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Design and Simulation of SPWM using Python

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Abstract

This paper explains how an open-source Python-Spyder tool used to develop the Sine PWM in Python environment. This open source tool is a Scientific Python Development Environment, includes many number of key features to create a SPWM for a two level inverter system. Along with the regular general-purpose array-processing package - numpy and object-oriented API for GUI systems - matplotlib another supporting package which works with the numpy is - scipy are used for the generation of the SPWM for a two level inverter. The results show that the Python-Spyder offers significant advantages over other approaches. It provides easy and fast simulation time and less complex coding than the other simulation tool packages.

Keywords: *Python, Spyder, numpy, scipy, matplotlib, SPWM.*

I. INTRODUCTION

Sinewave inverters with the capacity to control the output variables like frequency, amplitude and phase sequence are play a significant role in industry, office, and other appliances. Instances of these applications are sustainable power sources, uninterruptible power supplies, adjustable speed drives (ASDs), and so on. The output of a perfect inverter is relied upon to be an ideal sinusoidal waveform without harmonics. Numerous strategies have been created to accomplish this objective. The utilization of any of these techniques relies upon the power extend, the reasonable power losses, load sensitivity due to harmonics and final one is the cost. The pulse width modulation (PWM) strategy is famous for producing sinusoidal output in converters and has been discusses about broadly in [1]–[3]. A drawback of PWM converters is that PWM rectangular waveforms produce numerous harmonics and switching losses in semiconductors, which limit the use of the converters. Rectangular waveforms are causes the EMI [3], [4]. A survey shows that various procedures have been created to improve the presentation and the nature of the PWM inverters. The greater part of these works have been focused on reduction of harmonic content in output voltages and currents[5], [6], reduction of switching losses and upgrading the inverter output [7]–[9]. Traditional PWM and resonant inverters are attractive researches for low-control applications. In this paper, a new approach for the generating PWM pulses for a sine wave 2 level inverter are presented with using python-spyder GUI simulation tool.

1. Sine Pulse Width Modulation Method

In SPWM, the inverter pulses are obtained by comparing the reference sinusoidal wave with a triangular signal [2]. The generated pulses are rectangular in shape and the amplitudes are same, but the pulse width is differ from one another. In figure it can be observed that the pulses width is gradually increasing towards the center point of the half wave and having larger widths are located at the peak position of the waveform, and the pulse width is gradually decreasing when it is moving away

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from the peak position. It is true in case of negative half wave also.

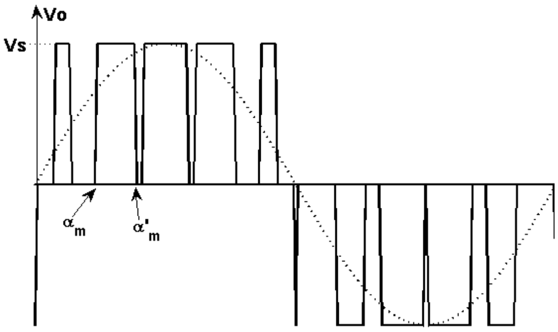

Fig. 1.Sine Pulse Width Modulation technique.

II. SINE PWM GENERATED PYTHON-SPYDER.

The following GUI environments are required for the simulation of the SPWM.

i. Anaconda Navigator(AN)

AN is a work area graphical UI (GUI) remembered for Anaconda distribution (AD) that enables you to dispatch end user requirements and effectively oversee anaconda packages, environments, and channels without utilizing direction line directions.

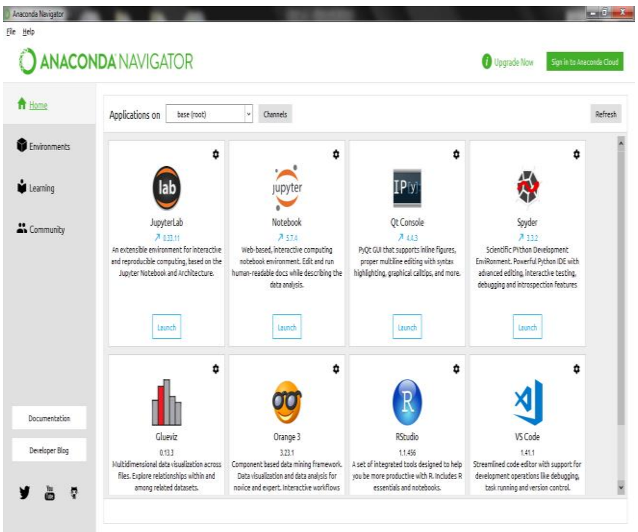

Fig.2. Anaconda navigator.

