A Look Over View Of Grid Connected Power Electronic Base DFIG Wind Energy System

V Suresh Kumar Lagudu

Abstract: With the increase in demand for power generation, there is an interest building for renewable energy generation due to their advantages like clean and harmless energy generation. Among all renewable energy sources, Grid-connected Photo Voltaic (PV) systems and wind energy systems are being developed ranging from a few kW to tens of MW. The increasing proportion of wind and solar energy in the power system also raises stability issues. Any system can be maintained with constant frequency using controllers. The controller gains are usually designs using gain scheduling which is vague due to the complexity of the existing system. In recent times HVDC transmission systems based on voltage source converters like VSC, MMC, and Diode-clamped (DC) converters have received more recognition. Wind and PV energy systems give qualitative power when fed through advanced multilevel converters. Multilevel Voltage Source Converters (VSC) are promising as an alternative converter for high-power, medium-power, and low-power applications. Modular multilevel converters (MMCs) are a breakthrough within the field of medium and high power applications, high voltage electrical energy (HVDC) being its primary application. The M-STATCOM system is suitable to symmetrical and asymmetrical ac network faults.. A MMC with phase disposition (PD) PWM technique could be connected with back-to-back converter of DFIG wind system.

Index Terms: RES Importance, Multilevel inverter, Multilevel inverter, Applications of MLI, AGC, Optimization Techniques.

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1. INTRODUCTION

AN energy system is a structure of network consisting of energy sources, storage, transmission, distribution, and consumption of energy. The basic primary use of energy is for transportation, heating, industrial and electricity sectors. Due to the increase in population, the rapid increase in demand can be seen and, to meet the demand, power generation must correspondingly increase, and hence a large number of the renewable energy system must be integrated with the power grid system to meet the rising demand for power generation. Over the past two decades, the influence of deregulation on the evolution of the Power Grid by the power Industry and the transition to the smart grid have raised several challenges to the power industry. During Power swing condition, the most important aspect is to maintain the frequency at the nominal value. Renewable energy sources such as wind, solar power, and battery storage technologies which are intermittent in nature cause frequency control to be a challenging task. Controlling frequency in electric power system design and operation is a major control problem and it leads to more significant issues in the present scenario due to the increasing size of and changes in the structure of emerging new distributed renewable power sources and various uncertainties, environmental constraints, and the complexity of power systems. Among all the renewable energy sources wind energy sources have more demand due to their availability. Presently, wind energy systems are integrated into the grid through back-to-back converters.Harmonic voltages which affect the supply network and the operation of other connected electrical equipment can cause an impermissible disturbance. Hence harmonic content should reduce to an acceptable level and before designing a converter with controllers one should consider the THD constraints. As we know, completely removing harmonic currents from an electrical system is very challenging and difficult but we can reduce the amount by using harmonic controllers. During the last two decades, many studies were concentrated on damping control and voltage stability and its related issues, but very few works were done related to power system frequency control, analysis and synthesis. Power system frequency control gives rise to new solutions to the technical obstacle introduced by the rapidly increased role of distributed generation and renewable energy sources (RESs) in modern electric grids. In the present scenario, the integration of RESs into the power system frequency regulation is interesting and the impact of RESs with respect to frequency control problem is more on the grid. Due to the high penetration of wind power, the impact of power fluctuation on the system frequency response is emphasized, addressed and solved in this thesis. This can be achieved by designing appropriate Proportional-integral-differential (PID) or advanced controllers.

2 IMPORTANCE OF RENEWABLE ENERGY

With the surplus amount of renewable energy, the human race would feel secure for generations. Khemani (2011) says: “As long as human life is there, there will be earth, sun, wind, and water, and the energy from these sources will also be available as long as they are there”. With the increase in energy demand, the world needs abundant energy resources. The Indian government has increased the target of RE capacity to 175 GW which is divided into 100 GW of solar power, 60 GW of wind power, 10 GW from bio-power and 5 GW of small hydropower by the year 2022. Under the scheme national solar mission (JNNSM) 100 GW target was set which comprises of 60 GW from large and medium scale grid connected solar power projects and 40 GW rooftop. Using a commercial grid simulation tool by US electric system the future Renewable Energy is analyzing hourly operability of high renewable penetration. The evaluation assessed various scenarios with order of levels of renewable electricity generation in 2050, from 30% to 90%, with a focus on 80% [nearly about 50% from intermittent wind and solar photovoltaic (PV) generation, So to accommodate certain levels of renewable energy we should identified the characteristics of the U.S. electricity system; and for future aspects describing some of the associated challenges and implications of realizing such a system.

