A STAND ALONE SOLAR SYSTEM BASED VFVDC WITH FULL BRIDGE INVERTER

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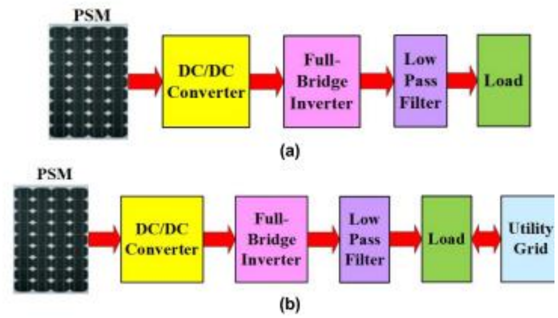
ABSTRACT: The maximum power point tracking (MPPT) and DC (direct current) to AC (alternating current) full-bridge inverter (FBI) control technologies were investigated in this study in relation to the independent solar power system (ISPS). This study integrated the suggested optimal FBI control approach to the ISPS using the perturb and observe (P&O) algorithm based on the output voltage control strategy. Frequency and duty cycle could be adjusted in the suggested variable frequency and variable duty cycle (VFVDC) optimum FBI control technique. The sinusoidal pulse width modulation (SPWM) and the suggested VFVDC control approach were contrasted. The operating frequency of FBI was 10 kHz when the output was at a low voltage level. On the other hand, the operational frequency was 1 kHz when the FBI provided a high voltage level output. By reducing the switching loss of the FBI's four power MOSFETs, this control enhanced low-harmonic performance. This study compared the suggested control strategy and SPWM control method using MATLAB in order to better validate the system under investigation. The simulation results confirmed that the low pass filter (LPF) volume was decreased after the suggested control strategy's total harmonic distortion (THD) of 1.02% outperformed the SPWM control method's THD of 3.23%. Lastly, measurement and verification were done using the real ISPS. Because of its low harmonic level and ability to function steadily and efficiently, the suggested control approach may be used to the real filament of electrical needs.

KEYWORDS: THD, VFVDC, P&O, MOSFETS, LPF.

I.INTRODUCTION: Electric power is becoming more and more necessary due to modern technology and industrial expansion. Coal, oil, natural gas, and other conventional power generation methods have been in use for many years [1]–[3]. The carbon dioxide and dioxide flow produced during the power generating process have led to environmental pollution and the greenhouse effect, despite the low cost of power generation using these technologies [4], [5]. Although nuclear power generating is less expensive, it produces radioactive waste in the process of producing electricity. In addition to being difficult to manage and possibly polluting the environment, the location of this radioactive waste has a significant impact on the living conditions and psychological well-being of the local population. Thankfully, scientists and technical specialists are persistently working to create and explore various clean and renewable energy sources, including geothermal, hydro, and solar electricity. Electricity produced by renewable energy sources has become a part of people's daily life in recent years. Examples include electric water heaters [8], street lighting [7], electric vehicle charging stations [6], and electricity for industrial and agricultural uses [9, 10]. The development of renewable energy enhances people's quality of life by lowering air pollution and the greenhouse impact while also reducing the radioactive waste produced by nuclear power generation. This study concentrated on solar power generation and the creation of an independent solar power system (ISPS) in order to further the growth of renewable energy. Nevertheless, there are still certain issues with solar power technology that need to be fixed. First of all, photovoltaic solar modules (PSM) generate power inefficiently due to their susceptibility to temperature and sunlight [11]. Second, for a PSM, the power electronic converters change the source of direct current (DC) into the source of alternating current (AC). To prevent compromising the load side equipment's service life, a high-quality output AC power is required [12]. Temperature and sunlight have an impact on PSM output power. As a result, numerous researchers have created various maximum power point tracking (MPPT) strategies to boost the PSM output power. The PSM generation system's efficiency is increased by controlling the PSM's output power at the maximum power point (MPP). The perturb and observe (P&O) method was introduced by Bollipo et al. It compares a P-V curve from two power points, then compares a P-V curve from two voltage points, and finally monitors the MPP.