AN can scan for packages on AD Cloud or in a nearby Repository. It is accessible for all personal computer operating systems Windows, macOS, etc., Many scientific packages are also available based on the request and requirement specific versions can be imported to our operating systems.

Researchers frequently use various forms of packages and utilize numerous versions of environments to separate these versions. The command line program of anaconda is a package manager as well as a environment manger also. This Anaconda navigator is used for the spyder IDE installation.

ii. Spyder- IDE

Spyder is an incredible logical environment written in Python, and specially designed researchers, data analysts etc., For programmers it offers a unique kind blend for debugging, editing, analysis. In this Spyder –IDE the python programming is used for the simulation.

iii. Python – Programming Language

Python is a universally useful and significant level programming language. Python can be used for creating different GUI applications, sites and web applications. Likewise, Python, as an elevated level programming language, enables you to concentrate on center usefulness of the application by dealing with regular programming errands. The straightforward syntax rules of the programming language further makes it simpler to coding. There are additionally various reasons why the programmers interested in Python than other programming objects.

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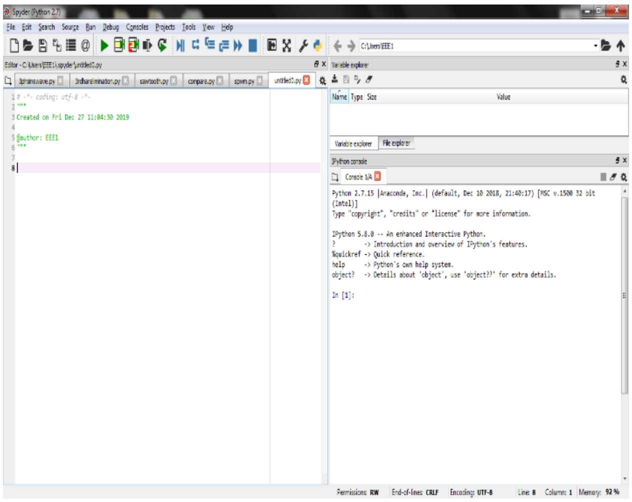

Fig.3. Spyder- IDE

III. GENERATION OF SINE WAVEFORM USING PYTHON

Python is a open source high level language and it is able to run on different operating systems like Windows, MacOS, Linux. Also it has feasibility to port to Java and other .NET supporting systems. To generate the waveforms like sinusoidal, triangular it is required to add some technical array packages in support to the python program. Here the numpy and scipy are added to support the python program. The numpy is having the vectorized code. Due to which the process will be more concise and easy to fetch the data and the vectorized code resembles the conventional mathematical notations.

scipy is having varieties of sub packages which help to solve issues related to scientific computation. It is having fast computational power. It can operate along with the array of numpy library. Naturally the scipy is built in top of the numpy. The most data science features are obtained from scipy rather than numpy. While coding, Import the library packages like scipy with i/o package and numpy. Here the sine wave has to create and then it should be convert in to modulated waveform. To create a sine wave first imports the signal library package from scipy. Then create the line space for the required frequency. Here the frequency of the sine wave is choose as 50 Hz. Then that sine wave is modulated as required. A sine wave is created with a frequency of 50 Hz and with a magnitude of -1 to +1 i.e., a unit sine wave with 50 Hz is created. A sine wave created with 50 Hz frequency can be seen in fig.4.

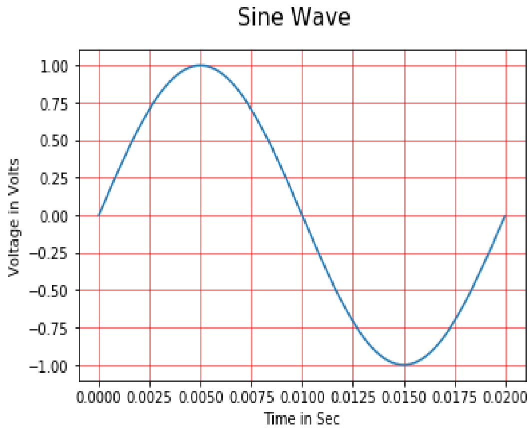

Fig.4. Sine waveform created with 50Hz frequency.