- *L V Suresh Kumar is currently working as assistant professor in GMR institute of technology at Rajam and similarly pusuing Phd in GITAM university at Vishakhapatnam, Indiap , PH-9000799361. E-mail:venkatasureshkumar@Gmail.com,sureshkumar.lv@gmrit.edu.in*

MULTI LEVEL INVERTERS

To design and construct a two-level inverter for high voltage as well as for high power applications is difficult. To overcome this problem, an alternative multi-level inverter (MLI) family was introduced for high power two-level inverters.An MLI not only helps in achieving high power ratings, but is also a good solution for renewable energy sources like wind, photovoltaic (PV) cells, and fuel cells for high power distributed energy resource. These multilevel inverters will permit the use of low rating power switches connecting in cascade or in parallel to meet high power requirements. Further, multilevel conversions find application in AC traction drive systems, a universal power conditioner (UPC), and modern advances in the FACTS devices. The three-level inverter topology gained attention after this work from the early 1990s with the work of Marchesoni He proposed a cascaded MLI for nuclear fusion experiment which became very famous and is still in application widely. From then the evolution of MLIs gained its pace with many patents observed from the mid-1990s considerably by [29-30]. A flying capacitor multilevel inverter (FCMLI) was developed by Meynard and Foch (1992) but later it was extended by Lavieville et al (1997). This topology finds a good application for three-level and five-level single phase system. Alternatively, Hammond (1997), proposed a practically-realizable FCMLI for the first time. During 1990 and 2000, different multi level inverter topologies were developed and implemented for various applications like drives, chemical applications etc. Novel techniques to achieve the cascaded multilevel inverter were significant with the works of Stemmler and Guggenbach (1993), Kawabata et al (1996), Corzine et al (1999) and Kang et al (2000). Few more interesting topologies which found remarkable attention is with the introduction of the modular-multilevel inverter (Lesnicar& Marquardt 2003; Glinka & Marquardt 2003, 2005; Hagiwara &Akagi 2008; Rohner et al 2009 and Antonopoulos et al 2009). Due to several advantages of MMC compared with conventional inverters [L V Suresh kumar et.al, R. N. Beres et.al, (2016)],over the last few years works on different topologies were performed, based on harmonic control, dynamics of MMCs. The basic operations of MMC [R. N. Beres et.al, (2016)], have been reported, but detailed expressions for the arm currents in terms of state space approach have not been presented so far. State Space approach of MMC for the arm currents, circulating currents for their interaction with the arm voltages is the key to understanding the detailed operation of the converter. Explicit expressions are very helpful to forecast the harmonic components and the phase angles of multiple frequency components present in legs of MMC. However, the multiple frequency components can vary by variation of the control signals, and different control schemes have been suggested in the literature. However, the main drawback is adding the extra switch which would lead to extra losses and, hence, the modified scheme of the inverter was proposed in [J. Rodriguez, et.al. (2007)],with a by passable converter within AC side. The complete schematic with its operation can be found in this paper. A method was proposed to mitigate circulating currents by calculating the instantaneous power of each arm under unbalanced voltage conditions. This control technique has the disadvantage of inclusion of a double-line-frequency ripple in ac-side similarly active power by controlling ac-side negative-sequence currents to zero under unbalanced voltage conditions.. MMC also consist of Various sub-modules [H. Akagi(2011), B. Jacobson,et.al., (2010), E. Solas, et.al., (2013) V. Dargahi, et.al., (2012)] are proposed and discussed of Half-Bridge SM (a). its configuration has simple structure and low losses compared to all other topologies. The output voltage is either equal to the capacitor voltage or zero. This configuration can provide the only unipolar output voltage. The second topology also [B. Jacobson, et.al.,(2010), E. Solas, et.al., (2013)] connecting two half bridge circuits in parallel a full bridge circuit (b) is formed. It can provide a bipolar output voltage. However, as the number of switching devices is doubled as compared to a half bridge, the power loss, as well as the cost, is also doubled. [B. Jacobson, et.al.,(2010), E. Solas, et.al., (2013)] are discussed about Clamped double topology (c). it is consists of two half bridge SM's, two additional diodes and an IGBT. It can also provide a bipolar output voltage. During normal operation, the IGBT (switch 5) is always ON and the circuit appears like two half bridge SM's connected in series. The losses for this circuit are more than that of half bridge and less than that of the full bridge circuit. [T. B. Soeiro (2011), A. Nami, et.al.,(2013), H. Akagi (2011), B. Jacobson, et.al.,(2010)] proposed a three-level flying capacitor(d). It provides an only unipolar output voltage. The intermediate capacitor voltages must be balanced. Losses are similar to that of half bridge circuit. This topology is not an attractive one due to its control complexity. Similarly, three-level neutral point clamped (e) can provide an only unipolar output voltage. Losses are intermediate between half bridge circuit and full bridge circuit [E. Solas, et.al., (2013)] discussed five level cross-connected (f), it is formed by connecting two half bridge SMs