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MITIGATION OF HARMONICS BY USING MULTILEVEL INVERTER IN HYBRID SYSTEM (PV & WIND)

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Abstract : The aim is to design a hybrid system model (PV & wind) using nine level inverter with less harmonic distortion in the output waveform and to improve the power quality. As, power quality became a key issue when power electronic devices like inverters, rectifiers are introduced in the system. This paper provides cascaded H-bridge nine level inverter with SPWM (Sinusoidal pulse width modulation) control technique to improve the power quality by mitigating the harmonics present in the hybrid system. The cascaded H-bridge topology is employed because of its modularized construction, adaptability and convinience to use. The use of different dc sources in cascaded topology ensures isolation between sources of each module. This model is analysed using MATLAB Simulink. The objective of this project is to obtain a sinusoidal waveform with low THD value.

IndexTerms **– Cascaded H- Bridge, Multi-Level inverter, THD, SPWM Technique, Hybrid system (PV & Wind), MATLAB.**

I. INTRODUCTION

Modern world offers a choice to reduce the burden on non – renewable energy sources in meeting the load demand to prolong its availabilty by partially meeting the load demand with renewable power generation. It is well known fact that non- renewable generation creates pollution. Generation of electricity by renewable energy sources neither creates pollution nor run out when we use.

Microgrids are essential for integrating and connecting renewable energy systems to the grid. Hybrid generation includes one or more sources combiningly working together to meet the demand. In recent years Hybrid generation (Solar and wind) are widely used for generation of electricity. Renewable generation affects the power quality due to its non-linear loads injecting current harmonics.

As the usage of power electronic devices grows, the quality of the electric supply as well as energy efficiency, has become a major concern. Harmonic distortion, which indicates the deviation from the ideal sinusoidal waveform is the most common representation of power quality. To minimize the distortion mutli level inverters are preferred. Harmonic mitigation can report good benefits for industries, Data centres etc., in terms of total installation cost, energy bill savings, and equipment fault protection.

A nine level inverter of single phase with spwm technique is used in this model to mitigate harmonics. Total Harmonic Distortion[THD] is reduced with control techniques used in the inverter. Multi-Level inverter produces the output voltage with high frequency and less distortion.

II. METHODOLOGY

A. Multi-level inverter

Inverters acts as source of backup power supply. The traditional inverter is a two-level inverter that shifts between two voltage levels to create an output voltage of +Vdc and -Vdc. Multi-Level Inverter generates multiple step voltage waveform with variable and controllable phase and amplitude, Generates voltage and current waveform of improved power quality. Multi Level inverter used for high power and power quality demanding applications.Some of the applications of Multi Level inverter are electric and Hybrid vehicles.

Generally there is a deviation between desired waveform and obtained waveform in conventional inverteres. The deviation is undesirable and it is termed as THD[Total Harmonic Distortion]. Inorder to decrease the THD value Multi-Level inverter is used. Multi Level inverter starts with 5-Level inverter. As we are going for higher levels the distortion is less. The different levels of inverters are 5,7,9,25,49 level etc.,As we go to higher levels the obtained voltage waveform is similar to desired waveform. Multi Level inverter uses switches(power semiconductor) along with several dc levels of voltage and convert dc power to ac by synthesizing a staircase voltage waveform.

The different Multi-Level inverter topologies are:

1) Cascaded H-Bridge inverter
2) Diode Clamped Inverter
3) Flying capacitor Multi-Level Inverter

Cascaded H- bridge topology is discussed in this paper. The Hybrid system(PV/Wind) is connected in Cascade Bridge topology.

B. Cascaded H-Bridge:

- Cascaded H-bridge topology deals with connection of H-bridges in series to get the sinusoidal voltage output. Based on levels of inverters H-Bridges are connected.
- Each H-bridge consists of four switches connected in H-Shape fig(i). The 5-Level multi level inveter consists of two H-bridges and 8 switches. Similarly, The 9-Level Multi Level inverter fig(ii) consists of Four H-Bridges Cascaded(connected in series) and 16 switches(IGBT's).
- The switches used in multi level inverter are bidirectional.
- The Cascaded H-Bridge of N Level Multi Level inverter needs 2(N-1) switches.