Now it is modulated to obtain the sine wave between 0 to +1 only. This can be done easily by using the fundamental mathematics. A modulated sine wave created with 50 Hz frequency can be seen in fig.5.

IV. RESULTS AND DISCUSSIONS

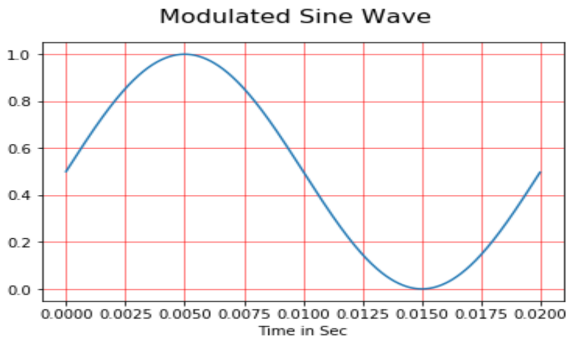

Fig.5. Modulated Sine waveform.

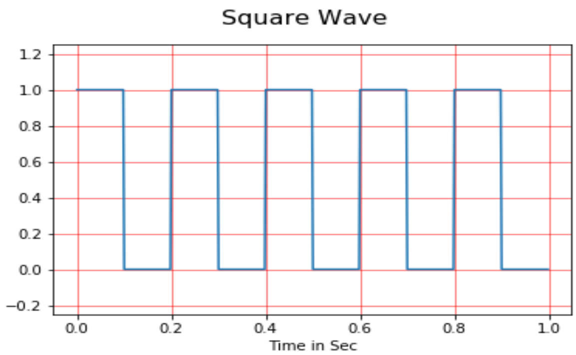

Fig.6. Square wave frequency of 5Hz.

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To obtain the PWM of this sine wave it is required to sample them with the square wave. So first create a square wave of required frequency then sample the sine wave with square wave. A square wave is shown in fig.6 with a frequency of 5 Hz. Square wave used for sampling with frequency of 1000Hz is shown in fig.7.

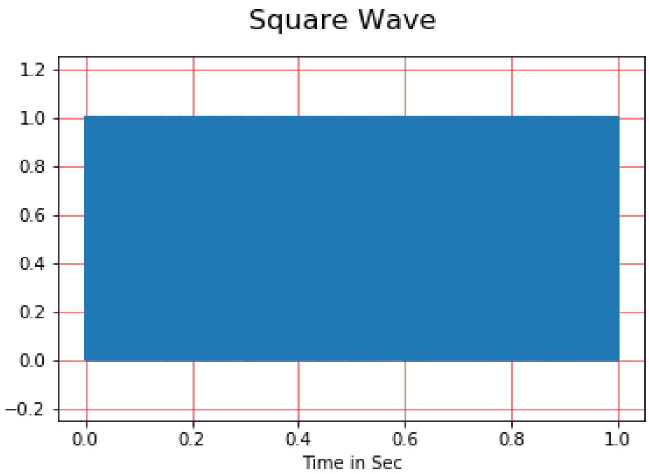

Fig.7. Square wave used for sampling with frequency of 1000Hz.

For simplicity and easy understanding a sine wave with different frequency and its sampling to obtain the PWM is shown in fig.8.