II. PROPOSED SYSTEM CONFIGARATION: This study indicates a unique VFVDC manipulate strategy for ISPS FBI. The running frequency is changed based on the vo stage, and the manipulate method frequently modifies the responsibility cycle in accordance with the unary quadratic equations that illustrate the connection among the ISPS output voltage vo and parameters a, b, and c. The low pass clear out's (LPF) size, capacitance, and inductance may also all be reduced through enhancing the FBI output voltage's harmonic the use of the modern VFVDC manipulate technique. As a end result, the advised VFVDC manipulate method may also gain a wonderful output strength, lower the LPF specification, decrease the voltage harmonic that the LPF absorbs, and boom ISPS efficiency. Both ISPS with plug-and-play talents and ISPS hooked up in a set role can be controlled by using the counseled device with a VFVDC control scheme. Additionally, with the cautioned layout, the ISPS can function as a transportable sun generator and beautify electricity excellent, ISPS performance, and the ability to deliver power to the area in which it's far needed. Two forms of sun energy systems are depicted in Figure 1. The schematic diagram of the ISPS, once in a while known as an off-grid solar electricity device, is proven in Figure 1(a).



The FIGURE 1. (a) off-grid solar PS (b) on-grid solar PS.

The ISPS FBI is usually smooth to manipulate, with the square wave gambling a main role. On the opposite hand, low energy quality will have an effect on the lifespan of the electric device if the ISPS's output AC voltage is rectangular wave. The utility grid's strength great will be impacted if the gadget is grid-linked. Therefore, the on-grid sun power gadget is not proper for rectangular wave regulation [Figure 1(b)]. Additionally, the ISPS's energy first-rate will enhance if it takes the FBI's SPWM management into account. Still, there may be room for development inside the SPWM manage's efficiency and harmonic. The cautioned VFVDC manipulate technique on this work can supply first-rate strength with a small LPF. The off-grid solar energy gadget is extra proper for this type of manipulate technique. Furthermore, an anti-reverse transmission device is hooked up between the sun power machine and the application grid in traditional grid-related sun power systems [38] to save you excessive modern or power with terrible harmonic portions from coming into the software grid and reducing the software grid's power exceptional. Because the electricity pleasant has progressed, the recommended VFVDC manage technique has a new effect at the solar strength system. Consequently, the cautioned design for the sun energy machine is similarly appropriate for the on-grid sun electricity gadget [Figure 1(b)].

Indeed, this have a look at's counseled VFVDC control technique can be used with a selection of strength structures, consisting of fuel cells, wind era, and others. The FBI can also supply exquisite power via the use of the VFVDC control technique. As previously indicated, the cautioned machine with a VFVDC control approach may be used for both plug-and-play and stuck configuration ISPS. By using the recommended VFVDC manipulate technique, it's miles viable to achieve a superb output power, lower the LPF's specification, decrease the voltage harmonic that the LPF absorbs, increase ISPS performance, and boom the ability of imparting energy to the specified area. As a end result, the sun energy gadget is the primary subject matter of this take a look at. However, portable mills cannot use wind power or fuel cells on the grounds that they may be too heavy to transport. To lower the THD of alternating voltage, the LPF quantity, and the layout value, this have a look at, which makes a speciality of the ISPS with the advised VFVDC control approach, transforms the sun energy system's DC input supply via FBI into an AC source according with the VFVDC manipulate method. Since the ISPS lacks any extra electricity technology system able to enhancing power excellent, the advised VFVDC manage approach is specially suitable.

II. PHOTOVOLTAIC SOLAR MODULE SPECIFICATION

Several semiconductors with p-n junctions make up a solar cell, which directly transforms light energy into electrical energy. According to the solar cell equivalent circuit depicted in Figure 2, where Iph is the electric current produced by sunlight, Dj is the p-n junction diode, and Rser and Rshu are the equivalent series resistance and equivalent parallel resistance, it is assumed that the solar cell operates to supply a load to an independent current source,

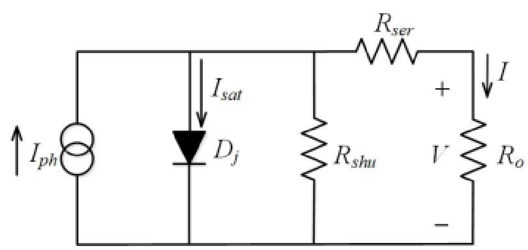


FIGURE 2. Solar cell equivalent circuit.

