Analysis of a novel seven phase uncontrolled rectifier system

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Abstract

Nowadays Multiphase systems involving multiphase machines expressly more than three phase, introduced good enhancement related to conventional systems. Multi-phase generators generate power in applications such as, "but not limited to, wind power generation, electric vehicles, aerospace, and oil and gas ". These types of generators output are connected to AC-DC converters, to feed DC load or inverter stage. In this paper mat lab R2017a modeled and simulated a seven phase uncontrolled rectifier. Different wave forms have been taken and analyzed in modern DC power systems, where multiphase converters are widely used more than three phase converters. A seven phase uncontrolled rectifier is designed to overcome supreme power supreme current. This research introduced completely analysis of an input/output voltage and current waveforms. The THD of an input current is also obtained

Keywords: multiphase-uncontrolled rectifier- THD- modern power system-seven phase

1. Introduction:

Recently three phase systems are widely used in many application such as three phase induction motor – variable speed drive (VSD) –industrial application...Etc.

Nowadays renewable energy power system like "wind energy conversion system (WECS)." Marine energy systems (MES) take a large remarkable by many investigators, the simple ideas for modern systems depends upon a multi-phase machine. These benefit over the three machines: decrease torque pulsation, lessening currents harmonics in rotor, lessening current per phase compared with other three phase motor having similar voltage, low dc link current harmonics, high power density, high efficiency, rising in fault tolerance and high dependability). [1]

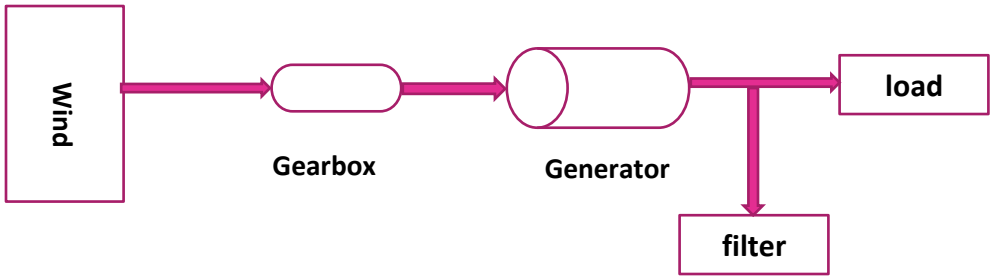


Figure (1) multi-phase wind energy system

A three phase power supply is commonly used in many commercial utilization. In application which needed to use multi-phase supply, there is two methods to obtain five, seven, nine, eleven phase …etc.:

a- Multi phase generator which is predominating (permanent magnet synchronous generators) the application of this machines gives an idea about the number of required phases are needed

b- Conversion methods used transformers with an appropriate arrangement of winding to get the number of required phase

2. The suggested model

Fig (2) explains the block diagram for the suggested model in this paper. A three phase Y-connection is supplying a three multi-windings transformers. The output of these transformers represent the input of the seven phase rectifier. The DC motor represents the load of the rectifier.

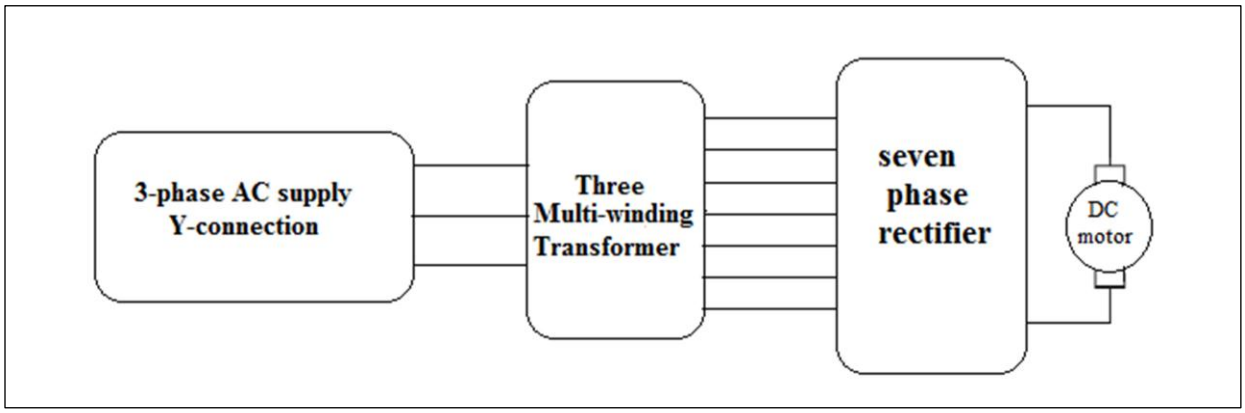


Figure (2) the block diagram of the suggested model

3. Novel three to seven phase transformer winding

Any transformer having more than three phase (i.e.) multiphase have been focused by researchers due their importance. Where some applications needed multi-phase supply like: multiphase power transmission, five or higher phases rectifier systems, and variable speed multiphase drive system.

