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Power Quality Improvement in Hybrid Power Generation for Distribution System Using PWM Technique

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ABSTRACT: Power quality is one of a major constraint in power system transmission and distribution. This project gives an idea on effective control of PV/Wind hybrid power generation scheme for standalone applications. This system consists of PV/wind hybrid energy system, boost dc-dc converter, a three phase DC to AC converter, PWM controller and non linear load. The boost converter can supply power to the load depending on the source of availability. A synthesized AC output voltage is produced by appropriately controlling the switches using PWM technique using average power control to control active and reactive power fed to the load. This technique reduces the harmonics and improves peak voltage. From this control method, the quality of output current is improved and also controls the power flow. Simultaneously the consumer thinks about getting more quality in generated power and to minimize the power tariff. To meet both ends we go for hybrid systems. While implementing Hybrid power system, it may consist of several issues in protection, synchronization, power quality, etc. This paper describes the consequences of power quality issues and also the methods to reduce power quality issues using MATLAB simulation.

KEYWORDS: PV Power quality, Hybrid power, Solar PV, Wind energy, PWM Techniques, SPWM, Multi-Pulse PWM, Harmonics, dc-dc converter.

I. INTRODUCTION

Power quality, the electrical networks are the grid's ability to supply a cleaned stable power supply. High power quality ideally creates a perfect power supply that is available, as a pure noise-free, sinusoidal wave shape, and is always within voltage and frequency tolerances. It can also be considered as the term which is used to define the power of electricity and it used to drive the electrical load and ability to drive function used in electric power. With the improper strength of power, an electrical load or device may additionally malfunction and device will be damaged before time period. In power system there are many causes for making power quality poor. There are various meanings for power quality as per different people[1]. The electric power industry comprises electricity generation (AC power), electric power transmission and ultimately electric power distribution to an electricity meter located at the premises of the end user of the electric power. The electricity then moves through the wiring system of the end user until it reaches the load. The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised. The quality of power is affected due to variation in voltage and current or frequency on the end side of the device. Voltage sag problem is the major issue in power quality. The primary cause of power quality problem occurs due to uses of highly solid state switching device, nonlinear load and electronically switched loads in equipment. In highly solid state switching device, the power quality issue and the problem have considered. In the case of non-sinusoidal current flow in the transmission line and distribution system, prevalent power semiconductor

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switches are used [2]. Some examples of problems that occur due to power quality problems are: Automatic Resets, Data Errors, Equipment Failure, Circuit Board Failure, Memory Loss, Power Supply Problems, UPS Alarms, Software Corruption, and Overheating of electrical distribution systems. These types of power quality issues can be reduced and may be terminated by using PWM techniques. In this project, we can reduce the harmonics produced due the presence of power quality issues in the distribution system by using various PWM techniques. In this project electricity is generated by using Hybrid power system. The hybrid power system used in this project consists of solar PV and Wind turbine. The main objective of this project is to reduce the power quality issues and maintain the THD (total harmonic distortion) within the IEEE standards. The IEEE standard level for the harmonics is below 5%. So, in this project, the THD is maintained within the IEEE standards and Power Quality issues are reduced by using various PWM techniques.

II. LITERATURE SURVEY

- i. Shalini Bajpai - Power Quality Improvement Using Ac To Ac PWM Converter for Distribution Line International Journal of Computational Engineering Research, Vol. 03, Issue 7, July 2013.

Drawbacks

- DVR and STATCOM used for voltage compensation in this paper.
- Voltage sag only be corrected.

- ii. Divyarani Mandloi, Nidhi Khurpia, "Power Quality Improvement using Power Converter and Different PWM Techniques" International Journal of Contemporary Technology and management November 2017.

Drawbacks

- THD level is not maintained within IEEE

- iii. Thangaraj R, Angelin Sreeja, "Power Quality Improvement in Grid Connected Hybrid System "International Journal of Recent Trends in Engineering and Research, October 2016

Drawbacks

- ANN Controller is used in this paper
- General gating pulse is given to the inverter for hybrid system.

III. MPPT TECHNIQUES

In the hybrid power system, Solar PV and Wind turbine are used for generating power. In solar PV system, abrupt variations occur during the day. Under these conditions, the maximum power point of the PV array changes continuously; consequently, the PV system's operation point must change to maximize the energy produced. There are many MPPT methods available, the most widely used techniques are described in the following sessions.