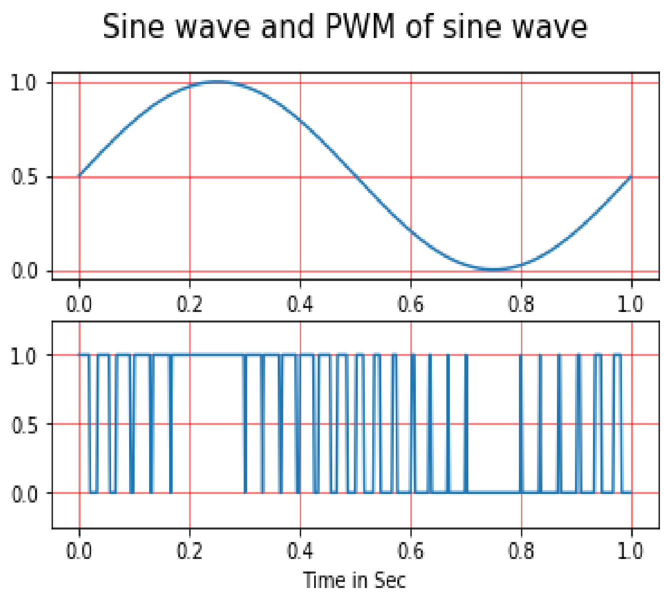

Fig.8. Sine wave and sine PWM.

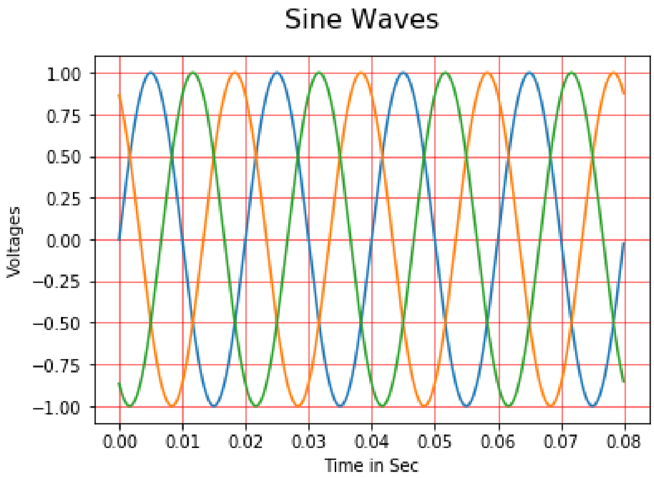

Fig.9. three phase Sine wave with 50Hz frequency.

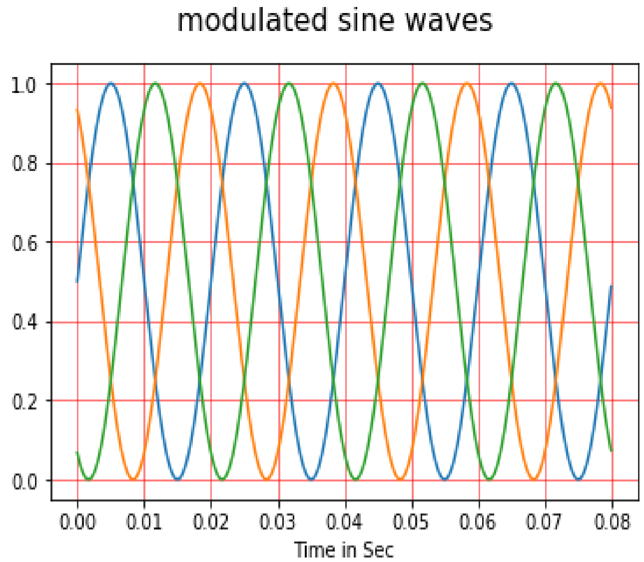

Fig.10. three phase modulate Sine wave.

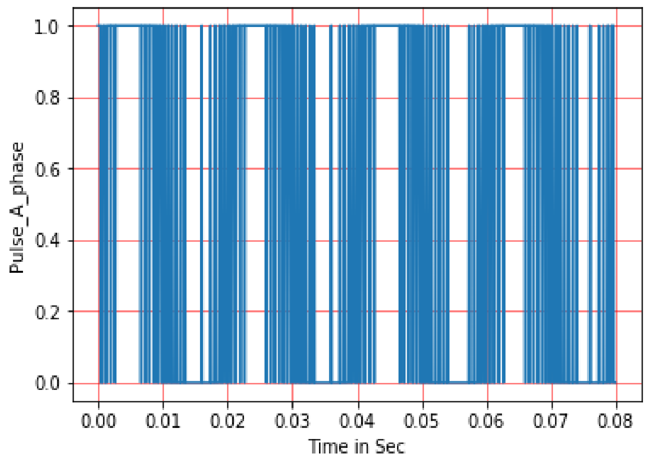

Fig.11. PWM pulses of Phase A sine wave.

