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Research on Single-Phase Grid Connected PV Systems

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ABSTRACT: ***The demand for renewable vitality based power production has been increased because of many reasons such as to reduce the level of carbon emission, to minimize the consumption of non-renewable energy source and to maintain the environment pollution free. Among the available renewable resources such as hydroelectric, wind, solar, biomass and ocean, solar energy has gained much attention by researchers in the recent decades all over the world. The abundant availability and increasing global warming threat urge the researchers to develop an efficient solar energy conversion system. This survey purposefully intended to elaborate the significance of solar power system. This system consists of set of a PV array to transform sunlight into electrical power (dc). Then the converter and inverter circuits are utilized to produce stable ac power. To overcome the challenges like non-uniform insolation, temperature and partial shading effects, various artificial intelligence and optimization techniques have evolved to maximize the power output from the panel. Even with recent technological breakthrough the efficiency is still less than 20%.***

This survey presents the several existing solar energy conversion systems with its challenges and mitigation methods under different environmental conditions for improving the power output.

I.INTRODUCTION

The exploitation of conventional energy sources coupled with alarming depletion rate of pollution and global warming urges the necessity to look into renewable sources for future power generation without harnessing the environment. The Sun is the only renewable and immense everlasting and ecofriendly energy resource. The light energy from the sun is directly converted into electrical energy using photovoltaic (PV) devices. Solar cell is the basic component of PV module. The modules are cross coupled (series and parallel) depending on the power output needed. The efficiency is determined from the tangibility and techniques used to from modules and it is about 12-29% based on semiconductor material used. As the panels are placed in open air, their performance is also limited. The insolation is same at all time and it varies with partial shading effect in real time. The optimum power point has to be tracked to derive highest power from the panel. To accomplish this, MPPT (maximum power point tracking) is necessary to maintain the maximum power (maximum voltage and current) from the module. Based on operational requirement solar power is classified as grid tied and stand alone. The power output (AC/DC) from the PV systems can also be interconnected with energy storage system. The grid connected PV system is generally associated in parallel with the grid through inverter. The inverter converts the DC output power from PV into AC with required power quality (IEEE 1547 standard) and fed to the grid. The basic requirement of inverter is that it must stop functioning if the grid is fault or under service. For this purpose, a bi-directional switch or contactor is utilized as interface between PV system and grid. Apart from power inversion, there are some essential functions such as optimum power point tracing, grid integration and isolation, and online monitoring to provide overall enhancement of solar power system for efficient power transfer.

II.PREVIOUS WORKS

1. Tyler J. Formica *et al* [2017] discussed the difficulties in present PV frameworks with an attention on the ROI as the key unwavering bottlenecks quality. In this paper, the different warranty structures provided by firms, the challenges in ROI, viability, and candidate claims to solve these concerning PV system. Yet, the problems on hardware components are not able to clarify as it not able to investigate before assembling the setup. The hardware failures may also induce shutdown of programming side.

2. Sandeep Anand*et al* [2014] proposed transformerless current backup inverters for PV systems. An inversion system to suppress the ground leakage currents without isolation transformer and boosting the efficiency at minimum cost compared to conventional system is proposed. The significant unbalances in the capacitor voltage are minimized using a null sequence dependent controller.

3. Albert Alexander Stonier *et al* [2018] proposed a smart issue tolerance structure for PV encouraged fell staggered inverter. This examination proposed a proficient power electronics interface whose exchanging activity is invigorated by the savvy controller. This deficiency discovery requires checking gadgets for the individual arrays, which makes the framework progressively unpredictable and costly

4. Andreas Spring *et al* [2016] proposed a work that concentrates on grid influenced by responsive intensity of PV inverter with unity power factor. In this paper, the impact of sustainable power source frameworks on the dispersed network and the new situations that emerge because of the more PV frameworks are examined. The usage pace of the links and transformers are expanded.