- a) Constant voltage method
- b) Incremental Conductance method.
- c) Perturb and Observe method

III. a. CONSTANT VOLTAGE METHOD

The constant voltage algorithm is one of the oldest MPPT control methods. The operating point of the PV array is each n^{th} step, kept near the MPPT by regulating the array voltage and matching it to a fixed reference voltage V_{REF} equal to the V_{MPP} of the characteristics PV module or another pre-validated best voltage value.

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The CV method assumes that insulation and temperature variations on the array are insignificant on the V_{MPP} , and that the constant reference voltage V_{REF} is an adequate approximation of the real MPP. Therefore, the operating point is never exactly at the MPP. The CV method needs the measurement of the PV array voltage V_{PV} in order to setup the Duty cycle of the Boost converter. So, the CV method is not that much effective and that is why it is usually combined together with other MPPT techniques.

III. b. INCREMENTAL CONDUCTANCE METHOD

Another type of MPPT control method is the incremental conductance method. This method offers good performance under rapidly changing atmosphere conditions. The algorithm is based on the observation of conductance on the PV array while solar energy is generated. The MPP can be tracked by comparing the instantaneous conductance I_{PV}/V_{PV} to the incremental conductance. Once the MPP has been reached, the operation of the PV array is maintained at this point and the perturbation is stopped unless a change in conductance is noted. Also in this method, the MPP is tracked by matching the PV array impedance with effective impedance of the converter. But the incremental conductance method is not as much as effective when compared with P&O method, because P&O method is the simplest method for Maximum power tracking in Solar Photovoltaic system with simplest algorithm.

III. c. PERTURB AND OBSERVE METHOD (P&O)

In this method the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called the perturb and observe method and is most common, although this method can result in oscillations of power output. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

The P&O algorithms operate by periodically perturbing (i.e. incrementing or decrementing) the array terminologies and combining the PV output power with that of the previous perturbation cycle.

In the P&O algorithm the array terminal voltage is perturbed every MPPT cycle; therefore when the MPP is reached, the output power oscillates around the maximum. This is especially true in constant or slowly-varying atmospheric conditions but also under rapidly-changing atmospheric conditions.

If the PV array operating voltage changes and power increases, the control system moves the PV array operating point in that direction; otherwise the operating point is moved in the opposite direction. In the next perturbation cycle the algorithm continues in the same way.

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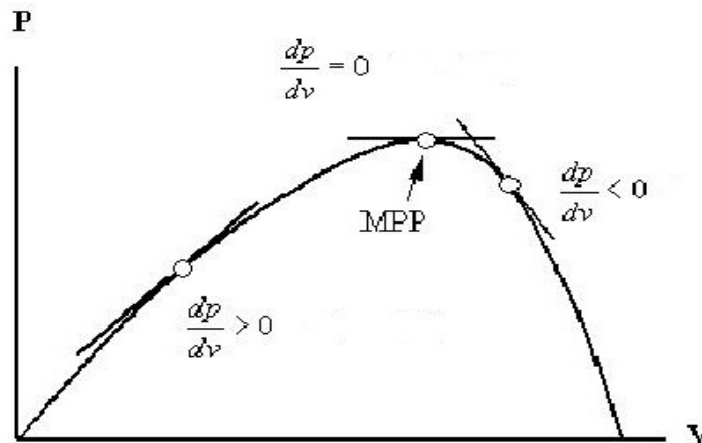


Figure 1 Sign of the dP/dV at different positions

III. c.1. FLOW CHART FOR P&O ALGORITHM

The algorithm is developed in such a manner that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller is used to move the operating point of the module to that particular voltage level. It is observed that there is some power loss due to this perturbation and it also fails to track the power under fast varying atmospheric conditions. But still this algorithm is very popular because of its simplicity.

