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Enhancement of controllability to improve the transient performance for captive power plant in islanding condition: A case of study

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ABSTRACT

In order to maintain power system stability and process survivability for major system faults under a variety of system configuration topologies, the selection of proper governor system is essential. Islanded power systems present very distinct challenges, whereby the lack of utility interconnection hinders the system's ability to recover from a loss of generation. In order to maintain power system stability in an islanded configuration, fast acting governor system in response to a specific event in the plant is the key factor governing plant survivability. In this paper an attempt has been made to study the performance of different excitation and Governor models of captive Generator sets for an Industry which supplies both process and utility load and exports to national grid. A new governor model is also developed to improve the transient stability performance captive generator system thus improve the reliability of power generation of captive power plant (CPP). The analysis was done using Electrical Transient Analysis Program (ETAP) Version 11 software and the simulation results are depicted in the graphs.

Introduction

In the era of de-regulated electric industry, any industry can sell power to Grid and that need not be necessarily a Generation Company. For that reason many process companies have shown lot of interest in setting up captive power plant such a way so that the captive unit is able to cater their own load and excess power sell to grid [1]. After implementation of smart grid policy, plant owners have open access to selling the surplus power in common trading platform, thus building up of captive power plant becomes an attractive option for many Process Industries [2–4].

Industrial sector is the largest energy consumer in the world and most of the industries now depend upon their own generation rather than utility supply due to insufficient grid supply, poor power quality and higher tariff rate. Insecure power supply and higher tariff rates results in higher production cost [5–7]. To cater both essential and nonessential loads of the plant, the captive generators run in parallel with the utility (grid) supply. Whenever the grid is not available due to fault on a transmission line, loss of generation, large loss of load etc, grid parameter vary widely [8,9], which may be detrimental to the captive generators or process conditions and the captive units have to be isolated from the grid [10].This phenomena is commonly known as islanding. The essential loads of the plant, to the extent possible, shall be served by captive plants until the grid supply is normalized. Rajamani and Hambarde [11], have addressed the problem of islanding and load shedding scheme for captive power plant. Singh and Saini [12] addressed the problem in their paper Fuzzy FPGA Based Captive Power Management technique during Islanding condition. But Singh and Saini have not addressed any stability issue of captive generator sets in their paper. After islanding from grid assessing, the transient stability performance of islanded generator is very important [13]. Current industry practice is to disconnect all distributed generators immediately after an islanding occurrence which is typically after 180 ms and 200 ms after the loss of main supply if the system has not regained its stability [14,15]. Critical clearing time of fault, voltage variation, frequency fluctuation and rotor angle variation are the transient stability index to assess stability in contingency period [16–18]. Transient stability limits depend on dynamic behavior of network [19–21] such as machine damping and armature resistance of machine and stability limit can be analyzed using equal area criteria Lyapunove method [22,23].

As grid disturbance is a major issue now-a-days, therefore improvement of transient stability index for captive power plant during grid disturbance and after isolation of grid is a major challenge for power researchers. Speedy recovery of transient performance of captive generator sets after grid isolation can be done by efficient governor control along with controlling generator

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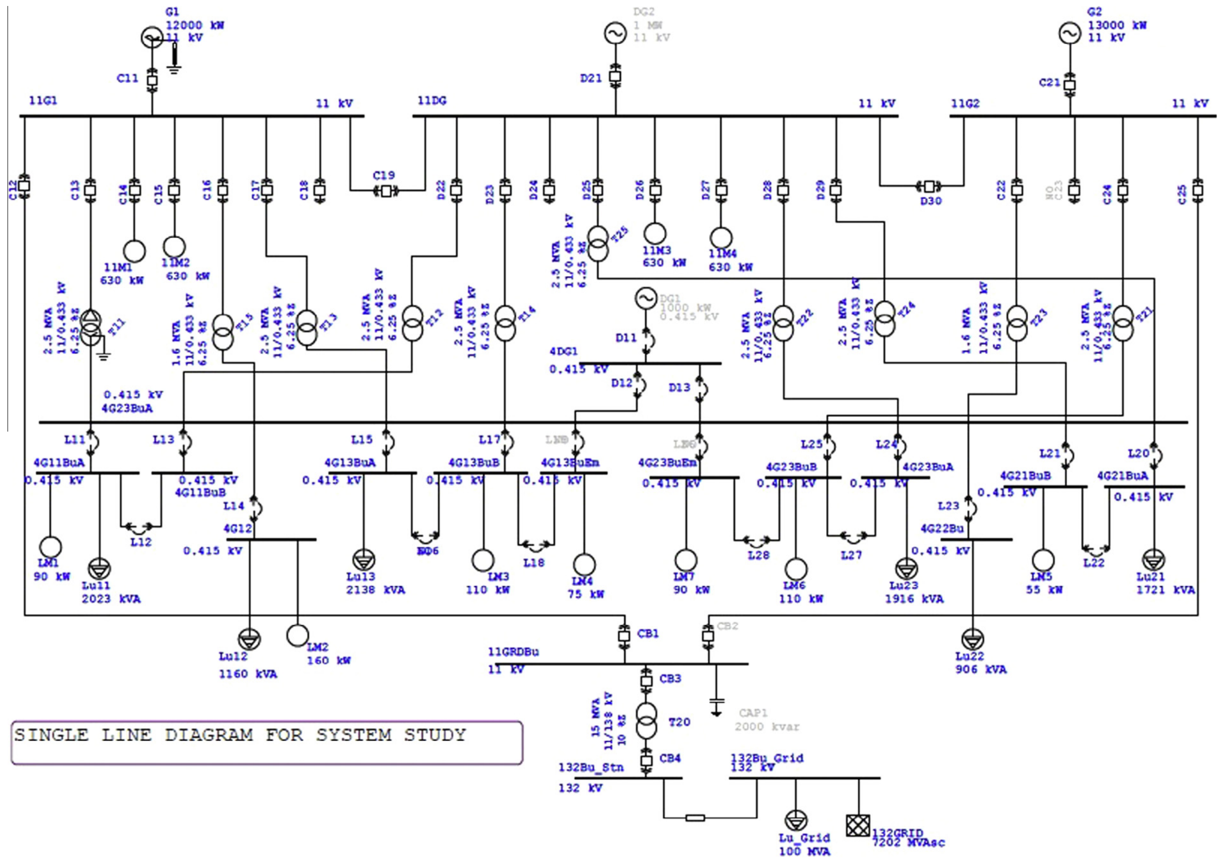