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This implies the genuine use rates are higher than the reproduced ones

5. M. Nawaz *et al* [2017] developed a prototype model with control strategy for solar fed resonant inverter in domestic heating. In this paper, the intensity methods did not find the system response in advance. Hence, a feed-forward sample prediction control is suggested. Overshoot occurs in higher order framework if predictive length is very small.

6. Mohamed A. Awadallah*et al* [2016] presented a paper to describe the effect of PV panels on distribution transformers. The simulation and experimental setup were developed to study the PV effects. It was shown that the lifetime of transformer was decreased by 8.3% under the worst case condition (reverse active power flow at full load condition).

7.AdityaShekhar*et al* [2018] proposed an energy efficient harvesting of solar energy installed at the PV bike path. This paper attempts to research the possibility of utilizing roadways transportation land for solar power generation. But, the capacity to produce valuable vitality from sun's illumination is restricted by the area limitation because of its scattered nature.

8. Seyed Ali Arefifar*et al* [2017] implemented an improved PV panel setup using different optimization methods.An elaborate investigation to design PV panel is exhibited to improve the potential advantages of sun power plants at low expenses. However, there are still issues remaining for solar power plant designers to reflect on for improvements.

9. F. Karbakhsh*et al* [2017] presented a scalar control of 2-switch flyback converter without current sensor for tracking MPPT. This paper minimizes the high-voltage transient issue that exists in single switch flyback converters during turning off of switch. A low budget microcontroller was more suitable to execute the developed control method.

10. Rajiv K. Varma, *et al* [2017] implemented sub synchronous resonance elimination of PV panel using a new control strategy integrated with STATCOM (PV-STATCOM). A novel quick strategy is proposed for reconnecting the sun oriented homestead while keeping the PV-STATCOM SSR damping capacity enacted. Systems ought to be advanced for remunerating the PV sun powered ranches monetarily for this significant assistance of SSR moderation.

11. Sumit K. *et al* [2017] proposed a novel asymmetric MLI for PV application of variable insolation. A PV panel of 9.4 kW is installed at the roof-top. If the voltage is dropped, the cover will be additionally expanded and there won't be any inaccessible vectors within the space-vector plane.

12. Namwon Kim *et al* [2018] proposed architecture to integrate PV and battery via series inverter with partial dc power optimization. This integration utilizes the partial processing of dc power optimization for adaptable power control by controlling the T-hub reimbursement current. The battery current is also changed unless the universal optimizer regulates enough.

13. YoashLevron*et al* [2016] discussedan efficient single phase inverter for PV system to control variable frequency peak current Controller. An economical design that functions with a low inductance to achieve 99.5% of efficiency and 99.15% of weighted efficiency is discussed. The controller monitors the maximum inductance current.

14. Rajan Kumar *et al* [2017] proposed a PV supplied brushless dc machine driving hydro pump. Our control strategy needs no current sensor. Additional control is not needed for controlling motor speed. A small torque ripple occurs due to the commutation of phase current and sensor-less function of the motor.

15. M. J. E. Alam*et al* [2014] proposed PV inverter for controlling reactive power via multi-mode control strategy in DG system. This sort of control strategy provides necessary VAr support during power generated from PV and also in the absence of PV power during night time and in different operating mode at the time of passing cloud. Nonetheless, proposing any punishment plan or appropriations depending on VAr would be a mind boggling task and would require subordinate nitty gritty examinations.

16. M. Flota*et al* [2016] proposed a passive controlling of PV inverters to correct power factor during night time. A double-loop controller is designed for this purpose**.**

17. Mathieu D'amours*et al* [2018] proposed solar power management based mobile network. A low cost cross breed PV-matrix framework for a solitary base station is proposed. Base station 1 has been quite often in the rest mode with the exception when the two traffic tops from 10:00 to 12:00 and 16:00 to 18:00. Base station 2 has been quite often on with the exception when the pinnacle time frames at 16:00 where the traffic is taken up by base station 1.

