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# A ROBUST CONTROL ALGORITHM BASED GRID-CONNECTED SOLAR PV-POWERED ELECTRIC VEHICLE BATTERY SYSTEM

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**ABSTRACT:**

In today's era the biggest problem World is facing is energy crises and we know that fossil fuels are available in very limited amount. Also there overuse in last 30-40 years has reduced them further. So, now to meet our energy demands the only option we are left is to utilize the Renewable resources of energy that is available in abundance. There are various sources of renewable energy like wind, sun and geothermal but most cost effective among them is Solar Energy. Solar energy can not only meet our existing energy demands but can also provide us clean and cheap energy. Solar Panels once installed can give energy for several years without having any maintenance cost. Solar photovoltaic systems are such systems which are used for harnessing solar energy but we since the earth is rotating around the sun due to which solar energy in existing Solar panels is available only for a limited time throughout the day. To overcome this problem solar trackers are used. Authors in this study have tried to explore the possibility of solar trackers and their cost effectiveness in solar photovoltaic.

***Keywords: PV array, MPPT, RES, Grid tied system.***

## INTRODUCTION

Energy resources and their utilization is a prominent issue all over the world. As the conventional natural resources of energy are exhaustible in nature and also there is exponential rise in demand for the power, the man is forced to explore the new sources of energy.

***PV array*** :

The solar energy is available abundant in nature. Also it is free of cost. Hence, there lies a challenge to extract this energy effectively and efficiently. Major advantages of solar cells over conventional methods of power system are:

(i) Solar cells convert the solar radiation directly into electricity using photovoltaic effect without going through a thermal process.

(ii) Solar cells are reliable, modular, durable and generally maintenance free and therefore suitable for isolated and remote places.

(iii) Solar cells are quiet and have an expected life time of 20 or more years.

(iv) Solar cells can be located at the place of use and hence no distribution network is required. Like other devices, solar cells also suffer from disadvantages, such as: (i) The conversion efficiency of solar cells is limited to 17-20%. Since solar intensity is generally low, large areas of solar cell modules are required to generate sufficient useful power. (ii) The present costs of solar cells are comparatively high, making them economically uncompetitive with other conventional power generation methods. (iii) Solar energy is intermittent and solar cells produce electricity only when sun shines and in proportion to solar intensity, hence some kind of electric storage is required making the whole system more costly. However in large installations, the electricity generated by solar cells can be fed directly into the electric grid system. Grid-tied PV systems are very promising. In many countries like Germany, Japan, USA, Korea etc national solar roof programs have been launched successfully. A grid connected solar system requires an effective Inverter circuit which injects harmonic free currents into the grid system. The current waveform injected by PV source into the grid contains ripple as it is the integral of the applied voltage. The magnitude of the ripple is a function of interconnecting inductor, switching frequency and the number of discrete input voltage levels. The number of levels that exists in a power circuit topology can reduce output current ripple. The ripple is less when the levels are more because the voltage differential placed across the inductor is reduced. With more number of levels, switching frequency can be reduced so also the filter effect is significantly reduced. Hence obvious choice is to use multilevel inverters to integrate PV system to the grid. However the complexity in the control of this type of converters increases as number of levels increases.

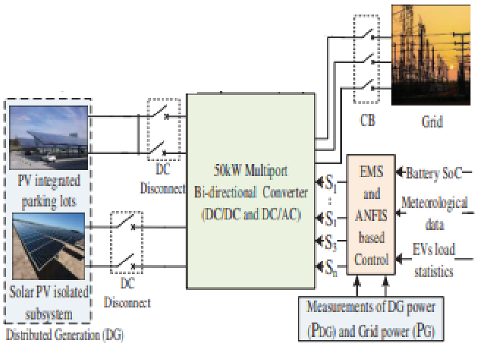



**Fig.1. Block diagram**

**BI-DIRECTIONAL CONVERTER**

Bidirectional converters are now primarily utilized in electric vehicles. Another name for it is a DC-DC half-bridge converter. The resultant circuit, a bidirectional converter, performs both boost and buck operations when the buck and boost converters are coupled in ant parallel across one another. A bidirectional converter functions both ways. A Half Bridge DC-DC converter is another name for it.

