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A Strong Action Power System Stabilizer Application In A Multi-Machine Power System Containing A Nuclear Power Plant

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Abstract— as the amount of traditional fossil fuels produced and supplied decreased, communities began to wonder: what will happen to electric systems of power? Instead of using traditional fossil fuel power plants, alternative alternatives and solutions are suggested. Among these top options are nuclear power plants. The El-Dabaa nuclear power station will be Egypt's first of its kind. This plant's first unit (reactor) will only feature a single big synchronous generator (machine) with a rated output of over 1000 MVA (1200 MVA). The 500 kV network will be connected to the synchronous machine, which must always be fully loaded and running continuously. In order to increase the stability of a nuclear power plant synchronous machine when it is connected to a large power grid to create a multi-machine power system, this study proposes a novel control design of a strong action power system stabiliser. System stability that permits a notable increase in the stability margin during the steady-state phase can be achieved by a strong action power system stabiliser. It stabilises both transient and sub-transient processes and efficiently dampens oscillations. It also aids in avoiding abrupt drops in bus-bar voltage. Various machine signals are selected as inputs to the strong action power system stabiliser that is connected to this machine in order to get improved damping behaviour for the rotor speed and terminal voltage of this machine. This technique demonstrated its effectiveness in reducing the machine's terminal voltage fluctuations and frequency oscillations. Better system stability is thus attained.

Keywords — Multi-machine power system, Nuclear power plant, Power system stability, Strong action power system stabilizer, Synchronous machine

I. INTRODUCTION

Modern power systems now day’s becomes huge positioning interconnected with continuously time varying operational state and numerous control objectives has to meet various requirements in all of these dimensions for power systems operation effectively. In the past century, specially, since the sixties, considerable efforts have been made towards on the raise of the dynamic and transient stability of large power systems. Distinctive methods have been reported in previous to provide the damping needed for enhancing these systems stability. There are different reasons led these research studies towards that direction. Of the most important reasons are: reduced margins of stability of these systems, economic conditions, reliability, and security requirements ... etc.

Different mathematical, and control methods are use theoretically, and are practically applied and implemented for stability studies. Few of these studies are devoted for studying system states and relations with stability. In present power systems, utility expansion is the main feature, which makes it to operate with reduced bounds of stability margins due to lower inertia constants and higher reactions of generation units.

Due to rapid growth of the population, and the ceaseless deficiency in providing conventional sources of fossil fuels … natural gas, oil, coal … etc., and the constrained quantities of water and hence hydro-electric generation, the works within the non-conventional power era increments from day to another; and the usage of nonconventional sources increases year to another.

Nuclear power plants are one of these leading non-conventional sources. Nuclear power plants with its continuously loaded large scale synchronous machines became one of the best solutions for satisfying the increased and continuous demand for electric energy due to its low running cost, high generated amount of energy and supposed to be environmentally clean source of base load electrical generation. Nuclear power plants became one of the best solutions for facing the increased and continuous demand for electric energy due to its very low running cost, its high capacity and supposed to be environmentally clean source of base load electrical generation. For these reasons Egypt decided to begin its nuclear program.

The strong action controller is used to achieve power system stability which allows increasing a significant steady-state stability margin that damp oscillation effectively, and stabilizing transient and sub-transient processes. Also, the proposed strong action controller helps to prevent sudden reductions of nodal voltages.

Electricity is widely acknowledged as one of the driving forces of economic development. Indeed, providing clean and affordable energy has been recognized as so pivotal to sustainable economic growth that it has been formally included in the United Nation's 17 Sustainable Development Goals as Goal 7 (SDG7). However, the challenge of continuously generating clean and affordable electricity to meet growing demands is particularly daunting for developing countries. With nearly 1.4 billion people and a very rapidly expanding economy, India faces a major electricity generation challenge. The country's electricity demand has more than doubled since 2000 and is expected to continue to rise sharply during this century. The increase in electricity consumption is coupled to a parallel growth in the power generation sector. However, although power generation has recently been increasing rapidly, supply has barely kept up with demand. Several important constraints have arisen concurrently. There has undoubtedly been an increase in the share of renewables in the power generation sector. The total capacity installed by the end of 2022 was 410 GW, with renewables accounting for 29.5 %, followed by hydropower and nuclear power, accounting for 11.4 % and 1.6 %, respectively.