C. *Control Techniques*:

The commonly used control techniques are:

1)Pulse width modulation (PWM) technique
2)Sinusoidal pulse width modulation(SPWM)technique
3)Space vector PWM (SPWM) technique etc.

This paper deals with SPWM control technique.

D. Sinusoidal pulse width modulation (SPWM)

Sinusoidal pulse width modulation technique is a typical PWM technique and a favorable method most widely used in power inverter. SPWM technique also called as Triangle-comparision PWM technique.

To generate gating signals for switches, this method compares a large number of level shifted or phase shifted triangle signals to a sine wave. A sinusoidal reference wave (AC voltage) is compared to a high-frequency triangular carrier wave in this SPWM approach.

Whenever ,
Sine wave > Carrier wave
S1 & S2 are turned on (+vdc/2)
Sine wave < Carrier wave
S3 & S4is turned on(-vdc/2)

This type of PWM approach is known as SPWM technique since the reference signal is a sine wave.

In the SPWM approach, the switching frequency of an inverter is equivalent to that of a carrier wave. Every period of the triangle carrier wave, the switch is turned off and on. As a result, the SPWM approach has the benefit of a constant switching frequency. Because of its simplicity, the SPWM technique is commonly employed.

E. Hybrid Renewable sources (PV&Wind) based micro grid

A hybrid energy system is made up of two or more renewable energy sources that are integrated to produce a high output. An Uninterrupted power supply is the requirement of the people. This paper presents a hybrid system of wind and solar integrated and connected to grid.

F. FFT (Fast Fourier Transform) Analysis

Total Harmonic Distortion (THD) is used for determining the harmonic content present in an inverter's output voltage waveform. The THD of a cascaded H-bridge nine-level inverter output waveform is calculated using MATLAB/FFT Simulink's analysis.

III. IMPLEMENTATION

This model consists of a hybrid system (PV & wind) cascaded together and the DC outputs of the both solar and wind are fed to each H-bridge of the nine –level inverter. Here, the nine-level inverter is designed with four H-bridges cascaded together with 16 IGBT switches. The switching operation of nine level inverter is given in the below table.

	0	5	10	15	20	15	10	5	0	-5	-10	-15	-20	-15	-10	-5
S1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1
S2	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
S3	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
S4	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
S5	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
S6	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1
S7	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
S8	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0
S9	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1
S10	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1
S11	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
S12	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
S13	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
S14	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
S15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S16	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 1. Switching states for single phase nine level inverter.

There are 16 switches used in the 9-level inverter. The output of each H-bridge is 5V. The nine-level inverter has four H-bridges and the total output voltage is 20V. Various switching states during the implementation are recorded in a table.

IV. MATLAB Representation of the system

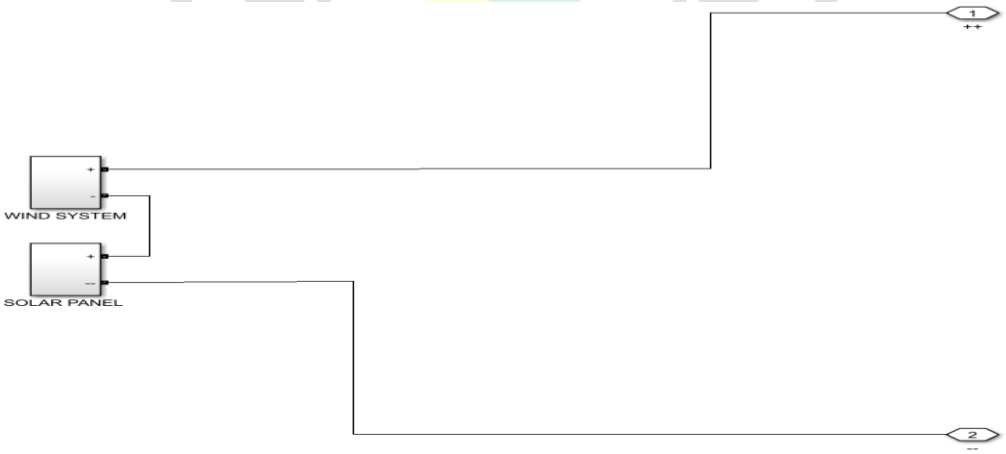

Fig. 1. Block daigram of Hybrid system(solar and wind).