18. Qingzeng Yan *et al* [2016] proposed an enhanced feed forward grid voltage control of highly powered 3 phase PV inverters using simple repetitive predictor. The LCL based feed forward strategy for single phase grid tied up inverter is proposed to deal with the deformed grid voltages. But, in advanced control frameworks, i_d, i_q, e_d, e_q, and u_{dc} are not the genuine esteems but rather the deliberate (tested) values from the power circuit; vd and vq are not the yield potentials of the inverter but rather the reference voltages applied to the PWM.

19. Yam P. Siwakoti*et al* [2017] proposed inverters without transformer for single phase PV system. This research unveils 3 new single-phase inverters without transformers for a matrix-associated PV system. However, the two-stage charging-discharging process (V_{in} to C1 and C1 to C2) enhances the power component quantity and system losses.

III.RESULTS & DISCUSSIONS

20. Rajiv K. Varma*et al* [2015] proposed a novel PV system based STATCOM to increase the power limit of grid. In this paper, a new idea for utilizing solar inverter as STATCOM is developed to improve the transmission power limit of the DG system. This controller utilizes inverter alone to get the optimum power point operation.

21. YoashLevron*et al* [2016] proposed a new grid voltage control mechanism for distortion-free and high bandwidth output from single phase PV inverters. The trade off is analyzed to propose a control strategy that requires no additional hardware. The two constraints of grid voltage loop such as high bandwidth and less harmonic distortion may contradict if bus capacitance is low.

22. Prashant Jain *et al* [2018] proposed a hybrid PLL to control master-slave configuration of centralized inverter in the high power PV plant.Theproposed PLL control is compared with conventional methods in MATLAB simulation environment and executed in hardware using TMS320F2812 Controller. The Integrator is reset only during the start of the PLL.

23. Moumita Das *et al* [2018] developed a new high performance (high gain and efficiency) stand alone PV framework with converters and inverters power stages. The proposed system requires optimum power point power tracking of the PV resource depending on the load requirement and eliminates the expensive circuits for managing dump loads. The efficiency of about 94% can be reached with this method.

24. AshuVerma*et al* [2018] proposed a new PV inversion control to maximize the penetration of wind power. An attempt to increase the possible utilization of solar, wind, etc is presented in this paper. The voltage range violation during both peak SPVG and peak burden may produce difficulty issues with increased RES combination, particularly in dispersed system.

25. Wenchao LIU *et al* [2015] proposed modelling and analysis of series voltage compensator to reduce the dc-link capacitor in grid connected PV system. This replaces the well known electrolytic capacitance with long life power film capacitance to extend the system lifecycle. The drawback of this method is the high voltage stress of components in the auxiliary circuits is as high as the DC-link voltage.

26. Hamid R. Teymour*et al* [2014] presented an advanced control strategy to integrate 3-level NPC inverter of PV system with battery storage. The effectiveness of the proposed method is examined from the simulation under several scenarios like battery charging and discharging with various levels of solar insolation. To investigate the ac-side behaviour, the accuracy of the generated voltage must be examined.

27. Luan Viet Nguyen *et al* [2014] developed a prototype of dispersed control of a guilt tolerance modulator MLI for photovoltaic system. In this paper, a (2N + 1) level particular staggered inverter is actualized utilizing H-bridge for making a framework tie associating the managed DC yield of each buck–support converter. The switching patterns of the modules never produce opposite polarity voltage being tied up with the grid.

28. Ui-Min Choi, *et al* [2015] proposed control mechanism of two capacitor voltage for tracking of maximum power in PV system using neutral point clamped inverter. In this system, to enhance the performance of MPPT by connecting the DC-DC converters to each string called multiple string inverters. The DC-tie potential is decreased from 700V to 650V.

29. SoumyaShubhra *et al* [2014] proposed Current-Feed Switching Inverters (CFSIs). The proposed CFSI integrates the high gain attribute of ZSI and less passive quantity of SBI. The Current-feed dc to dc converter provides higher gain without utmost duty cycle.

30. EmilianoDall'Anese*et al* [2015] proposed highly efficient residential PV inverters under different insolation. This paper discusses about the additional services required in PV system which deals with forecast errors.However, a computationally bearable convex optimization is achieved by installing additional regularization circuits and semi definite relaxation techniques.