back to back by two IGBT's. It can provide bipolar output voltage. By cross-connecting configuration, the number of voltage levels is possible. The losses are intermediate between the half bridge and full bridge circuits. A comparison of various sub module circuits in term of number of switches, design complexity, control complexity and losses. The comparisons of various MLI topologies are shown in Table.1.1 where m is the number of components. Similarly the comparisons of various MMC sub topologies are shown in Table 1.2.Because of their distinctive advantages, mainly due to their excellent harmonic performance at higher voltages, independent control of active and reactive power in transmission lines, voltage control in wind farms, high modularity in their construction, simple scalability, usage of low cost filters, robust control schemes, and wider employment in HVDC, Modular multilevel converter (MMC) based Voltage Source Converters (VSCs) have become the most effective and high power quality alternative for the industry. Different diode clamped topologies and techniques are done by these authors. In detail, a single coupled inductor for a five-level diode-clamped PWM inverter [K. Hasegawa and H. Akagi, (2011)], five-level Z-source based is done by [F. Gaoet.al., (2010)]. PV based systems analysis on a single-phase transformer-less photovoltaic [PV) inverters for leakage current suppression review is done by [W. Li et.al. (2015, S. B. Kjaer et.al. (2005)]. Few review papers with a single current sensor technique for three-phase PWM-VS inverters [F. Blaabjerget.al., (1997)], resonant link topologies by [S. J. Finney et.al. (1993)], IGBT fault diagnostic and protection methods for power inverters [B. Lu and S. K. Sharma, (2009)] are proposed. For AC microgrids, review of power-sharing control strategies for islanding operation [H. Han et.al., (2016)], non-isolated high-voltage SSSC and VMC is studied in [F. L. Tofoli et.al., (2012)], [W. Sarjeant et.al., (1990)], electrostatic shielded induction motor [D. F. Busse et.al., (1997)], [J. Rodriguez et.al., (2007)], Madichetty, S et.al., (2015)].The losses are intermediate between half bridge and full bridge circuits [Nami et.al, (2015)].The losses for this circuit are more than that of a half bridge and less than that of a full bridge circuit [N. Thitichaiworakorn et.al. (2013 and H. Akagi, (2011)]. Various types of control strategies for MMC have been reported in the literature [Tu et.al., (2011), Ilves et.al., (2012), M. Sreedhar and D. Abhijit (2014), M. Hagiwara, H. Akagi (2009), Maharjan et.al., (2008), Tu et.al., (2010), L. Xu and V. G. Agelidis (2007), Sreedhar et.al., (2014a), Sreedhar et.al., (2014b), Zhang et.al., (2014), Li et.al., (2014), He et.al., (2015)]. The authors [Makoto Hagiwara, et al., (2010)] proposed a circulating current controller based on averaging and balancing control. The combination of averaging and balancing control enables the MMC to achieve suppression of circulating currents and voltage balancing without any external circuit [M. Hagiwara, H. Akagi, (2009)]. The proposed controller not only eliminates the circulating current but also improves the quality of converter ac output voltage [Tuet.al. (2010)]. The aforementioned circulating current controllers can yield better suppression results; however, they are confined to a three-phase system. In[Zhang et.al. (2014)], circulating current control is achieved by adopting two controllers are repetitive controller and a traditional PI controller. But due to the parallel arrangement of the repetitive controller and PI controller, a conflict arises between the PI controller design and repetitive controller design which challenges the performance of the system. [Binbin Li, et al, (2014)] proposed a control structure which consists of a repetitive controller paralleled with a P controller rather than with PI controller. In [Heet.al. (2015)], a different circulating current controller has been proposed. The two controllers viz.the repetitive controller and traditional PI controller are cascaded instead of paralleling them. Such a cascaded structure improves the transient response of the system. For proper operation of MMC, the submodule capacitor voltages must be maintained at their nominal values. A number of balancing schemes have been reported in literature [Sreedhar et.al., (2014, Hagiwara et.al., (2010), Adam et.al., (2010), Wang et.al., (2012), J. Qin and M. Saeedifard (2013), Ryan Blackmon (2013), M. Saeedifard and R. Iravani, (2010), Rohner et.al., (2010a), Rohner et.al., (2010b), KalleIlves et.al., (2015), Shengfang Fan et.al., (2015), Ilves et.al., (2014), M. Hagiwara and H. Akagi, (2011) and Wang et.al., (2013)]. The capacitor voltage balancing can be achieved by implementing a logical modulation algorithm [Solasetet.al. (2013)].The authors [J. Qin and M. Saeedifard, (2013)] proposed a general framework for the capacitor voltage balancing of an MMC. Authors have investigated different voltage balancing strategies at reduced switching frequency [J. Qin and M. Saeedifard, (2013)]. In [Ryan Blackmon (2013, M. Saeedifard and R. Iravani, (2010)], a general capacitor sorting algorithm based on the measured capacitor voltages and the direction of arm current has been proposed. In [Ilvesetet.al. (2014)], a predictive sorting algorithm which combines a low switching frequency with low capacitor ripple has been presented. Various control methods are proposed for MMC inverters, which is suitable for both voltage based and energy-based control methods, and includes voltage balancing between the upper and lower arms [Shengfang Fan et.al., (2015), K. Ilves et.al., (2014), M. Hagiwara and H. Akagi, (2011) and Wang et.al., (2013)].