The above Figure represents the block daigram of solar (PV) and wind system cascaded together. The DC output of wind and solar systems are given to inverter through port-1 and port-2 respectively.

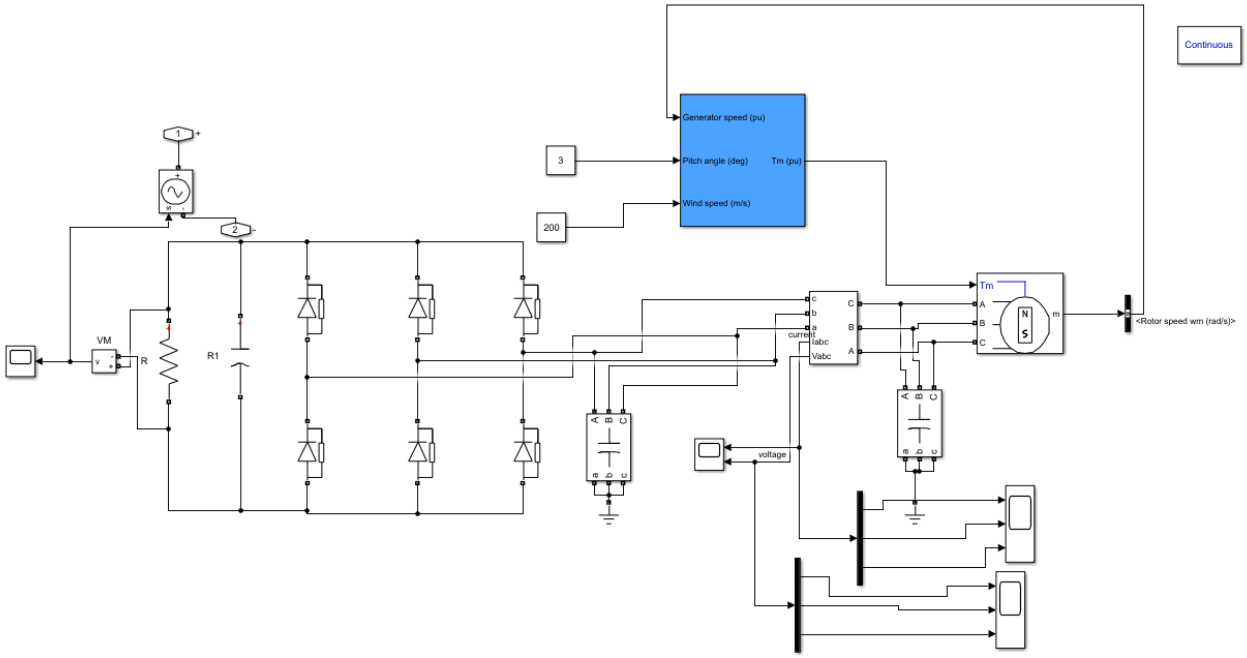

Fig. 2. MATLAB representation of wind system.

Wind kinetic energy is turned into mechanical energy by a wind turbine, and mechanical energy is converted into electrical energy by a 3-phase permanent magnet synchronous generator. Mechanical input Tm is given as input to the generator. The output of generator is connected to a rectifier circuit . Thus, we get a output in terms of dc. The dc voltage is fed to the multi level inveter.