One of the key factors facilitating the worldwide shift to economies with lower carbon emissions may be the advancement and use of renewable energy generation technology. However, the characteristics of solar, wind, tidal, and other renewable energy sources are unpredictable and changing. Additionally, because power electronic converters disconnect renewable energy generators from the grid, their inertia contribution to the system is nearly zero. As a result, frequency stability problems always arise in IPSs that integrate a significant amount of renewable energy sources, and these power systems typically need an appropriate LFC method design.

There are often two or more interconnected markets that are cleared at different times that go into the planning and running of energy markets. The sequence of markets trades the commodity that is physically created and consumed in real time. Each market, be it a day-ahead hourly market or one of the real-time markets connected with that hour, trades the MWh commodity at different prices that reflect the information on the system and market conditions available at the time the MWh commodity is cleared. As these conditions are subject to constant changes in real time, real-time markets (RTMs) are cleared at a high frequency, typically every 5 minutes. When markets aren't in real time, on the other hand, they clear less often. For example, in day-ahead markets (DAMs), they clear once an hour, which shows that they don't have as much accurate information about what will happen in real time the next day. The hour h DAM is cleared on the predictions of the real-time conditions for that hour the next day. Each RTM is affected by the hourly clearing in almost real time during that hour. The RTM clearing determines the volume of deviations from the hour h DAM value and the related price. Such a market design with different lead times and clearing rates is commonly referred to as a multi-settlement system.

In the last decade, efforts have been focused into the enhancement of the stability problem of power systems. For the increase in power systems, the problem of stability bas a great attention. Different approaches have been discussed in literature to provide the damping needed for improving the system stability. The main methods have led to the development of two types of controllers; the power system stabilizers (PS Ss) and the static V AR compensators (SVCs). The design of PSSs and SVCs have applied many different control techniques such as conventional controllers, adaptive controllers, optimal controllers, etc.

II. LITRATURE SURVEY

India is a developing country that is facing a big energy challenge. At the heart of this challenge lies the provision of electricity, which is important for India's sustainable economic development yet faces major uncertainty in the future. A growing collection of literature on planning studies has evaluated the future pathways open to India's power generation sector. In particular, several system planning studies have been performed at the state level to capture specific local features in energy supply–demand dynamics and to inform policies and initiatives for sustainable growth at the national level. the wider electricity planning literature, considering those states that have so far been studied the most from a modelling perspective (i.e. Andhra Pradesh, Assam, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Rajasthan and West Bengal), and scrutinizes the various analyses performed by considering their modelling approach and analytical methods, programming techniques, evaluation criteria/objectives (e.g. economic, technical, environmental), planning horizon and time step, energy mix configurations (including the technologies implemented, fuels and storage systems), and key relevant technical and economic modelling features [1].

Fractional Order PID (FOPID) controllers have been heavily studied in recent years, but most of the methods developed for its optimal design depend on the idea of including several robustness and performance specifications in the objective function. Thus they suffer from the same problem, namely the trouble in finding the optimal controller parameters due to the impossibility of meeting all the specifications, and the high sensitivity to the initial parameter values. In this work, a new optimization based tuning method for FOPID controllers is suggested. The method presents fast convergence and consists of stating a desired closed-loop transfer function and finding the FOPID controller which gives the closed-loop behaviour closest to the specified. The parameterization of the controller is shown, and the optimization method used is detailed. Then the proposed method is applied to design a FOPID to control an underdamped third order system with time delay, getting good robustness and performance [2].

Modern power systems are confronted with widespread worry on the frequency stability issue due to the widespread integration of randomly fluctuating renewable resources. To address the above concern, this work proposes a load-frequency-control (LFC) scheme based on a parameter tuning approach for fractional-order proportional–integral–derivative (FOPID) controller. Firstly, a two-area interconnected power system (IPS) model, including thermal, hydro, solar, wind, and gas power generator and a hydrogen-based energy-storage unit, is created [3]. Then, a FOPID controller is created for this IPS model, and an improved gradient-based optimizer (IGBO) is developed to adaptively regulate the parameters of the FOPID controllers. Finally, the effectiveness of the offered LFC scheme is tried through load disturbance and renewable energy fluctuations test scenarios and provides a comparison and robustness analysis among different schemes. The test results validated that the offered LFC scheme can effectively reduce the frequency fluctuations of the IPS and has excellent robustness.