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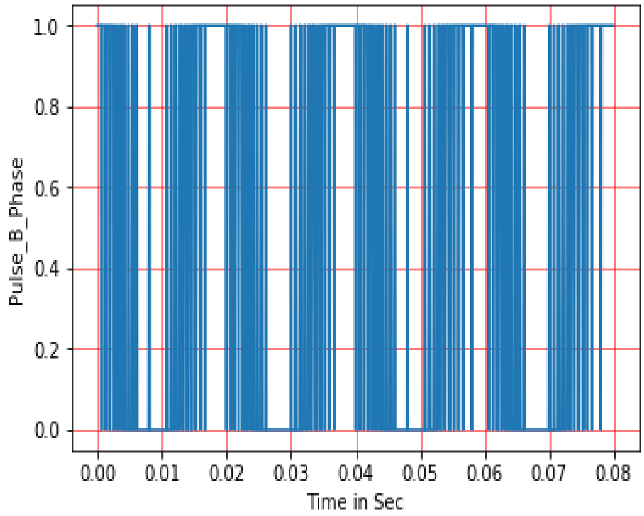

Fig.12. PWM pulses of Phase B sine wave.

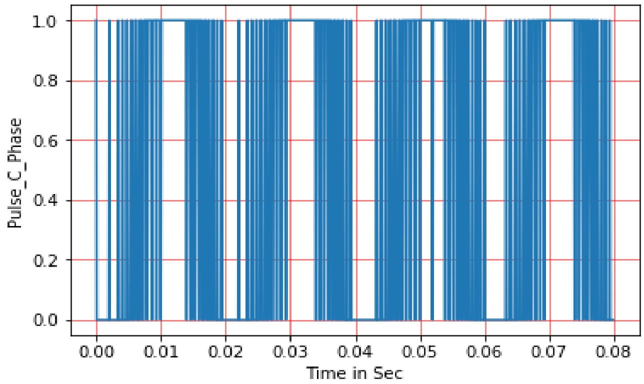

Fig.13. PWM pulses of Phase C sine wave.