V is the solar cell's output voltage, I is its output current, and Ro is the external load, in that order. The analogous circuit for a solar cell is depicted in Figure 2. Equation can be used to express the solar cell output current based on the semiconductor properties of p-n junctions. (1):

$$I = n_p I_{ph} - n_p I_{sat}\left[\exp\left(\frac{q}{kTA}\frac{V}{n_s}\right) - 1\right] \quad (1)$$

Equation is used to determine the number of solar cells in parallel (np) and series (ns), the charge of an electron (1.6 × 10−19 coulomb), the Boltzmann constant (k), temperature (T), contact material factor (A), and reverse saturation current (Isat) (2):

$$I_{sat} = I_{rr}\left(\frac{T}{T_r}\right)^3 \exp\left[\frac{q \cdot E_{Gap}}{kA}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right]$$

EGap is the energy needed for semiconductor materials to traverse band gaps (EGap of silicon ≈ 1.1 eV), Tr is the solar cell's reference temperature, and Irr is the solar cell's reverse saturation current at Tr.

The Shell PSM (model: SP75) was used in this investigation. The study's conditions were temperature T = 25 ◦C, sunshine G = 1 kW/m2, single PSM open-circuit voltage Voc = 21.7 V, short-circuit current Isc = 4.8 A, MPP voltage VMPP = 17 V, and MPP current IMPP = 4.4 A. The Ipsm–Vpsm characteristic curves are simulated by MATLAB using a single PSM under G of 0.2 kW/m2, 0.4 kW/m2, 0.6 kW/m2, 0.8 kW/m2, and 1 kW/m2, and T = 25 ◦C, as shown in Figure 3(a). The Ppsm–Vpsm characteristic curves are simulated by MATLAB using a single PSM under G of 0.2 kW/m2, 0.4 kW/m2, 0.6 kW/m2, 0.8 kW/m2, and 1 kW/m2, and T = 25 ◦C, as shown in Figure 3(b). Voc = 86.8 V, Isc = 14.4 A, VMPP = 68 V, and IMPP = 13.2 A are the results of the 12 PSM in this investigation being arranged in 4 series and 3 parallel.

III. SOLAR POWER SYSTEMS' MAXIMUM POWER POINT TRACKING ALGORITHM

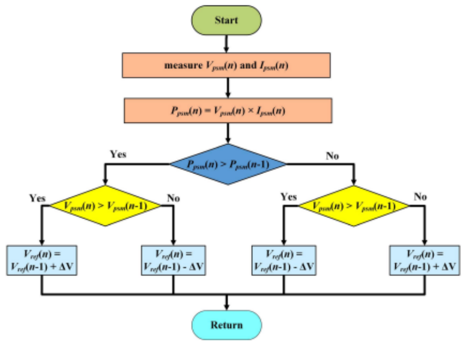


FIGURE 4. A flowchart of the classic P&O algorithm.

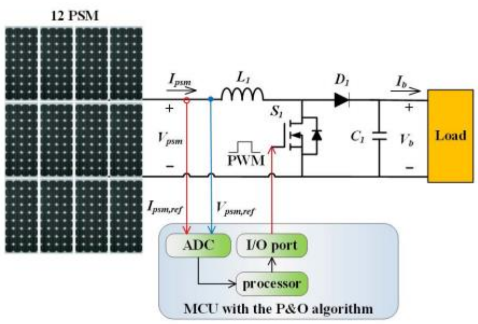


FIGURE 5. A schematic of 12 PSM combined with a boost converter to embed the P&O algorithm controller.

IV. THE FULL BRIDGE INVERTER'S PROPOSED OPTIMIZED CONTROL STRATEGY

The FBI architecture is depicted in Figure 6. There are four power MOSFETs in this architecture: S2, S3, S4, and S5. FBI output voltage is denoted by va, boost converter output voltage by Ib, and boost converter output voltage by Vb. The DC voltage Vb of 155.54 V is further transformed to the AC voltage of 110 Vrms using the 4 power MOSFET switching technology.