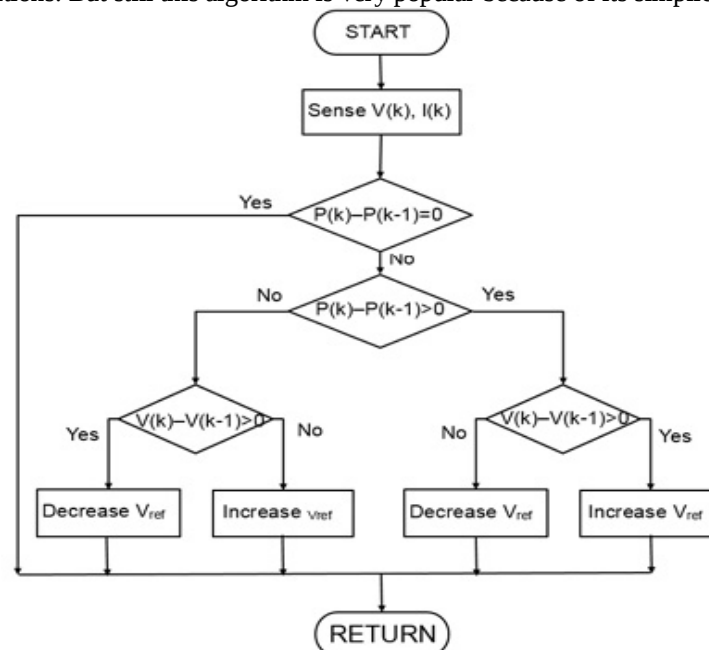


Figure 2 P&O algorithm flowchart

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IV. PWM TECHNIQUES

The type of PWM techniques which used in this project is :

- Sinusoidal Pulse width modulation
- Multi-Pulse PWM

IV. a. SINUSOIDAL PULSE WIDTH MODULATION

In this method of modulation, several pulses per half cycle are used as in the case of multiple pulse width modulation. Instead of maintaining the width of all pulses the same as in the case of multiple pulse width modulation, the width of each pulse is varied proportional to the amplitude of a sine-wave evaluated at the centre of the same pulse. By comparing a sinusoidal reference signal with a triangular carrier wave of frequency, f_c , the gating signals are generated. The frequency of the reference signal, f_r , determines the inverter output frequency, f_0 , and its peak amplitude, V_r . The number of pulses per half cycle depends on the carrier frequency.

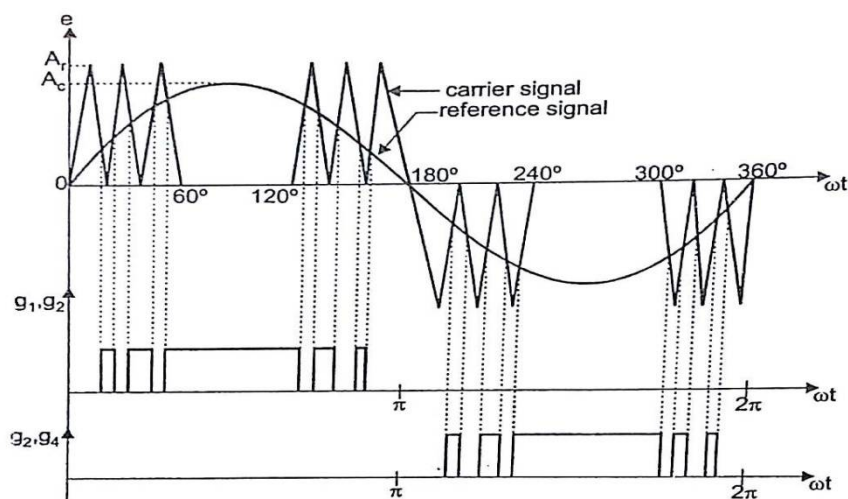


Figure 3 Sinusoidal pulse width modulation

By varying the modulation index MI, the RMS output voltage can be varied. It can be observed that, the area of each pulse corresponds approximately to the area under the sine-wave between the adjacent midpoints of off periods on the gating signals. If P_m is the width of the m^{th} pulse, the RMS output voltage.

In simple source inverter, during each cycle, as per requirement, the switches can be turned OFF and ON. Due to this switching condition, the output is the square wave. For getting pure sine wave form, we have to increase the number of switching timing as per cycle. In sinusoidal PWM technique waveform is produced due to comparing the given modulated waveform through triangular waveform at high frequency. In comparing both waveforms the resulting output voltage is negative or positive it depends on whether the voltage of the signal is smaller or larger than carrier waveform. In this technique considers each modulating voltages as separate identity and each modulating voltages are compared to the carrier signal. It is unable to fully utilize the available DC supply voltage. It has more Total harmonic distortion value. It compares high frequency triangular carrier with sinusoidal reference signals. It is not used for more advanced vector control implementation.

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IV. b. MULTI-PULSE WIDTH MODULATION

[3] In Multiple PWM method, there is multiple output pulse generated during half cycle period and all pulses width are equal. The gating signals are produced due to comparing the amplitude of message or control signal with the amplitude of carrier or reference signal. In Multi PWM technique frequency of the message signal sets the output frequency (f_0) and carrier frequency (f_c). The number of pulses is calculated in half cycle during this expression: $P = \frac{f_c}{f_0}$. Figure-2 shows the output sinusoidal wave generator using multiple PWM technique.