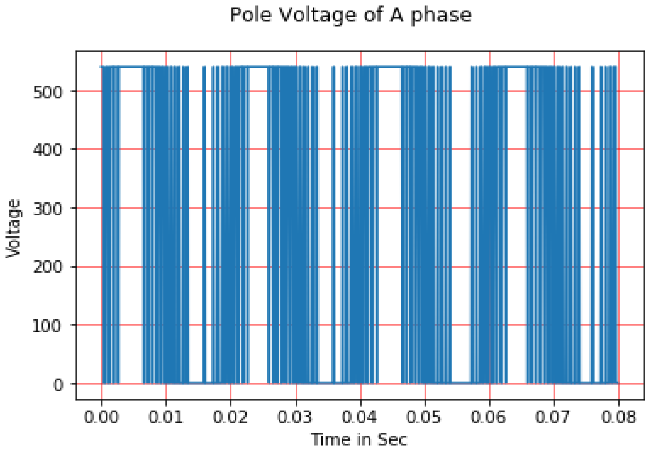

Fig.14.Inverter pole voltage of Phase A

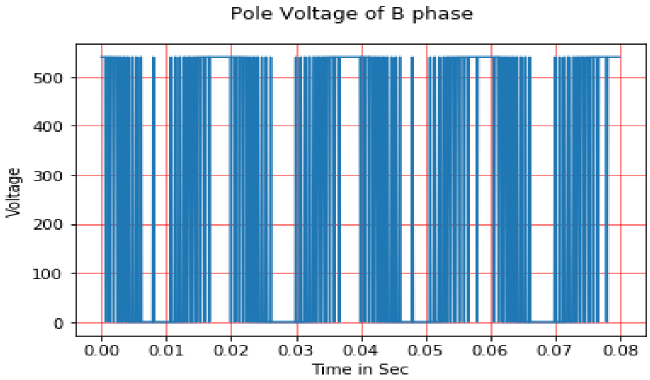

Fig.15.Inverter pole voltage of Phase B

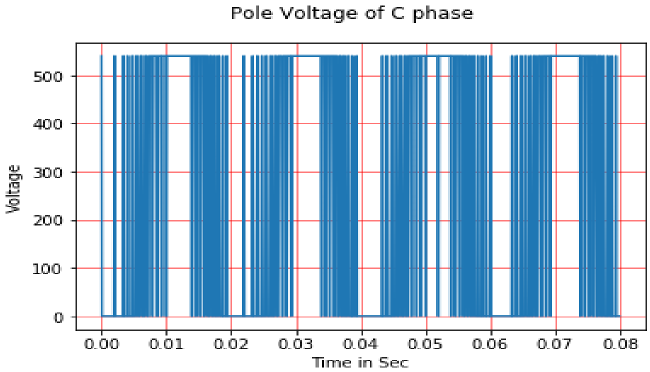

Fig.16.Inverter pole voltage of Phase c

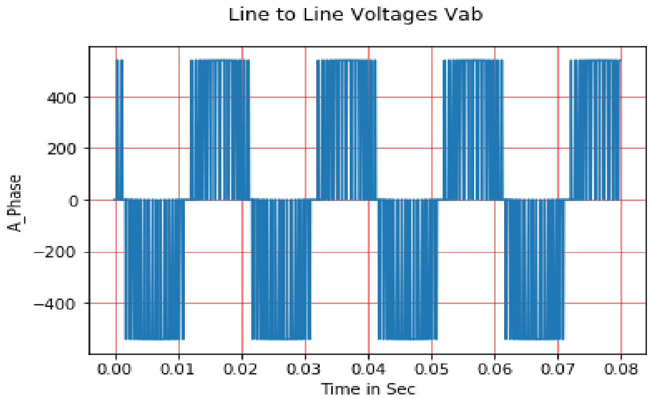

Fig.17.Line to line voltage of Phase A and B

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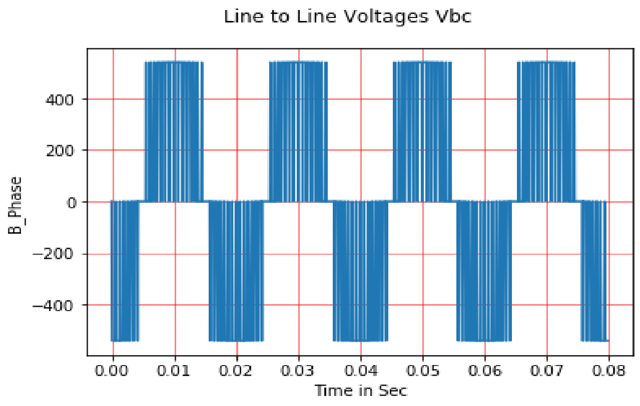

Fig.18.Line to line voltage of Phase B and C

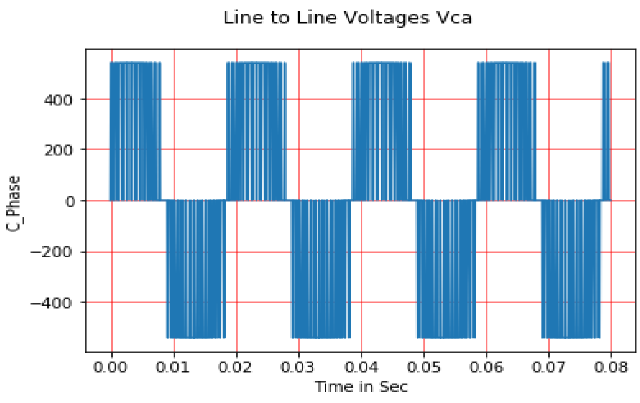

Fig.19.Line to line voltage of Phase C and A

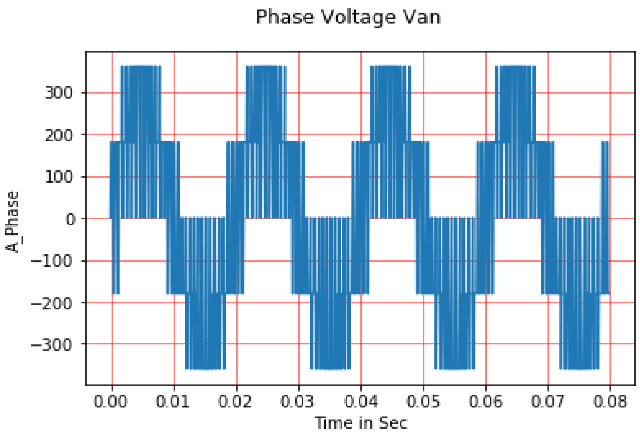

Fig.20.Effective phase voltage of inverter of Phase A.