5 APPLICATIONS OF MLC

The significance of shunt compensation, basic operating principles of STATCOM and comparison between STATCOM and SVC are presented in [Hingorani and N.G.Gyungi, (2010), Lee et.al. (2003), Akagi et.al. (2007), Mohammadi et.al. (2010), Mohammadi et.al. (2011), Yang et.al. (2011a), Yang et.al. (2011b) and Adam et.al. (2012)]. The MMC STATCOM configuration and the relative control strategies have been proposed in [Mohammadiet.al.(2010), Mohammadi et.al. (2011),Yang et.al. (2011a), Yang et.al.(2011b) and Adam et.al. (2012)]. The author [Hassan MohammadiPirouz, et al, (2011)] proposed a transformer-less STATCOM based on a modular multilevel converter. It introduces a new time-discrete appropriate current control algorithm and a phase-shifted carrier modulation strategy for fast compensation of the reactive power and harmonics, and also for the balancing of the three-phase source side currents. Authors also applied the proposed control algorithm to the extended modular multilevel converters [Mohammadiet.al. (2010), Mohammadi et.al. (2011)]. [Xiaofeng Yang, et al], proposed an M-STATCOM configuration which can not only be controlled in static var generating condition for reactive power compensation purpose but also is suitable for the comprehensive mitigation of all the power quality problems under the three-phase unbalanced power systems [Yang et.al., (2011a)]. Furthermore, the authors also presented the harmonic analysis of the DC capacitor voltage in M-STATCOM by using a quasi-harmonic elimination technique [Yang et.al. (2011b)].The author [Adam et.al. (2012)], the behavior of MMC-STATCOM has been assessed by subjecting the test system to symmetrical and unsymmetrical ac network faults. All the potential applications of the MMC are presented in [M. Bahrman and B. Johnson, (2007, Spichartz et.al., (2013), Hussennether et.al., (2012), Angquist et.al., (2011), Coppola et.al., (2012), Trintis et.al., (2011), Hillers and J. Biela, (2013), Pereira et.al., (2011), S. Du and J. Liu, (2013), Ghetti et.al., (2012) and Montesinos et.al., (2013)].Wind energy is one of the available non-conventional energy sources, which is clean and an infinite natural resource. Muller, Seul-kiKimand Lucian Mihet-pophad clearly explained the overview of wind turbine generation system and their operation is also discussed with the speed [Muller et.al. (2002), Seul-ki Kim and Eung –Sang Kim, (2007) and Lucian Mihet-popa and FredeBlaabjerg, (2004)]. The Variable speed wind energy systems have several advantages as compared to fixed speed wind energy systems such as yielding maximum power output, developing lower amount of mechanical stress, improving efficiency and power quality [Muller et.al. (2002)]. Muller Wind energy supply systems are among the most interesting, low cost, and environmental friendly for supply power to remote communities which are affluent in wind energy resource. The authors [R.C. Bansal et.al. (2005, Zhe Chen et.al. (2009 and M. Chinchilla et.al. (2006)] added their explanation with Muller's explanation for clear understanding of the operation of the wind turbine system with different ac generator that is induction generators and permanent magnet synchronous generators. The proposed technologies have multivariable speed wind turbine configurations that are used to generate high voltages when the demand increases. Hence to capture the voltage coming from these systems multi-winding transformer has to be implemented. Transformers generally have one single primary winding and one single secondary winding. Transformers which have more than one winding is known as Multiple Winding Transformers. Multiphase transformers are needed at the input of rectifiers. [Zhe Chen et.al. (2009)] explained the multi-wind energy systems. Authors [Carl Michael et.al. (2013),MeruguMysaiahet.al.