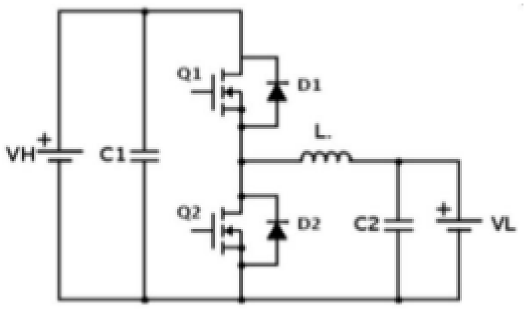



Fig. 2 Bi Directional converter circuit

Now a days Bidirectional converter is mainly used in electric The resultant circuit, a bidirectional converter, performs both boost and buck operations when the buck and boost converters are coupled in anti parallel across one another. A bidirectional converter functions both ways. A Half-Bridge DC-DC converter is another name for it. The resultant circuit, a bidirectional converter, performs both boost and buck operations when the buck and boost converters are coupled in anti parallel across one another. The functionality of a bidirectional converter is reciprocal. Depending on how Mosfets Q1 and Q2 are turned on, the circuit described above can operate in either buck mode or boost mode. Due to the fact that the anti-parallel diodes D1 and D2 function as freewheeling diodes, the circuit can adjust the voltage supplied across the switches Q1 and Q2 in parallel as needed. To ensure that the inductor current flows continuously, the minimum inductor size is set at an inductor value that is 25% bigger than the minimum inductor value.To cut switching losses, lower switch costs, and boost converter efficiency, switching frequency selection is crucial. Boost Mode, Mode 1: Switch Q2 and diode D1 start conducting in this mode based on duty cycle, but switches Q1 and D2 are always off. Additionally, it is possible to divide this mode of operation into two intervals dependent on the conductivity of the switch Q1 and the diode D2. Buck Mode, Mode 2: In this mode, switch Q2 and diode D1 are always off, whereas switch Q1 and diode D2 begin to conduct as the duty cycle increases. The conductivity of the switch Q2 and the diode D1 can also be used to divide this mode into two intervals.

## VOLTAGE SOURCE CONVERTER

During the day time the voltage source converter works as inverter which converts DC to AC to the grid. Because during day time power supplied to the battery is by solar panel. 3 E3S Web of Conferences 391, 01041 (2023) https://doi.org/10.1051/e3sconf/2023391 01041 ICMED-ICMPC 2023 During night solar power is not active so the power is generated by the grid so the converter acts as rectifier which converts AC to DC. In order to store the excess power during times when there is less need for it, a battery with a low voltage rating is selected. The grid's energy management and control strategies with regard to the PV battery system are presented. The voltage source converter is operated using a recursive digital adaptive filter-based control approach, which automatically detects when to run in rectifier mode and inverter mode.

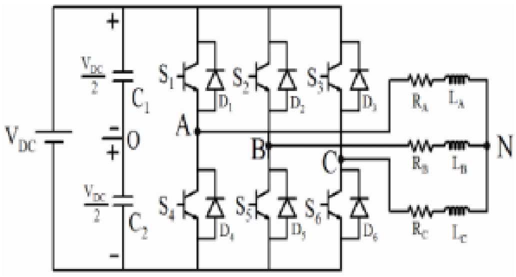



Fig. 3 Voltage Source Converter Circuit

## ANFIS control strategy

The ANFIS incorporates the optimal features of artificial neural network systems (ANNs) with a FIS to realize the power flow information based on the training dataset. The proposed FIS guides a rules base, attributes of input/output, membership functions (MFs) of input/output, and decision variables related to desired single-value output. The ANFIS model is designed by the FIS whose MFs are customized either through an algorithm (least-square type or backpropagation) for variable input/output data sets [49, 50]. The architecture of the proposed ANFIS is depicted in Figure 4. The ANFIS architecture comprises five distinct layers with number of inputs as error (e1 ) and change in error (de1 ) that are associated with layer 1. The output of layer 5 is f , which provides the summation of all incoming signals associated with the adaptive node. In Figure 4, the adaptive nodes are referred to by a square and a fixed node is referred to by a circle. All layers have a distinct function that is suitable for obtaining input/output data sets. Some layers have a similar number of nodes, with analogous functions. The adaptive network is usually trained through a hybrid-based learning algorithm grouping of least-squares type (hybrid learning algorithm) and backpropagation type (gradient-descent (GD) algorithm). Thus, it allows the FIS to learn by the data set and is intended at corresponding the proposed ANFIS output with the trained data set [51]. To get the desired outputs and the error rates (d⁄de) execute the proposed system for all iterations. Further, the training dataset is exported to FIS controller for test output response. The rule base can be formulated by the function of each layer:

## WORKING METHODOLOGY

The shift from conventional fossil-based resources several solar power resources are available in like geothermal energy, wind energy, bio-energy as well as solar power. Solar energy is among the most significant attempting to solve the issue of worldwide heating in addition to is a source of fresh energy. it may also assist in provided that an alternative so sensational fossil-based energy resources in addition to as a cost-effective source of energy besides. Consumption is actually tined enclosed by photovoltaic and thermal energy, making use of solar panels as well as solar collectors, respectively. there will be numerous applications given that photovoltaic thermal sporting goods. At low-temperature ranges, space conditioning and domestic hot water by-product tend to be the overall most typical use. at medium temperature ranges, solar temperature reduction, desalinization furthermore postindustrial process high temperature tend to purpose which can deed alternative energy. at high-temperature stages, concentrating solar power plants are going to be sensational programs that catch the overall most attention of worldwide. furthermore, for very high-temperature ranges up to 1000 °c, processes specified hydrogen production in addition to methanol-reforming can use sun irradiation [1]. Accompanied by all of the anticipated res, solar energy (SPV) systems experience has taken major toleration in addition to investment funds wondering its around the world potential in addition to its tot potent to set off-world power very little time. so, within the coming years, SPV techniques will experience the highest participation in energy production among all of the res. moreover, the SPV module is really a dc source, something that often sets off powerful dc whose amplitude is dependent on the availability containing daytime sunlight as well as the temperature at standard test condition (STC) consisting of 25°c along with Solar Constant of1 kW/m2 [2]. Significantly, the SPV module indicates the overall unidirectional characteristic. Hence, the power output of the SPV module is usually withstanding broadens along with atmospheric temperature along with room temperature. Also, the SPV generator indicates only one MPPT under full exposure to sunlight. On this context, the main objective consisting of utilizing the MPPT tracking method is to exactly track and distinguish the overall global MPPT, as well as thereby gathering the overall maximum power. Additionally, MPPT techniques are compared in order to as an organised set of rules that is normally needed in order to operate on the system with efficiency. This signified, multiple MPPT tracking algorithms have already been published in the scientific literature, which is, actually, the heterogeneous ways in order to match the source and load impedances [3]. The correct geographical orientation of such devices would possibly raise the light intensity of the incident solar radiation flux, and that depends upon azimuth and inclination angles.

Generally, most of researchers have agreed that the solar trackers increase the overall efficiency of a PV panels and CSP systems. However, clear indications should be provided indicating where, when and how maximum power efficiency can be achieved. Consistent with the aforesaid, many problems have been identified and each of these problems has been addressed individually including miss-tracking and failure of the control systems and/or the electronics of the trackers among others. More importantly, the studies confirmed that most of the problems limiting the overall efficiency of both the fixed and tracking PV systems are similar. However, few problems are uniquely related to solar tracking systems such as those cited above. Moreover, different types of solar trackers present different advantages and challenges when considering their performance and efficiency, and studies have shown that tracking the sun position significantly increases the efficiency especially in cloudy days. For this reason, using ST could be the ideal way to boost up the efficiency and performance of both the PV panels and the CSP systems irrespective of what the weather looks like.

## RESULTS EXPLANATIONS

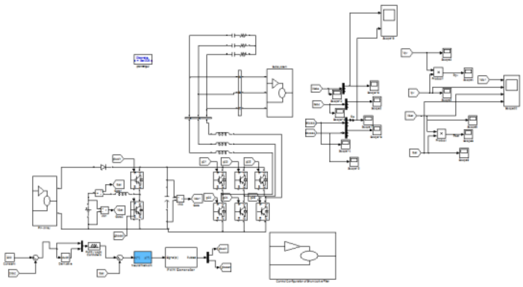


**Fig.2. Proposed system**

A prototype for a 2.62 kW of solar power is developed in the laboratory, to authenticate the practicality of the system. The developed prototype in the laboratory is shown in below Fig. The solar PV power is generated from solar PV simulator. In order to sense the signals vsab, vsbc, Vdc, isa, isb, iLa, iLb, Ievbt and Ipv, current sensors (LA-55P) and voltage sensors (LV-25) based on Hall effect are utilized. The control of proposed system is implemented by loading the algorithm into a real-time controller OPAL-R Thaving 20 μs sampling time. The opto-couplers are used to give optical isolation between output pulses of OPAL-RT and the power circuit. A digital storage oscilloscope and power analyzer are utilized for recording the test results. The estimated parameters for experimental prototype of PV-EVB system are indicated in Appendix. The control technique's dynamic response is analyzed under variation in solar insulation and load.