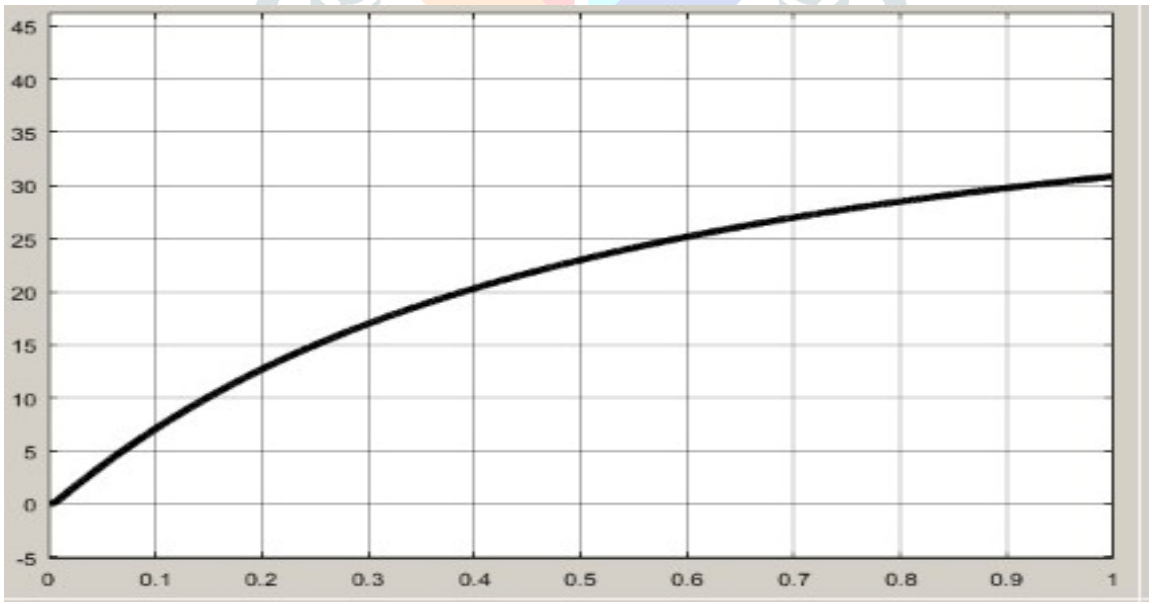

Fig. 3. wind output voltage waveform.