(2006)] gave a detailed review ofmulti-winding transformers with phase conversion and connection configurations. The modeling of nine phase to three phase transformer for developed three wind energy systems [Somashekar et.al. (2013), Carl Michael et.al. (2013)], MeruguMysaiah et.al. (2012) and ShaikhMoinoddin et.al. (2012)]. Power electronics devices with a variable speed system are very important, where AC–DC converter is used to convert AC voltage with variable amplitude and frequency at the generator side to DC voltage at the DC-link voltage. The DC voltage is converted again to AC voltage with constant amplitude and frequency at the load side for electrical utilization. [Zhe Chen et.al. (2009) and Carrasco et.al. (2006)] presented the back-to-back power electronic converter section. The reliability of the variable speed wind energy systems can be improved significantly by using a permanent magnet synchronous generator [PMSG)]. M. Chinchilla had given a clear explanation of PMSG advantages and operation with wind turbine system [Chinchilla et.al. (2006)]. In back-to-back power, electronic converter scheme multilevel inverters are replaced in the place of voltage source inverters due to the advantages of low harmonic distortion. Multilevel power conversion has achieved wide acceptance for its capability of high-voltage [HV)] and high-efficiency operation. [FredeBlaabjerg and Ke Ma, (2006)] gave an explanation about the power electronic converters in the future applications, and the most popular advantages of the multilevel inverter compared with the traditional voltage source inverter are high-power-quality waveforms with lower distortion and a low blocking voltage by switching devices. [J.Rodriguezet.al. (2002 and Jing Zhao et.al. (2011)] had explained the multi-level converter advantages over the normal voltage source inverters.While cascade inverters are ideal where separate dc sources are available, Authors M. MalinowskiM. Glinka Poh Chiang Loh all had presented the clear explanation about the cascade multi-level inverters [Malinowski et.al., (2010, M. Glinka and R. Marquardt, (2010 and Poh Chiang Loh et.al., (2003)] and in capacitor clamped multi-level inverter when the number of levels increases then the number of storage capacitors will be increased so the operation of the inverter is complex, for these cases, a multilevel diode-clamped converter can best interface with the source of ac power and yet still meet the high-power and/or high-voltage requirements of the driven motor. [Jing Zhao et.al., (2011, Mohan M. Renge et.al., (2008), M. Marchesoni et.al., (2002), AlirezaNami et.al., (2011) and Z. Pan et.al., (2005)] presented a clear description about the diode-clamped multilevel inverters [Mohan M. Renge and Hiralal M. Suryawanshi , (2008), M. Marchesoni and P. Tenca , (2002), AlirezaNami et.al., (2011), Z. Pan et.al., (2005, Rosmadi Abdullah et.al., (2014) and AlirezaNami et.al., (2011)]. There are several modulation strategies to control the multilevel converters. The most commonly used is the multicarrier PWM technique. The advantage of multi-carrier PWM strategies is that it can be easily implemented to low voltage modules. The authors [Zhiguo Pan et.al. (2009, G. Konstantinou and V. Agelidis, (2009 and A. Hassanpooret.al., (2012)] explained the multi-carrier sinusoidal PWM technique and space vector PWM technique.These pulse width modulation (PWM) strategies applied to MLCs. It is subcategorized into four areas depends upon their practical applicability and dominant contribution such as phase disposition (PD) PWM, phase opposition disposition (POD)] PWM, alternate phase opposition disposition (APOD) PWM, carrier phase shifted (CPS) PWM. D.G.Holmes, J. Mei, R. Naderietc.all had explained the different types of multi-carrierPWM techniques [G.Holmes and B. P. McGrath, (2001), Mei et.al. (2014) and R. Naderi and A.Rahmati, (2008)]. The DFIG is getting more importance described by [Mohammadpour et.al., (2015), Frede Blaabjerg and Ke Ma, (2013)] than other class of generators because of partial rated converters analyzed by [T. D. Vrionis et.al, (2014)], maximum power extraction capability using different techniques as explained by [Ali M. Eltamaly, Hassan M. Farh, (2013), Yung-Tsai Weng and Yuan-Yih Hsu, (2015)], variable rotor speed operation with desired and faster control of reactive power by [Hua Geng, Cong Liu, Geng Yang, (2013)]. Due to low converter ratings, the cost incurred on converter devices will be low. Besides all the advantages, the DFIG is very sensitive to voltage dips caused by grid faults is proven using Hu et.al, (2011)].In direct and indirect methods are studied by [Mohammadi, J et.al, (2014)] and Baggu, M.M et.al, (2015)] for reactive power control schemes which aims to achieve actual reactive powers equal to the reference value. Extraction of maximum real power from DFIG using tip-speed ratio proposed by Jerson R.P. Vaz, David H. Wood, (2016)] and more famous perturbation and observation suggested by R. M. Linus and P. Damodharan, (2015)].

