing and 300 ms clearing delay. Therefore the developed IPSA model of the Sri Lankan power system can be used for further studies of the system.

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