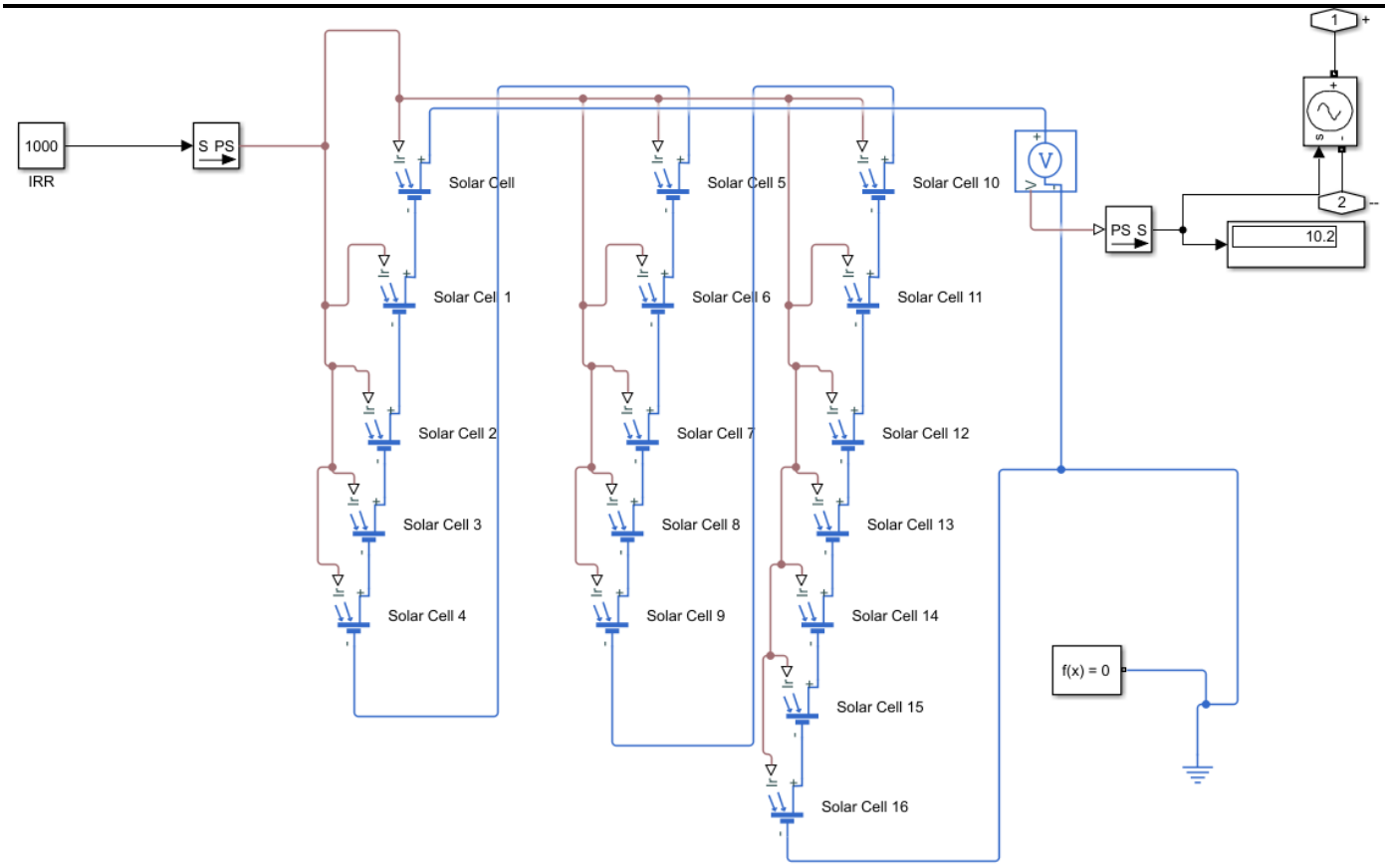

Fig. 4. MATLAB representation of PV (Solar) system.

The above Figure is the MATLAB representation of PV system.To provide the requisite DC output voltage, 16 solar cells are connected in series. The given pv system is fed with 1000 irradiance.