6 AUTOMATIC GENERATION CONTROL

[Chad Abbey, and GézaJoos, (2007, Lu et.al. (2009, C. Abbey and G. Joos, (2007)] all had explained about the energy storage equipment description for wind energy systems. Also, it can remove the fluctuating power from wind energy system and maximize the reliability of power supplied to the load. [B. S. Borowy and Z. M. Salameh, (1997), J. P. Barton and D. G. Infield, (2004 and LiyanQu, and Wei Qiao, (2011)] described the operation of energy storage system and control.A distributed AGC problem with high wind energy penetration has been investigated in [Variani, M.H.; Tomsovic, K., (2013)]. It has been applied through flatness based approach, where n-linear control systems can be decoupled. Various test cases are performed and results were promising. However, the steady state frequency deviation was reached aftera long interval of time, which may not be practically acceptable. The wind turbine system with Maximum Power Point Tracking [MPPT] algorithm has been modeled in [Le-Ren Chang-Chienet.al. (2014)]. A new model predictive control technique has been applied to AGC in [Ersdalet.al. (2016)] and found many fascinating results comparable to conventional controllers. A complete review of load frequency controlling mechanisms has been given by [H. Bevrani, (2009)]. It provides a comprehensive review about the AGC mechanism with various optimization techniques. A double-fed induction generator [DFIG)] with MPPT technique has been applied in [Chang-Chienet.al., (2011 and Chang-Chien et.al. (2008)]. Various optimization techniques have been applied in literature which includes Particle Swarm Optimization, Bacteria Foraging Optimization Techniques for multi area power generating systems can be found in [Nanda et.al., (2009), Nanda et.al., (2006), Nanda et.al., (2006), Xu et.al., (2016), Jin et.al., (2014, Suvire et.al., (2012), L.-R. Chang-Chien and Y.-C.Yin, (2009) and W. Yao and K. Y. Lee, (2011)].[Sreedhar Madichetty, A

Dasgupta et.al] proposed modular multi level converter integration to Three level AGC system stability performance is analyzed. O. I. Elgerd and C. Fosha(1970) proposed to use controllers in each area which are to be operated in response to the integral of the ACE for that area. M. S. Calovic (1972) proposed an approach to determine the optimum parameter values of conventional load frequency regulation of interconnected power systems and discussed the significance of sensitivity consideration in connection with the proposal made in K. Yamashita, and T. Taniguchi(1986),Z. M. Al-Hamouz, and Y. L. Abdel-Magid(1993). The detailed design of automatic generation and voltage control including the effect of coupling between AGC and Automatic Voltage Regulator (AVR) loops for steady the performance of power systems was presented by. Bengiamin, and W. Chan(1982).Considerable attention has been given by the researchers to consider the system nonlinearities A. Y. Sivaramakrishnan et.al.(1984). The destabilizing effect of governor dead band nonlinearity on the conventional AGC system was shown by S. C. Tripathyet al.(1984)and it is demonstrated that the governor dead band nonlinearity tends to produce continuous oscillations in the area frequency and tie line power transient response. R. P. Aggarwal and F. R. Bergseth (1968)proposed supplementary controller based on tie-line bias control strategy and demonstrated that ACEs can be regulated to zero effect. K. Yamashita and H. MiyagiIn (1989) proposed load-frequency self-tuning regulator for interconnected power systems with unknown deterministic load disturbances. The effect of Generation Rate Constraints (GRCs) was included in AGC studies by considering both continuous and discrete power system models D. Daset al. in (1990).Conventional control strategies for the AGC problem generally take the integral of the control error as the control signal. In the classical control methodologies, Bode and Nyquist diagrams, as well as root locus, are usually used to obtain the desired gain and phase margins. Thus, the design procedure of the classical methods for the AGC problem is straightforward, easy and amenable for practical implementation. However, the investigations conducted using these approaches reveal that they exhibit poor dynamic performance, especially in the presence of other destabilizing effects, such as parameter variations and nonlinearities. A decentralized proportional-plus-integral control design method for interconnected power systems was proposed by S. Mishra et al.(2011).