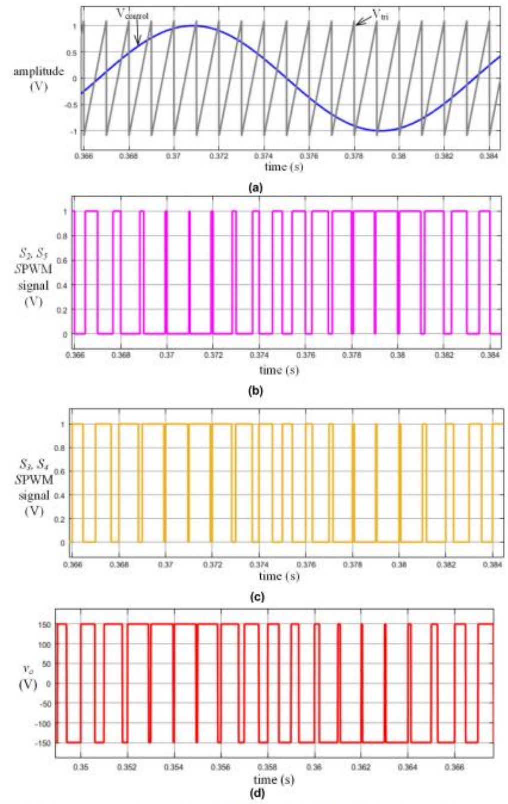


FIGURE 7. MATLAB simulates the SPWM signal generated by comparing a triangle wave V_{tri} with a sinewave $V_{control}$: (a) the waveform of triangular wave and sinewave; (b) the FBI power MOSFET S_2 and S_5 SPWM signal; (c) the FBI power MOSFET S_3 and S_4 SPWM signal; (d) the FBI output AC voltage waveform v_a.

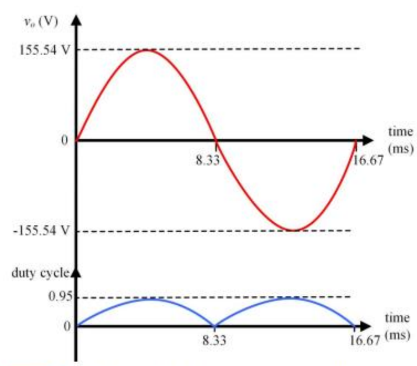


FIGURE 8. The relationship between the ISPS output sinusoidal voltage v_o, the duty cycle for FBI 4 power MOSFET, and time.

The SPWM signal produced by comparing a triangular wave with a sinewave is simulated by MATLAB, as seen in Figure 7. The blue sine wave's Vcontrol frequency is 60 Hz, while the gray triangle wave's Vtri frequency is 1 kHz in Figure 7(a). The following is the expression for the relationship between the amplitude modulation index ma, Vcontrol, and Vtri:

$$m_a = \frac{V_{\text{control}}}{V_{\text{tri}}} \qquad (7)$$

The following is the expression for the relationship between the sinewave fundamental frequency (f1), triangular wave frequency (ftri), and frequency modulation index (mf):

$$m_f = \frac{f_{tri}}{f_1} \qquad (8)$$

In order to describe the frequency change control technique, this study controls the switching frequency in accordance with reference, which is that the switching frequency varies at various voltage levels (as shown in Figure 9). The suggested improved FBI control techniques diagram is displayed in Figure 9. The two components of the FBI control strategies (as shown in Figure 9) The FBI 4 power MOSFET can improve system performance and lower switching loss by employing this variable frequency management technique. Finally, to lower the harmonic amount and, consequently, the LPF volume, the ISPS output sinusoidal voltage vo is near the 60 Hz operating frequency.

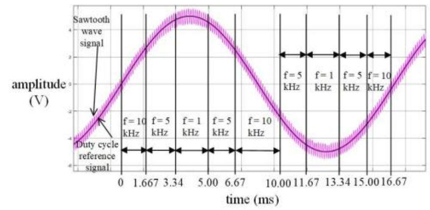


FIGURE 9. The proposed optimized FBI control strategies diagram.