V. SIMULATION & RESULTS

The simulation for the hybrid model with sinusoidal pulse width modulation is done and given below is the simulation diagram for the hybrid power system with sinusoidal pwm technique. The positive or negative dc bus voltage is applied at the output. Over the period of one triangle wave, the average voltage applied to the load is proportional to the amplitude of the signal during this period. The total harmonic distortion is not affected by the PWM process. The harmonic components are automatically filtered due to inductances in the ac system.

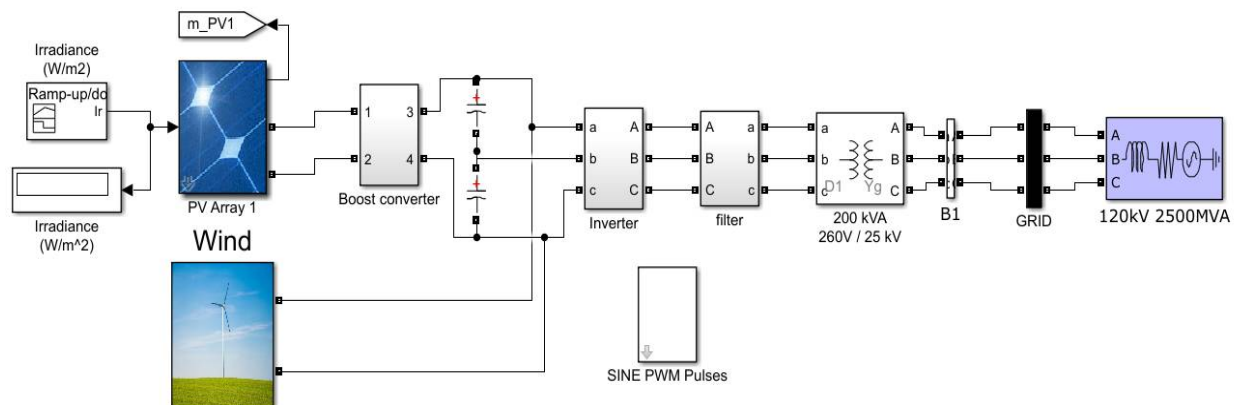


Figure 4 Hybrid model with SINE PWM

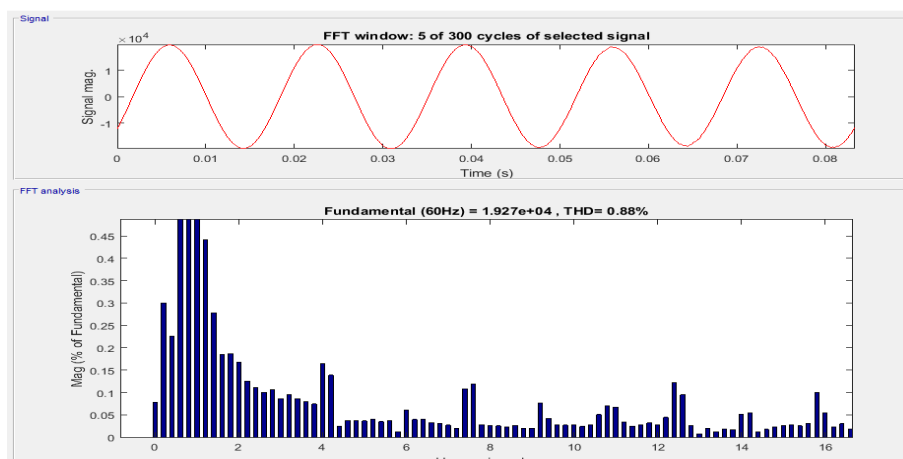


Figure 5 Harmonic analysis of voltage on Sinusoidal Pulse Modulation

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The harmonic content can be reduced by using several pulses in each halfcycle of output voltage. The generation of gating signals for turning on and off transistors is shown in Figure (3). The gating signals are produced by comparing reference signal with triangular carrier wave. The frequency of the reference signal sets the output frequency (f_o) and carrier frequency (f_c) determine the number of pulses per half cycle, p : The simulink hybrid model with multi pulse width modulation.