7 OPTIMIZATION TECHNIQUES

Artificial Intelligence (AI) techniques which provide a global optimum or nearly so, such as Expert Systems (ES), Artificial Neural Network (ANN), Fuzzy Logic (FL), Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Differential Evolution (DE), Gravitational Search Algorithm (GSA), Teaching Learning Based Optimization (TLBO) algorithm etc., have emerged in recent years in power systems as a compliment tool to mathematical approaches. ES is a knowledge-based or rule-based system, which uses the knowledge and interface procedure to solve problems that are difficult enough to require human expertise for their solution and has been applied in various areas of power systems, including: power system planning, alarm processing, fault diagnosis, power system protection, power system restoration and reactive power/voltage control. ANN has been mainly used for planning, capacitor placement/voltage control, economic dispatch/unit commitment, load forecasting, fault diagnosis, static and dynamic security assessment, hydro scheduling and analysis of power systems. Fuzzy logic uses human experiences and preferences via membership functions and fuzzy rules and so the system can be made understandable to a non-expert operator. Fuzzy logic can be used as a general methodology to incorporate knowledge, heuristics or theory into controllers and decision makers and has been applied mainly in voltage and reactive power control, load forecasting, fault diagnosis, power system protection/relaying, power system control and stability. DE, GSA,and TLBO techniques are promising algorithms for handling the optimization problems and are finding popularity within the research community as design tools and problem solvers because of their versatility and ability to optimize in complex multimodal search spaces applied to non-differentiable cost functions. ANN, FL,and ES suffer from the requirement of andexpert user in their design and implementation, a lack of the formal model theory and mathematical rigor and so are vulnerable to the expert's depth of knowledge in the problem definition. DE, GSA and TLBO techniques, by contrast, access deep knowledge of systems problem by well-established models and have much more potential in power systems. In view of the above, modern heuristic optimization techniques likeDE, GSA,and TLBO techniques have been employed in the present thesis for tuning the control parameters for AGC.L. R. Chang-Chienet al. (2011),S. Pothiyaet al. (2006),S. Pandaet al. (2008),H. Gozde, and M. C. Taplamaciogluet al. (2011),B. Mohantyet al. (2014),U. K. Routet al. (2013),R. K. Sahuet al. (2013),R. K. Sahuet al. (2014),Z. Sun(2014).