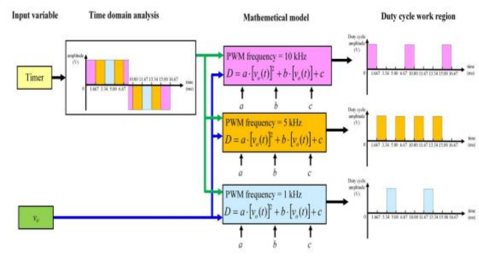
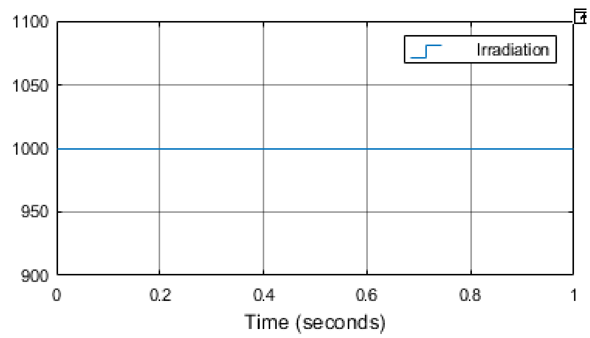
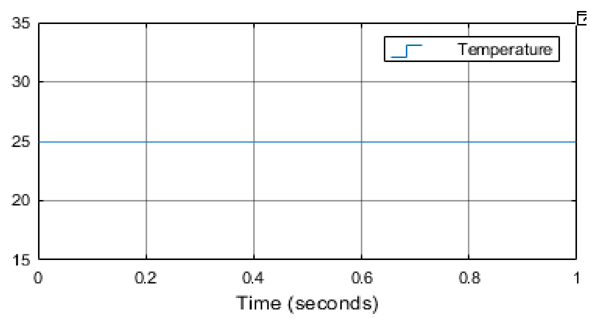


FIGURE 10. Diagram of the duty cycle work region with the proposed VFVDC control strategy.

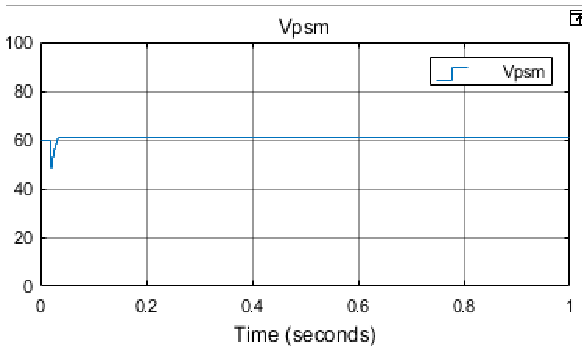
V.SIMULATION RESULTS: Constant irradiation:



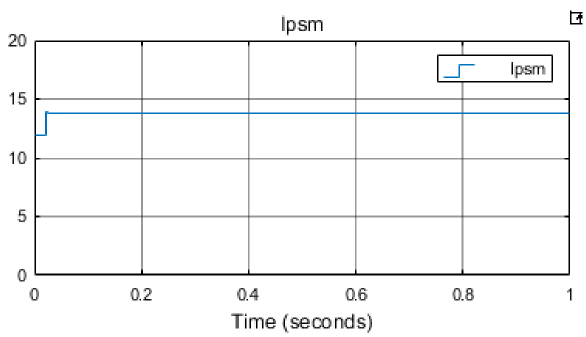
Irradiation



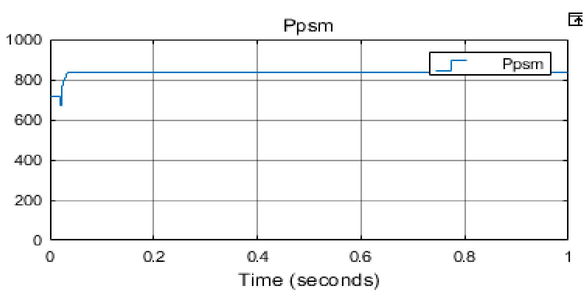
Temperature



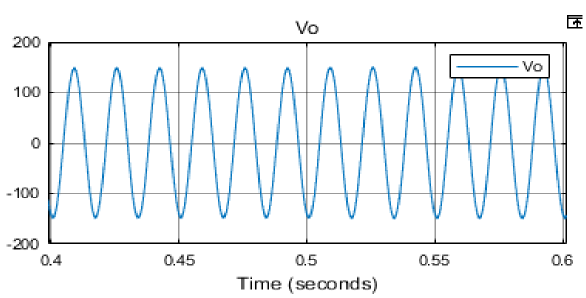
Pv voltage



PV current

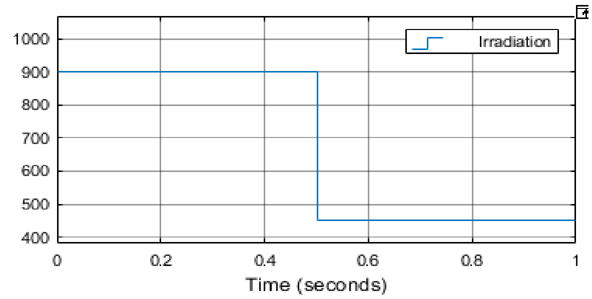


PV power

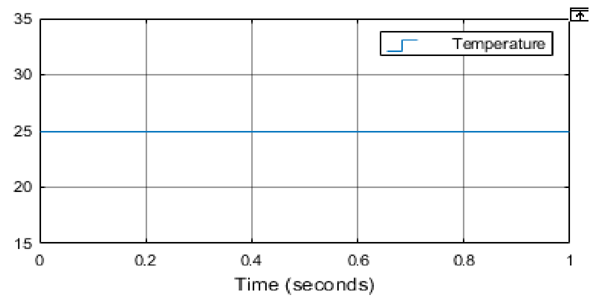


Output voltage

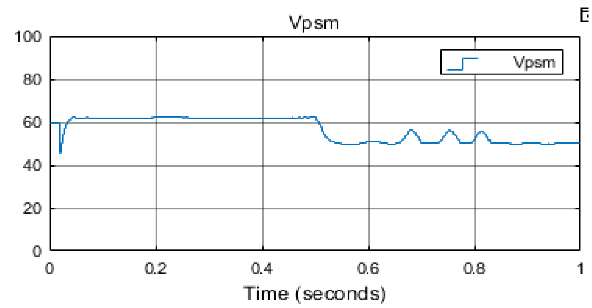
Variable irradiation at 900 to 450



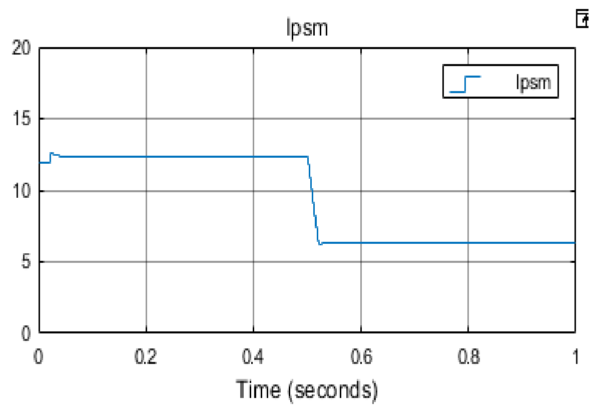
Irradiation



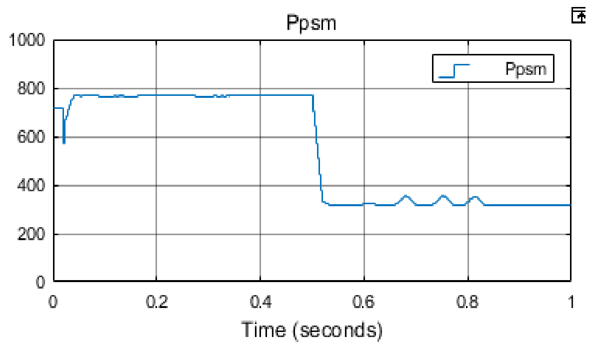
Temperature



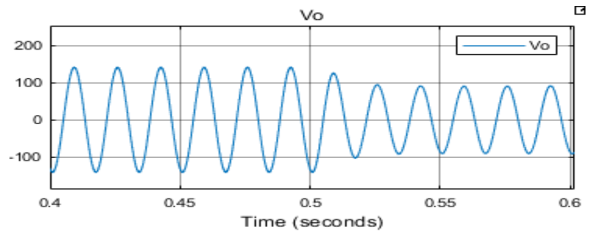
PV voltage



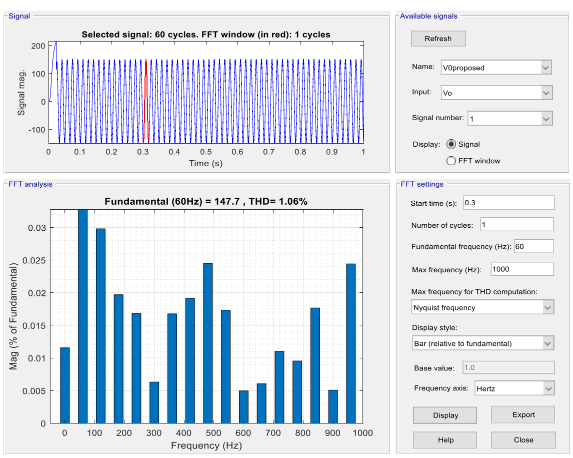
PV current



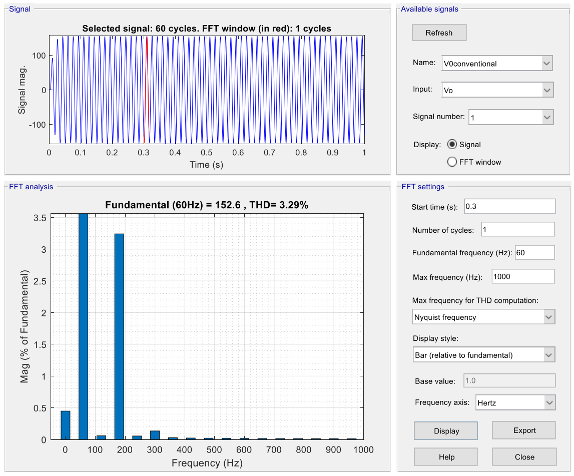
PV power



Output voltage



THD of PROPOSED CONTROL Output voltage



THD of CONVENTIONL Output voltage

VI.CONCLUSION:

This study contrasted the suggested VFVDC optimal control strategy with the SPWM control method, examined the FBI control approach to lessen the issue of power harmonics, and concentrated on the ISPS. The suggested approach, THD = 1.02%, outperformed the SPWM control method, THD = 3.23%, according to another MATLAB simulation conducted under the identical circumstances. Subsequently, the solar power systems integrated the output voltage control method with the P&O MPPT algorithm. This system uses an output voltage control approach to enhance converter output voltage Vb = 155.54 V when the solar power system supplies the load with sufficient power. MPPT is used if the load is not receiving enough power from the solar power system. This study used MATLAB to model a G of 1 kW/m2, and the ISPS could be stabilized at the MPP, resulting in an MPP power of 900 W. A reduction in G from 900 W/m2 to 450 W/m2 could also be regulated in MPP, resulting in a reduction in power from 810 W to 405 W. Real-time system testing revealed that the suggested approach had a low harmonic quantity, making it viable and dependable for use in real solar power systems.

This optimal control technique can extend the device life of the load, decrease the LPF volume, and increase system efficiency. The ISPS will be integrated with a battery system or other power supply systems in subsequent projects. The solar power generation system is unable to supply enough power for the load when there is not enough sunshine. In order to meet load demands under varying time and climate circumstances, the solar power system must be coupled with a battery system or another power system in order to reach the MPP from the MPPT. This makes the system a hybrid power system. To increase the ISPS's efficiency, the innovative MPPT technology can be refined and used in low-light or shaded settings. Additionally, the combination of the suggested VFVDC control approach and a unique inverter may be taken into consideration in order to further reduce the harmonics of the ISPS output voltage.

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