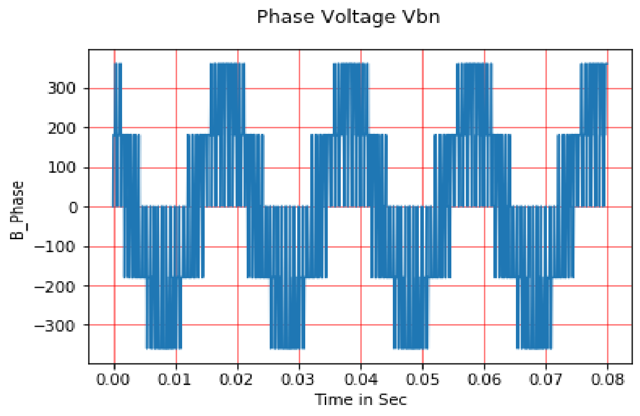

Fig.21.Effective phase voltage of inverter of Phase B.

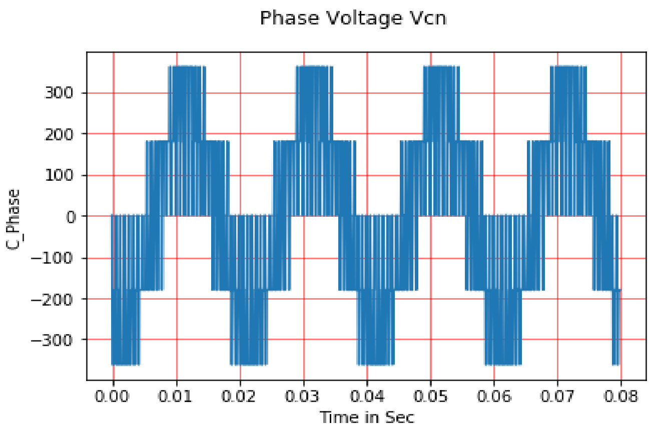

Fig.22.Effective phase voltage of inverter of Phase c.

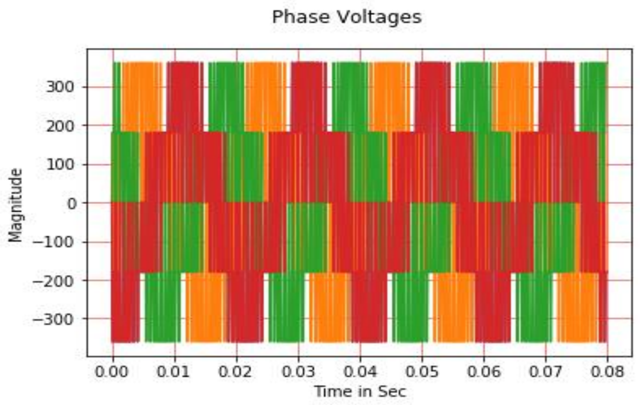

Fig.23. Effective phase voltages of 2 level inverter.

Similarly a Three phase sine wave with a frequency is created and is shown in fig.9. Then sine waves are modulated and sampled to 1000 Hz for creation of the PWM pulses. The modulated three phase sine

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wave is shown fig.10. These pulses are having a magnitude from 0 to 1. The PWM pulses are shown in fig. 11 to 13. The inverter pole voltages are simulated and they are shown in fig.14 to 16.

The simulated line to line voltages are shown in fig.17 to 19. The effective phase voltage of inverter phases are shown in fig.20 to 22. In fig.23 all effective phase voltages are shown.

IV. CONCLUSIONS

Spyder has developed into a fairly mature and very productive tool. Here a simple approach to produce PWM pulses for a sine wave of 50Hz is discussed. Along with the regular general-purpose array-processing package - numpy and object-oriented API for GUI systems - matplotlib another supporting package which works with the numpy is - scipy are used for the generation of the SPWM for a two level inverter. It provides faster simulation time and less computational intensity than the other simulation tool packages.

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