Fig. 1. Network diagram for system study.

excitation [11]. In captive power plant rating of 5–50 MWs during any grid disturbance accurate logic, control responses and first acting Governor is essential for safe islanding operation as otherwise system instability occur in terms of turbine speed variation, voltage variation, etc., [14]. If disturbances are not recovered immediately, results cascaded outage of generation units thus processes suffer. Hence proper selection of turbine governor system is essential during initial design of captive power plant [4].

When the captive power plant generate power more than its internal load requirement and excess power supplies to utility grid, during this process any disturbance on utility side forces the captive power plant (CPP) go to islanding mode and immediately reduces its generation as per its internal load requirement [24–48]. The governor systems of CPP need to adjusted the speed of turbine instantaneously so that over seed should not occur at that moment. If the speed variation is more than 2.5% then the over speed trip occur, results in immediate shutdown of CPP unit [18]. To anode this situation this paper compares the performance of different excitation system like IEEE Type ST1, AC5A [23,49] along with different type of turbine governor system like Steam turbine (ST), Single reheat steam turbine (ST1) and IEEE General Steam-Turbine (STM) [50,51].To improve the stability performance of CPP, a new governor model is developed and compare the performance of the proposed governor model with aforesaid turbine governor models.

Profile of the power system

Description

The power system considered in this paper is a Process Industry having the captive generation facility. The process plant has two independent power supply lines. Electric power supply for line1 supplies power with the help of 11 KV/415 V distribution transformer to following 415 V Power and Motor Control Centre denoted as 4G11BuA, 4G11BuB, 4G13BUA, 4G13BUB, 4G12 and 4G13BUErm. 11 KV/415 V Transformer is supplied by 11 kV Switchgear denoted as 11G1. 11 KV Switchgear is provided supply from 12 MW Generator 1. Line 2 supplies power with the help of 11KV/415V distribution transformer for supplying power to following Power and Motor Control Centre named as 4G21BuA, 4G21BuB, 4G22BUA, 4G22BUB, 4G22Bu and 4G23BUErm. Line 2 is provided supply from 11 KV switchgear denoted as 11G2. 11 KV switchgear is connected with 13 MW generator G2. One (1) no. 415V DG set (DG1) and one (1) no. HT Diesel Generator is installed as stand-by for emergency condition during total black out of the process plant [52].

Start-up power of any of the generators is generally available from the electric Grid. Alternatively, 11 kV Diesel generator (DG2) is available to provide start-up power also. Second Turbine Generator (G2) also can manage the start-up power from the first Turbine Generator (G1), if already started or vice versa. Basic power system arrangement of all Generators along with interconnection is shown in Key Single Line Diagram showing all Circuit Breakers prepared for the study. As per the system philosophy, for feeding the process lines G1 and G2 generally run in parallel continuously. However, in case one Generator (G1 or G2) is out of service, the other generator can take over total process plant load. The 11 kV, 12 MW and 13 MW generating units are connected to 11 kV switchboards. Auxiliaries of this unit will be fed from a new 2.5 MVA distribution transformer connected to the said 11 kV switchboard. 15 MVA generator transformer will be connected to 132 kV Switchyard. The 132 kV switchyard will be