Based on ideas of energy collection and the sun tracking techniques, ST can be divided into two categories viz. active types and passive types. These two major types of STS can, in turn, be divided into many other different categories based on a number of parameters such as the number of axes, the tracking directions and methods among others. Inactive STS, single/double-tracking modes are used. Each of these systems presents their own advantages; the double-axis STS provide better power stratifications while single axis processes are cheaper and less complex [18]. the comparison between the energy returns of both tracking methods (single and double) with the fixed traditional PV systems open that the sun tracking system's energy return is always higher than that of the traditional fixed PV panels. Although the double-axis tracking systems give better energy return when compared to other types of systems; the literature indicates that they suffer from high energy losses during their operation due to auxiliary units and moving joints. Serious problems occur when any of the sensors is shaded up since this phenomenon can cause an asymmetrical control signal leading to the malfunction of the entire system.

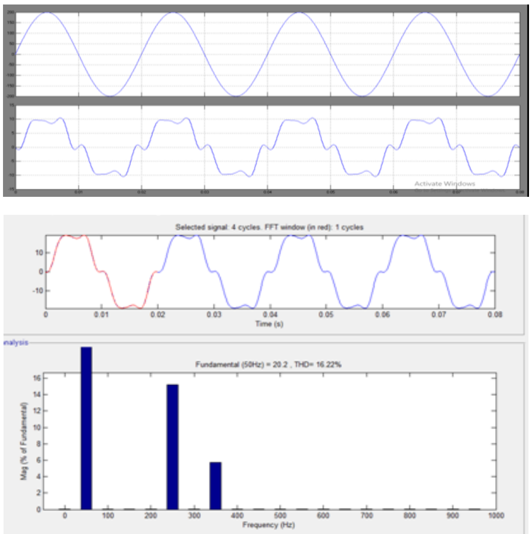
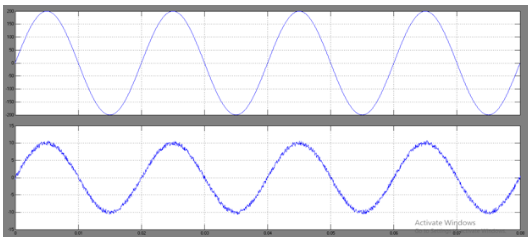


**Fig.3. Steady-state response of system.**

**Dynamic behavior of proposed system at load variation**

The response of system during load perturbation is presented in Figs. show that Isa is decreased and increased under rise and reduction in iLa, correspondingly. The magnitudes of vsab are unaffected. There is no change in solar PV power on change in load, therefore, no variation is observed in ivsca.

The PWM signals are produced from the *dq* components at the last phase of the control algorithm. At this point, the *abc* coordinate frame is used for transforming the components. After, a triangular wave with a 6050-Hz signal is used for comparative analysis and generation of the inverter switching frequency. The inverter switches are converted to produce an SPWM signal [29]. The SPWM controls the pulse width of the inverter insulated-gate bipolar transistors (IGBTs) in order to deliver sine-wave-shaped AC voltages. A control signal (sinusoidal) is produced to modulate the duty cycles of IGBTs (sinusoidal), which in turns helps to obtain the frequency and voltage of the inverter at desired levels.



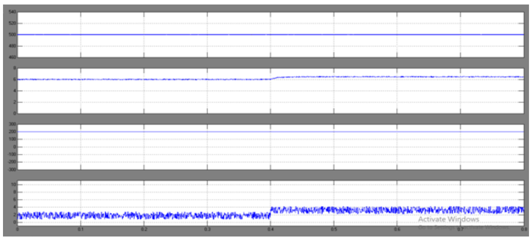


**Fig.4. Dynamic response of system**

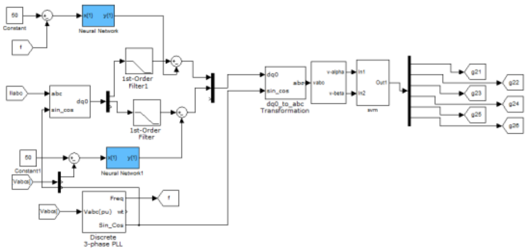



**Fig.5** *System configuration and controllers schemes*

several studies have been executed over the past few years. Various researchers characterized the harmonics effects of a grid-tied PV system along with contemplation of a few nonlinear loads. In [8], the authors proposed that the DC link voltage regulation is optimized to match the reference current resolution to mitigate large harmonics. However, the comprehensive and systematic analysis of the formation process of the harmonic in the PV inverter output current is missing. In [9], the adaptive current regulation is proposed to reduce harmonics in a grid-connected PV system. The algorithm is trained using a recurrent neural network