The tight coupling between system and market operations means that there are strong inter-relationships between system security management and market performance [4]. Therefore, the assurance by the regional transmission organization (RTO) of secure system operations strongly depends on, and directly impacts, energy markets. Typically, electricity is traded in a series of markets that are cleared at different frequencies and with different lead times. In this paper, we focus on the hourly day-ahead markets (DAMs) and their associated real-time markets (RTMs) that clear, usually, every 5 to 10 minutes. The DAMs' clearing impacts the type and the extent of the participants' responses to real-time conditions and, therefore, the real-time system operations, which, in turn, impact system security. The basic thrusts of this work are to quantitatively describe the linkages between the real-time system security and the day-ahead markets as well as to investigate the role of the financial entities in a multi-settlement system. We develop a systematic method that allows us to quantify the auction surplus attained through the multi settlement system and evaluate the impacts of the DAMs on market participants' bid/offer surpluses as well as on improving the ability to facilitate real-time secure power system operations.

Modern energy grids continue to be vulnerable to large-scale blackouts. As all states leading to large-scale blackouts are unique, there is no algorithm to spot pre-emergency states. Moreover, numerical conventional methods are computationally expensive, which makes it difficult to use for the on-line security review [5]. Machine learning techniques with their pattern recognition, learning capabilities and high speed of identifying the possible security boundaries can offer an alternative way. The aim of this paper is not to suggest that one particular kind of machine learning technique for security assessment would be more appropriate than others. We start from the idea that almost every method may be useful within some restricted context. Based on this idea, we created an automated multi-model approach for on-line security assessment. The proposed method allows us to easily test the different state-of-art techniques in order to find both the best algorithm and its top performance tuning for particular analysed power system. A case study using the IEEE RTC-96 system shows the effectiveness of the proposed approach.

In this study, a novel control method of fuzzy logic power system stabilizer (FLPSS) for stability enhancement of large scale power systems. The FLPSS is applied for each machine in the system. In order to accomplish best damping properties for rotor speed and terminal voltage of each machine in the system, two signals from each machine are picked as inputs to the FLPSS of this machine; deviation of rotor speed and deviation of terminal voltage [6]. These methods proved its efficiency in damping oscillations in the frequency and variations in the terminal voltage signals of each machine in the system.

Bulk electric power systems (EPS) face tens and hundreds of thousands of disturbances yearly. Most of the disturbances are removed by relay protection and emergency control devices. Failures of these devices, personnel mistakes and some external factors may result in a cascading development of the emergency that is normally localized and eliminated by emergency control system. The insufficient efficiency and reliability of emergency control system as well as other related reasons lead to unique severe outages – blackouts − often with catastrophic effects for EPS and consumers [7].

According to Recent cascading failures in several power systems worldwide require immediate and thorough attention [8]. Adequate analysis, study, and development efforts are needed to investigate the cascading processes, determine conditions and triggering events that cause blackouts, evaluate the consequences and spot potential blackouts, and develop preventive transmission planning solutions, operating procedures, and automatic protection systems. The North American Electric Reliability Council (NERC) has established four categories for events where the system impacts must be limited or reviewed.

Identify algorithms and tracking technologies for the identification of full system states and dynamic behaviour of system. The algorithms are verified with realistic models from the European and Russian power structures. The results lead to a coordination platform which uses Distributed and Dynamic State Estimation in order to manage cross border flows [9].

The installed capacity of photovoltaic (PV) power keeps increasing quickly [10]. However, the typical control goal of the PV system is to provide as much active power to the system as possible, ignoring the reactive operating features of PV inverters. On this basis, an active and reactive power coordinated control method of PV system suitable for electromechanical transient stability analysis is suggested in this paper. Firstly, the mathematical model for PV inverters is created. Then, a novel active and reactive power coordinated control method based on an improved double-loop control scheme is suggested, according to the steady-state active and reactive power operating limits of PV inverters. The voltage control loop is to get active and reactive current component references, combining the maximum active power point tracking under present solar irradiation and reactive power controlling under system voltage requirements; the current loop realizes the active power and reactive power coordinated control. Finally, the efficiency of the proposed control method on power system transient stability is tested, based on the IEEE standard test system. Simulation results show that the proposed coordinated control method for solar inverters is helpful in improving the angle stability and voltage stability of power systems.

III. CONCLUSION

Unusual energy sources will be used a lot in power systems of the future. One of these unusual sources is nuclear power plants. The strong action power system stabilizer is a new type of controller that might be able to work with nuclear power plants. The proposed power system stabilizer for the nuclear power plant synchronous machine is meant to make this machine more stable when it's linked to a big power network to create a system with more than one machine. A strong-action power system stabilizer can make the system stable, which increases the stability margin significantly at both dynamic and steady-state periods. It can also successfully stop oscillations and stabilize sub-transient and transient processes. It also helps keep bus-bar volts from dropping quickly. A test of this method showed that it effectively stopped changes in the machine's frequency and terminal voltage readings.

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