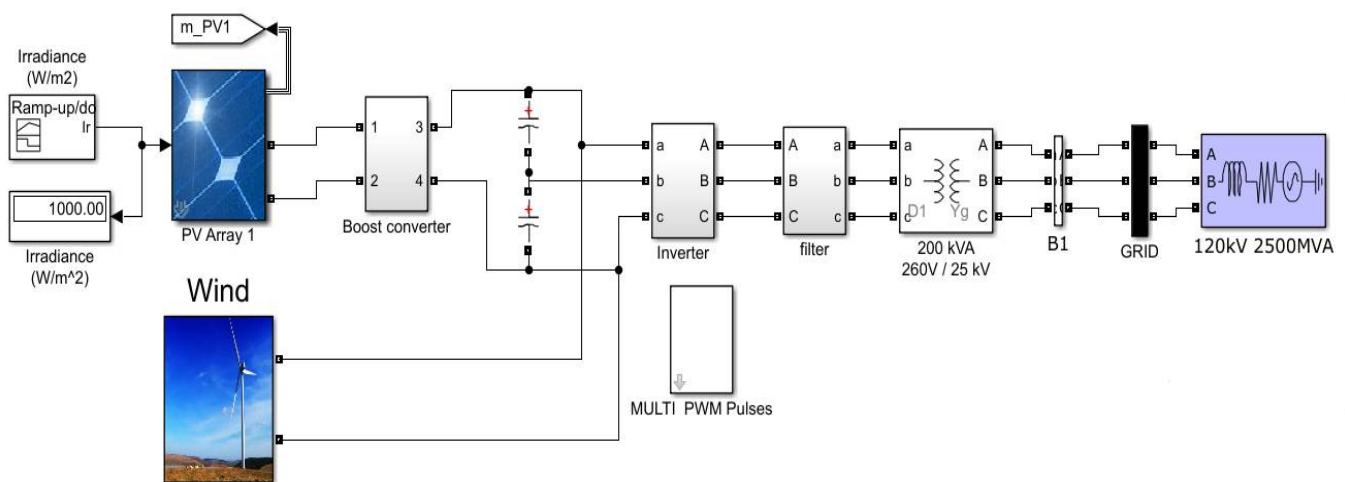


Figure 6 Hybrid model with Multi-Pulse Width Modulation

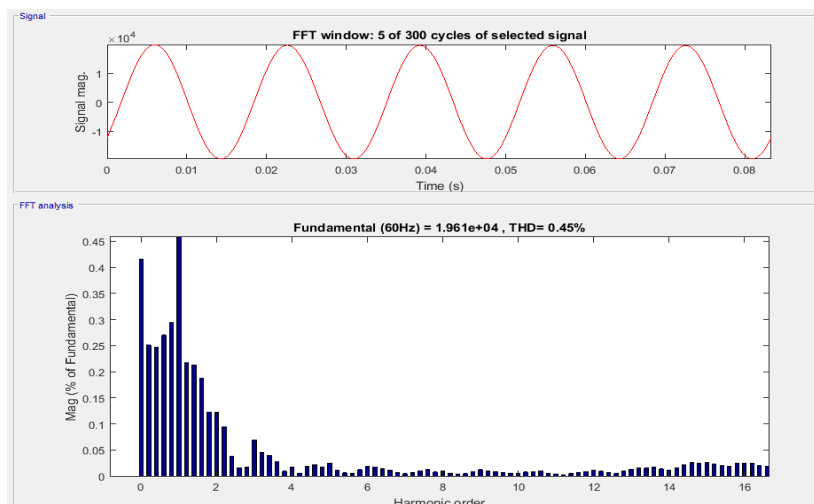


Figure 7 Harmonic analysis of voltage on Multi - Pulse Modulation

In this paper, the presence of harmonic distortion in higher values are reduced to a very low level by using two PWM techniques – Sinusoidal and Multi-Pulse Width modulation. The fundamental harmonic analysis for sinusoidal and multi pulse width modulation are done and the results are given below.

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PWM Technique	Frequency (Hz)	THD (%)
Sinusoidal-PWM	60	0.88
Multi-PWM	60	0.45

Table 1 Total harmonic distortion value

VI. CONCLUSION

This paper gives a wide background of power quality in terms of its issues, definitions, causes and effects. A comparison between sinusoidal and multi-pulse width modulation is done in this paper. Harmonics are one of the major problems occurred in power transmission system. By using this comparison, an analysis can be done on the values of harmonics present in both the types of power generation by using hybrid power system with the two types of PWM techniques. In the hybrid power generation system, MPPT technique is used for solar PV for tracking the maximum Power generated. Another source is the wind energy system, which is used to produce electricity by using wind turbines. The main reason for choosing the solar and wind for hybrid power generation is to reduce the use of non-renewable energy sources, and to encourage the generation of electricity by using renewable energy sources. Also, by choosing the renewable energy resources, the cost of energy production can be reduced to a very low amount.

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