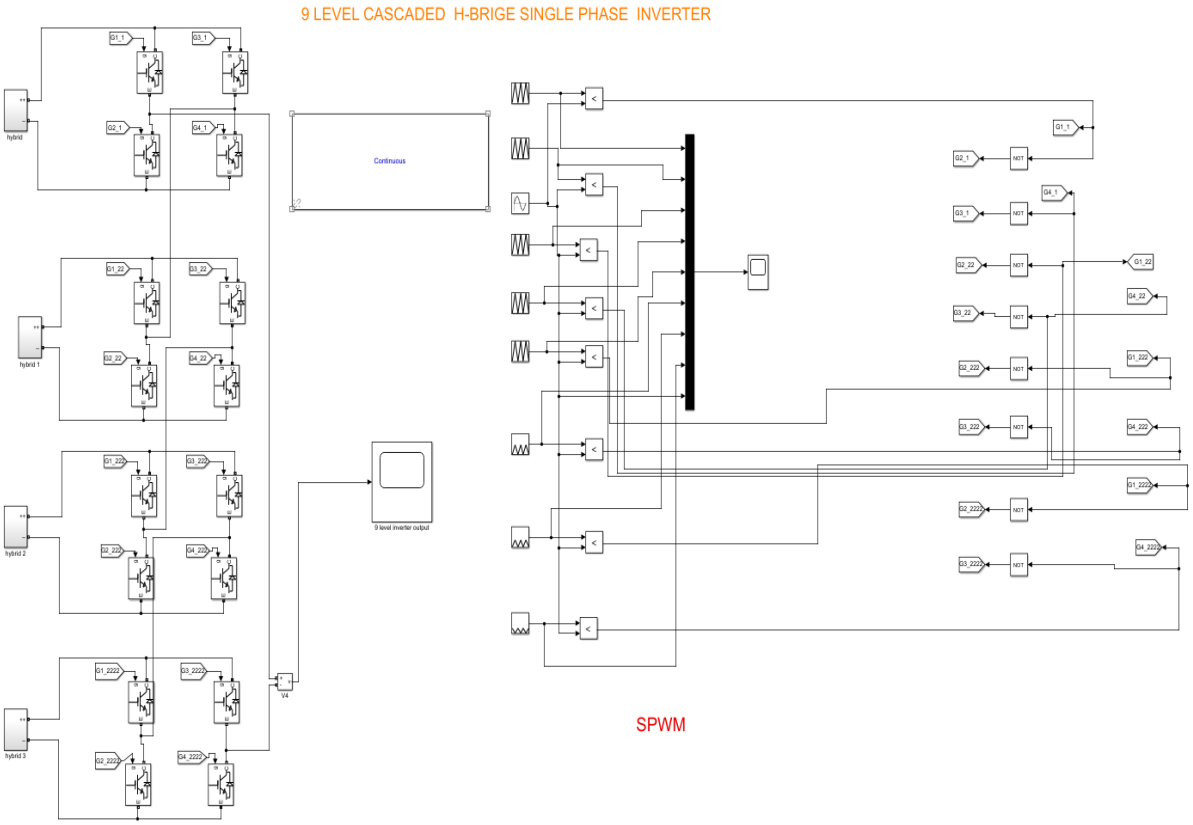

Fig. 5. 9- Level cascaded H-bridge single phase inverter with SPWM technique.

V. RESULTS AND DISCUSSION

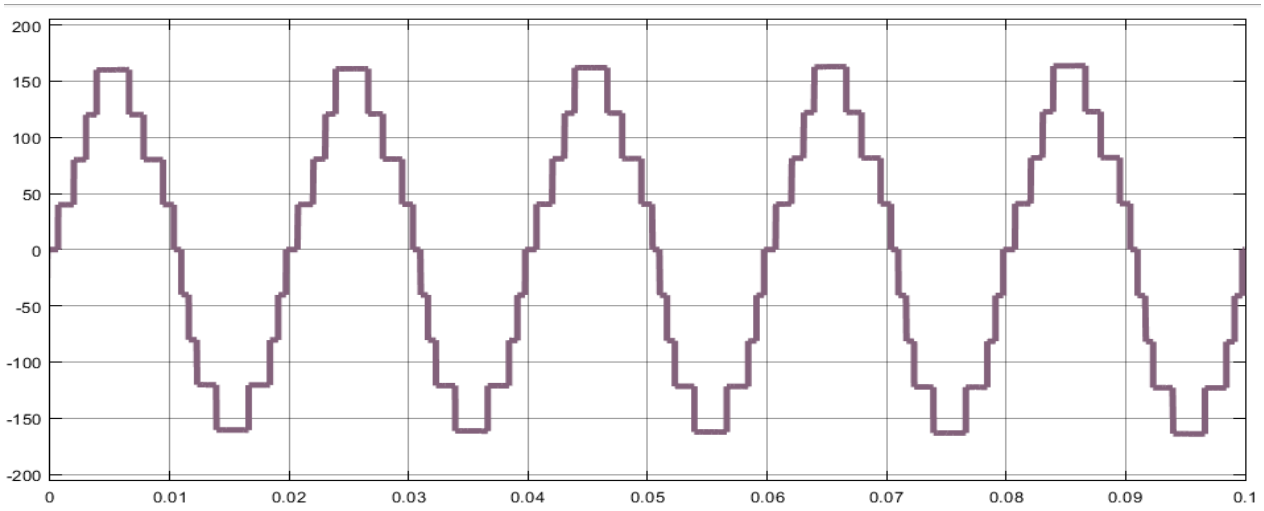

Fig. 6. 9-Level inverter output voltage waveform.

The output waveform of the 9- level cascaded H-bridge inverter is stepped waveform with 9-steps which is closer to the desired sinusoidal waveform with less harmonic distortion compared to other lower levels.