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(RNN) to determine the three-phase reference currents for the generation of pulse width modulation (PWM) signals to drive the grid interfacing inverter to enhance the power quality of the system. The proposed system was modeled and simulated using MATLAB Simulink software.

The authors of [13] proposed two innovative fault-tolerant methods based on fuzzy logic and model predictive control to investigate fault effects owing to common power-loss in PV arrays in the presence of microgrid uncertainty and disturbance. In a hybrid microgrid benchmark, the efficacy of the proposed system is proven and compared under actual fault situations. The suggested approach also considers the sudden couplings and disconnection of dynamic loads, which is a significant difficulty. The techniques do not need a specific collection of fault situations. The suggested approach for imprecise gain scheduling was performed flawlessly. However, the technique is unsuitable for severe power-loss failures. As a result, the suggested model predictive control approach is designed to tolerate and accept more severe failures than its competitors.

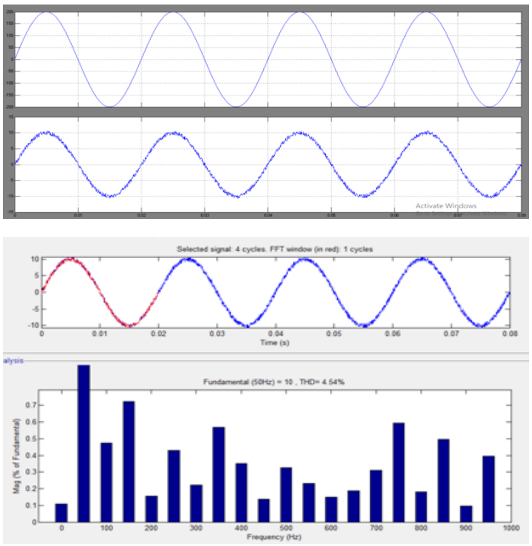


**Fig. 6** *Steady-state behaviour of system*

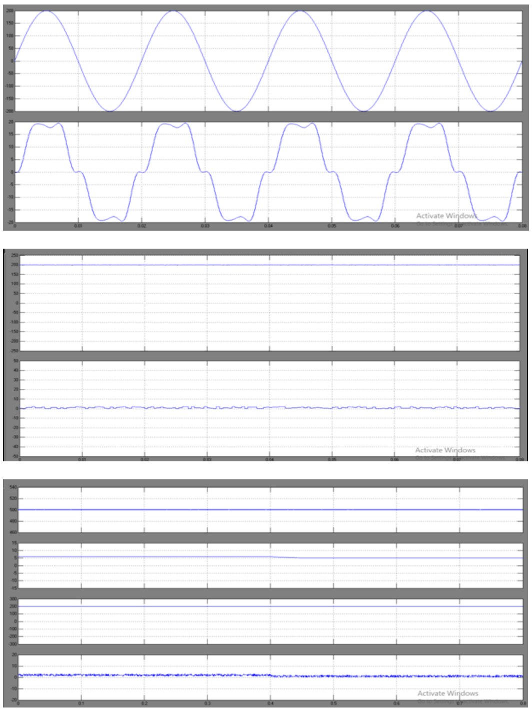

**Fig.7. Dynamic response of system**

## CONCLUSION

The performance of the adaptive recursive digital filter control of solar PV powered EVB grid intertied system has been demonstrated. This system provides active power to the grid, ensures power quality improvement at PCC. The EVB stores additional power, when the load demand is less, whereas it dissipates when the demand of the load is high. The EVB integrated through bidirectional DC–DC converter has attained MPPT voltage at DC link. The buck–boost converter has been used to maintain charging and discharging operation for the battery of vehicle. The recursive filter technique has produced no phase delay between the fundamental current constituent and the load current. Experimental results have validated unity power factor operation, elimination of harmonics of grid currents, thus maintaining the grid current THD.

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