31.SushilSilwal*et al* [2018] discussed about the transient responses of PV inverters. Explains the particular yet general types of grid tied PV inverter (single-phase or single-stage with the current control approach) exhibits reverse inertia. However, their aggregation at higher DERs penetration could raise stability problems during grid disturbances.

32. ManoranjanSahoo*et al* [2015] proposed 3-level LC switch based voltage boosted NPC inverter. It has the ability to increase the input DC voltage and provide the necessary 3-level output in a single stage unlike conventional NPC VSI. The efficiency is a little low because of additional switches and diodes which introduces switching losses.

33. SubhenduDutta*et al* [2018] proposed a buck-boost based grid tied PV inverters to increase the power output from PV panels under different loading situations. A grid tied transformerless PV inverter operates in buck or boost mode in order to extract most of the power from two serially linked panels under different environmental scenarios. The measured peak efficiency and the European efficiency (_euro) are found to be 97.65% and97.02%.

S.NO.	REFERENCES	PURPOSES	PERFORMANCES METRICS/ PARAMETERS	REMARKS
1	Tyler J. Formica *et al*[2017]	Discussed the reliability issues with the present solar PV system and essentially the reliable bottleneck with a concentration on ROI.	Changing frequency is 50kHz for the SiC inverters.	The warranty of inverter is less than 15 yrs, meanwhile the PV panel and mounting equipments are last for 25 years.

2	Sandeep Anand*et al*[2014]	Developed a Transformerless grid fed Current Source Inverters for PV Framework to reduce high ground leakage current into the grid.	-Grid phase voltages -DC-link voltages -AC filter inductor -AC filter capacitor -sampling frequency	2 back blocking electronics switches utilized as the 4th leg of CSI reduces the undesired current flow through CL filter
3	Albert Alexander Stonier *et al*[2018]	Proposed a smart criticize tolerance framework for PV cascaded multi level inverter.	Vdc=330V that is much more than the square root of the grid potential 325V	It can provide power to the load even during the guilt partial shaded conditions.
4	Andreas Spring *et al*[2016]	proposed responsive power control of PV inverter to achieve near unity power factor.	power factor= cosϕ	The loss in grid power is minimized by a capacitive responsive power flow (reactive power compensation).
5	M. Nawaz *et al*[2017]	presented a predictive control strategy for PV fed series-resonant inverters in domestic heating	The space vector model is utilized to create the prediction control scheme. Some parameters: reference load current, *A* actual load current, *A* control signal , *V* incremental control signal, *V*	Maintain a fixed DC potential at the info of the inverters which is essential when series resonance load is available at the yield.
6	Mohamed A. Awadallah*et al*[2016]	Presented a paper to study the effect of PV panels on distribution transformers.	THD	Fixed firing angle of the inverters keep the dc-tie potential constant while maximum power is absorbed through duty ratio control of the boost converters.
7	AdityaShekhar*et al*[2018]	measured the execution of the integrated PV system.	Power(W) Area(m^2) Voc(V) Ioc(A) Vmpp(V) Impp(A)	cost saving was obtained in transportation of hydro, and further, the yearly energy output of 770kWh was achieved for every 6m² of road area by combining solar-thermal.
8	Seyed Ali Arefifar*et al*[2017]	implemented an improved solar powered PV plant using multi model analysis optimization.	Inverter parameter: Prated (kW) Vmin (V) Vrated (V) Vmax (V) Cost ($) PV Module Parameter : SPV (m2) TCIsc (%/C) TCVoc (%/C) TCPmax (%/C) Ns Type Cost ($)	Long-Term Memory (LTM) is used to leave the nearby maximum and to divert the look into the unexpected region of the solution locale.