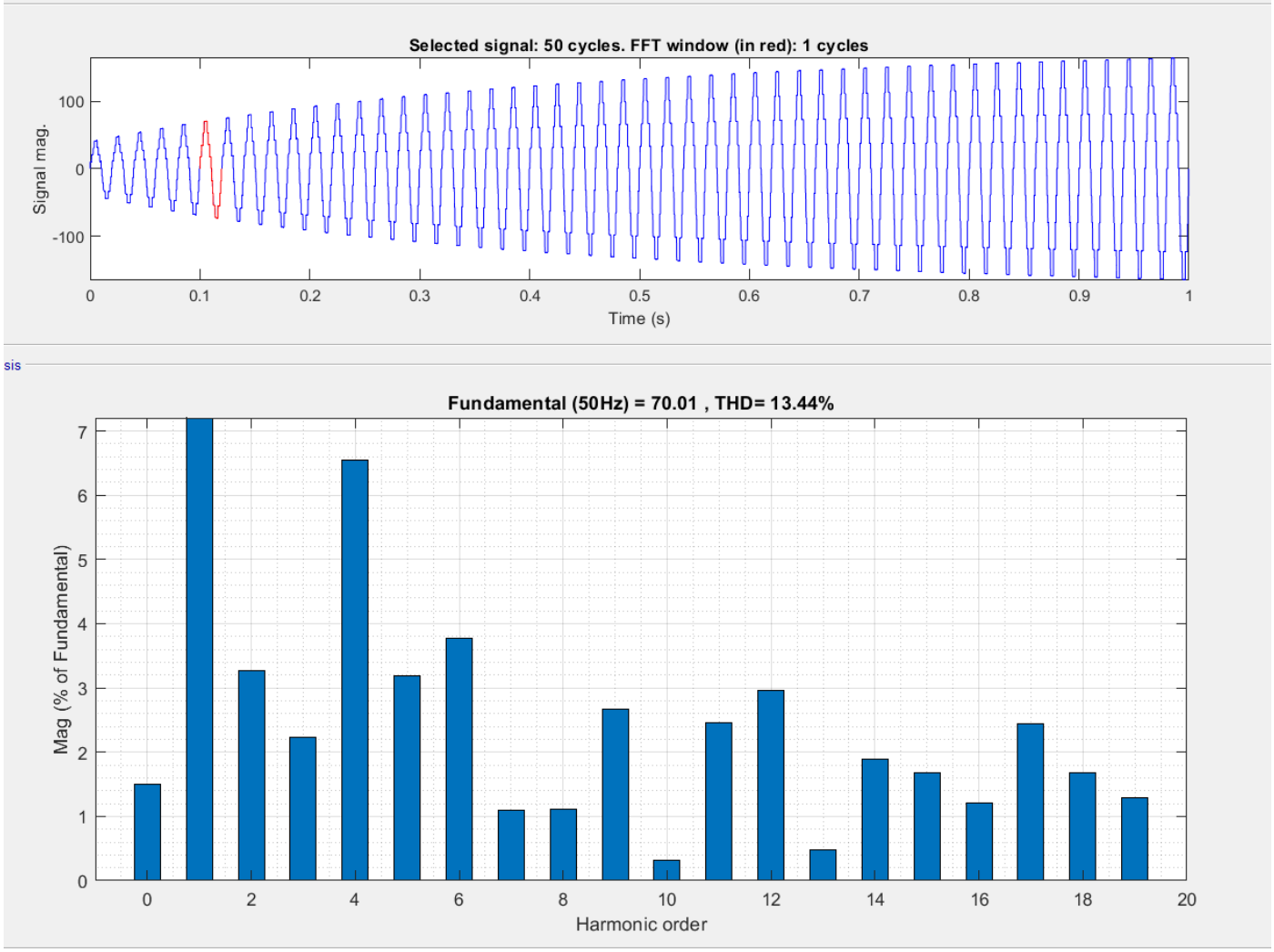

Fig. 7. MATLAB FFT analysis of 9-Level inverter with SPWM technique.

A cascaded H-bridge multilevel (9-level) inverter of symmetrical topology with SPWM(sinusoidal pulse width modulation technique) is designed for Hybrid micro grid System (PV&wind) in MATLAB and simulated, to obtain 9-level stepped output voltage with less harmonic distortion. The multilevel inverter using SPWM is carried out. Harmonic content is reduced compared to lower levels. Power quality is increased by using multi level inverter. Thus, Harmonics are mitigated by using multilevel inverter in hybrid system(solar and wind).

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