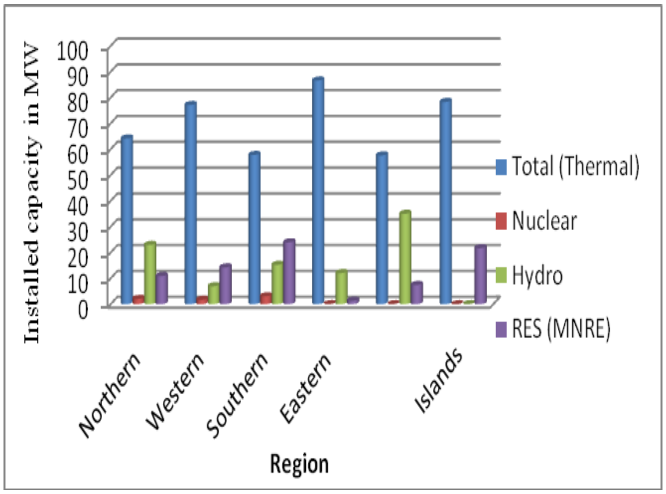

***Fig. 1** Installation capacity histogram in india*

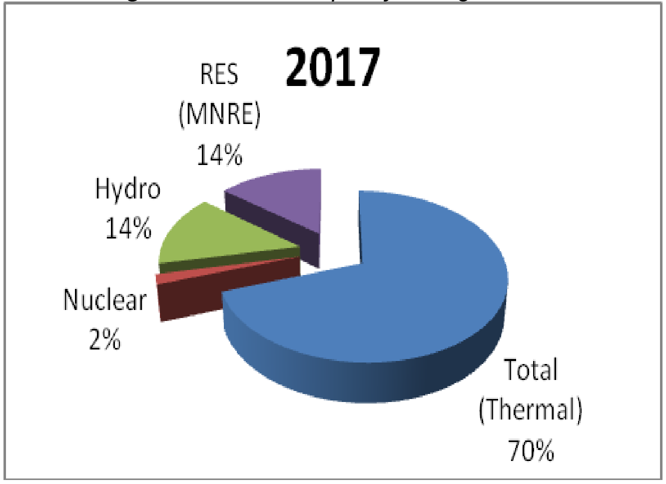

Fig. 2 *Installation capacity percentage in india*

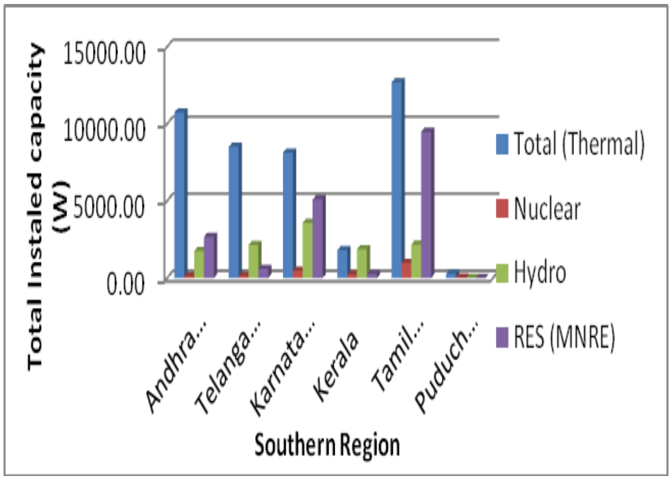

Fig. *3 Installation capacity histogram in south india*

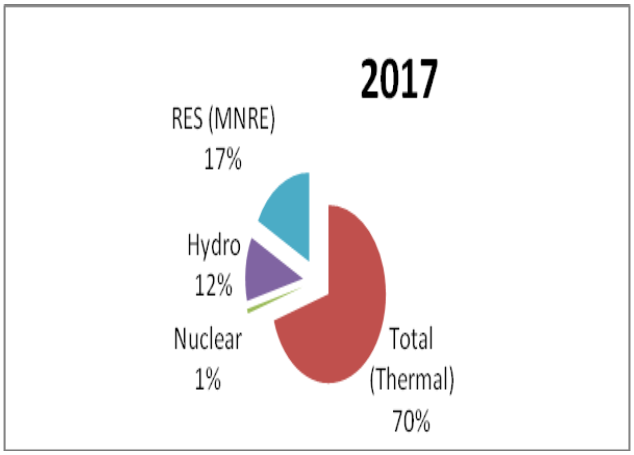

Fig. 4 *Installation capacity percentage in south india*

Topologies	MMC	GMCSI	RVMLI	GMLI	CMCI	CCMLI	NPCMLI
Sources	2	1	$3(\frac{m-1}{2})$	$3(\frac{m(m+1)}{2}-1)$	$\frac{3m-1}{2}$	3(m-1)	3(m-1)
Diodes	12(m-1)	$6(\frac{m-1}{2})$	3(3(m-1))	$6(\frac{m(m+1)}{2}-1)$	6(m-1)	6(m-1)	6(m-1)
Switches	12(m-1)	$6(\frac{m-1}{2})$	3(3(m-1))	$6(\frac{m(m+1)}{2}-1)$	6(m-1)	6(m-1)	6(m-1)
Clamp diodes	0	0	0	0	0	0	3(m-1)(m-2)
Clamp cap	0	0	0	0	0	$\frac{3(m-1)(m-2)}{2}$	0
Inductors	2	$\frac{m-3}{2}(\frac{m-3}{2}+1)$	0	0	0	0	0
Transformer	0	0	3	0	0	0	0

Table.1.1 *Comparative analysis*

In this above fig.1 to fig.4 the total renewable power generation is provided based on the southern countries as well as state wise and similarly fig.5 multilevel inverter comparative analysis provided.

CONCLUSION

Improve the performance of modular multi level converter by reducing THD, voltage imbalance and circulating currents. By applying MMC as a potential converter as a STATCOM for reactive power and harmonic compensation. Increase the efficacy of MMC in DFIG based wind energy systems for power control as well as STATCOM. Improve power system stability of wind energy integrated power system using optimization techniques.

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