9	F. Karbakhsh*et al*[2017]	Presented two-switch flyback inverters based on sensor-less MPPT and scalar control for economical solar pumps.	"Perturb and observe (P&O)" and "hill-climbing" algorithms. Parameters for Motor Specifications, Inverter specifications and PV Panel Specifications is presented	This paper utilize the storing system as an alternative to save PV vitality as a PE in water storage system to be utilized based on the requirement.
10	Rajiv K. Varma, *et al*[2017]	Implemented SSR mitigating method with a novel controlling of PV - STATCOM.	Phase-locked loop (PLL) block. generator rotor speed stabilized at t = 10 sec.	The PV-STATCOM SSR damping control using generator rotor velocity as the control sign is created in d-q edge of reference
11	Sumit K. *et al*[2017]	proposed an asymmetric MLI for PV appliances with different insolation.	-voltage VHM > voltage VLM i.e. 14 times VLA MPP voltage @ 1sun and 25°C Range of operating voltage -Main bridge voltage range -Main LDN voltage range -Auxiliary bridge voltage -Auxiliary LDN voltage -RMS grid voltage line to line (3-Φ)	Presented a unique asymmetrical multi level inverter of nominal voltage ratio 14:7:2:1. THD=1.7%
12	Namwon Kim *et al*[2018]	proposed PV integrated battery connected series inverter for continuous integration with partial-power Optimizer.	DC bus voltage is regulated as 207V	Iit handled 2.5kW PV output power and 1.0kW battery output power with 1.4kW rated power.
13	YoashLevron*et al*[2016]	Discussedhighly efficient single phase PV inverter for a variable frequency peak current controller.	AC voltage of 220 Vrms @ 60 Hz, mean AC power of 300 W, grid voltage of 425 V, and an inductor of 300 µH built on a PQ 26/20 core.	Used silicon devices and a small inductor of 360µH to achieve a weighted efficiency of 99.15 %.
14	Rajan Kumar *et al*[2017]	proposed single phase PV fed brushless dc motor driven water pump.	initial duty ratio is set to 0.5	The motor-pump speed is smoothly controlled by the duty ratio at each irradiance level. Therefore, successful operation is validated under dynamic condition.
15	M. J. E. Alam*et al*[2014]	Proposed a multivariate control method for reactive power control by PV inverters in DG network.	A 570-second window from the real PV output profile used in the dynamic simulation is used for the long term quasi-steady-state analysis	Can reduce voltage ramp, and enhance the voltage profile even though the Wide Potential change in the irradiation in cloud passing time and also in the absence of PV yield in the night.
16	Mathieu D'amour*set al*[2017]	proposed solar fed energy-management in mobile network.	Metrics such as Length of period t, Installation cost for solar panels, The amount of electrical energy produced by the solar panels at base station j during period t, Minimum battery capacity, Energy required by test point i in period t.	The unit cost of solar power is smaller than that of the grid.

17	Qingzeng Yan *et al*[2018]	proposed an enhanced feed forward method for high power three-phase grid-connected inverter based on the simple repetitive predictors	GP I (*z*) PI controller *GC* (*z*) Control delay GPW M (*z*) ZOH characteristic of PWM GP L (*z*) Plant GOR (*z*) Open-loop simplified repetitive predictor *GB* (*z*) second-order Butterworth low-pass filter	Grid-voltage feedforward strategy is improved to 250-kVA
18	Yam P. Siwakoti*et al*[2017]	proposed a common-ground-based transformerless inverters for single phase PV systems.	Input Voltage Vin DC-link voltage, Vdc Output voltage vac Power Rating PO Carrier frequency (*fs*) Line frequency Flying Capacitor CFC Lf and Cf Switches Diode D Load	Topology has ≤ 2 switches in the load current path during active states.
19	Rajiv K. Varma*et al*[2015]	Proposed a novel Controller for PV Solar Farm as STATCOM (PV-STATCOM) for increasing grid power Transmission Limits During Night and Day.	Power output from the generator ,Pg is 731 MW.	Improve power transmission limits which would have otherwise required expensive additional equipment such as, series/shunt capacitors, or separate Flexible AC Transmission System (FACTS) Controllers
20	YoashLevron*et al*[2016]	Proposed a grid voltage control for distortion-free and high bandwidth based single phase PV inverters.	Designed for a 300 W PV panel. output voltage of 220 V rms and a 60 Hz frequency	eliminates the distortion due to a notch in its transfer function, and it is quick enough to obtain highly stable dynamic response that maintains the bus voltage well regulated during transients

IV.CONCLUSION

The research done by various scholars in the field of energy model, PV topologies and advanced specializations with their problems and solving methods are highlighted. The emerging technologies on PV are analyzed concentrating on economical and technical perspectives to justify the need of renewable energy. The energy flow optimization model for PV installation is required to balance supply and demand. The survey on hybrid PV-thermal system is restricted and need to be concentrated further. The large scale deployment PV system is limited by the financial and technical barriers. By analyzing number of control techniques, a comparative study is made.The conventional techniques are evaluated in detail to get an insight for further development. With the progress of artificial intelligence, the researchers are encouraged to research on continuous enhancement of solar power system.

REFERENCE

1. G. Auer et al., ‘‘energy efficiency analysis of the reference systems, areas of improvements and target breakdown,’’ hialeah, fl, usa, cordis, tech. Rep. Infso-ict-247733 earth, 2012.
2. H. Alsharif, ‘‘a solar energy solution for sustainable third generation mobile networks,’’ energies, vol. 10, no. 8, p. 429, mar. 2017.
3. j. Wu, y. Zhang, m. Zukerman, and e. K. N. Yung, ‘‘energy-efficient base-stations sleep-mode techniques in green cellular networks: a survey,’’ ieeecommun. Surveys tuts., vol. 17, no. 2, pp. 803–826, 2nd quart., 2015.
4. Budzisz et al., ‘‘dynamic resource provisioning for energy efficiency in wireless access networks: a survey and an outlook,’’ ieeecommun. Surveys tuts., vol. 16, no. 4, pp. 2259–2285, 4th quart., 2014.
5. N. Piovesan, A. F. Gambin, M. Miozzo, M. Rossi, and P. Dini, ‘‘energy sustainable paradigms and methods for future mobile networks: a survey,’’ comput. Commun., vol. 119, pp. 101–117, apr. 2018.
6. A. Bousia, E. Kartsakli, Alonso, and C. Verikoukis, ‘‘energy efficient base station maximization switch off scheme for lte-advanced,’’ in proc. Ieee 17th int. Workshop comput. Aided modeling design commun.Links netw. (camad), barcelona, spain, sep. 2012, pp. 256–260.
7. A. Bousia, a. Antonopoulos, l. Alonso, and c. Verikoukis, ‘‘‘green’ distance-aware base station sleeping algorithm in lte-advanced,’’ in proc. Ieee int. Conf. Commun. (icc), jun. 2012, pp. 1347–1351.

8. A. Bousia, E. Kartsakli, A. Antonopoulos, l. Alonso, and C. Verikoukis, ‘‘game-theoretic infrastructure sharing in multioperator cellular networks,’’ ieee trans. Veh. Technol., vol. 65, no. 5, pp. 3326–3341, may 2016.
9. A. Bousia, E. Kartsakli, A. Antonopoulos, l. Alonso, and C. Verikoukis, ‘‘multiobjective auction-based switching-off scheme in heterogeneous networks: to bid or not to bid?’’ ieee trans. Veh. Technol., vol. 65, no. 11, pp. 9168–9180, nov. 2016.
10. C. Jia and T. J. Lim, ‘‘resource partitioning and user association with sleep-mode base stations in heterogeneous cellular networks,’’ ieee trans. Wireless commun., vol. 14, no. 7, pp. 3780–3793, jul. 2015.
11. S. Cai, l. Xiao, H. Yang, J. Wang, and S. Zhou, ‘‘a cross-layer optimization of the joint macro- and picocell deployment with sleep mode for green communications,’’ in proc. 22nd wireless opt. Commun. Conf., may 2013, pp. 225–230

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