Conventional generation units used three phase systems to supply customers, for obtaining multi-phase it needed to use transformers with specials type of connection.

There are three cores of iron designed each one represents one primary and four secondary except one having five secondary windings instead of four. There are six terminals in primary side connected in an apt way to get star or delta connection. At the other side (secondary) there are twenty six terminals connected in a different manner to get a star or heptagon style. Fig(3-a) shows the way of connection of transformer and fig(3-b) shows the arrangement of connection of transformer windings in mat lab Simulink .

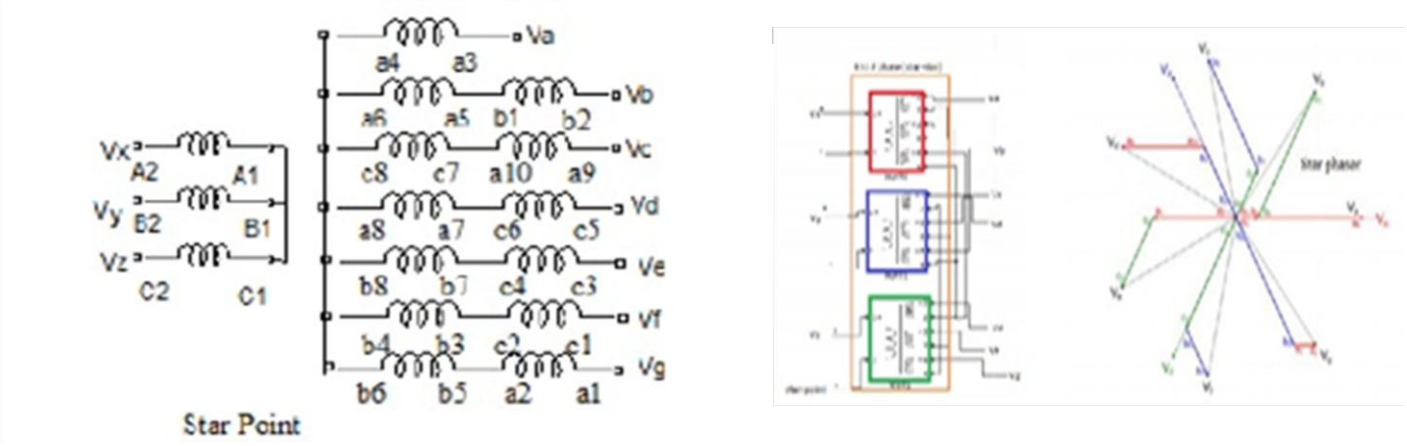


Figure (3-a) proposed transformer winding (star-star connection)

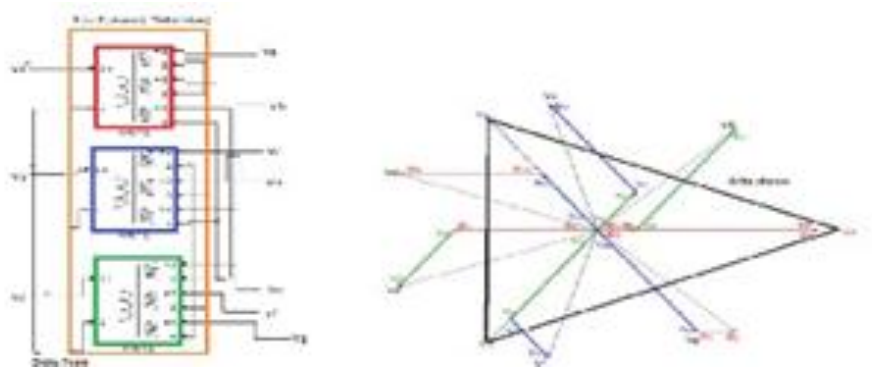


Figure (3-b) proposed transformer winding (star-delta connection)

The phase angle between the input waveform voltage is (2π/3) and output waveform has angle (2π/7). The choice of turn ratio decides the requisite phase displacement in the output phases. [1, 2]

4. Seven phase uncontrolled rectifier

The seven phase uncontrolled rectifier illustrates in fig.4

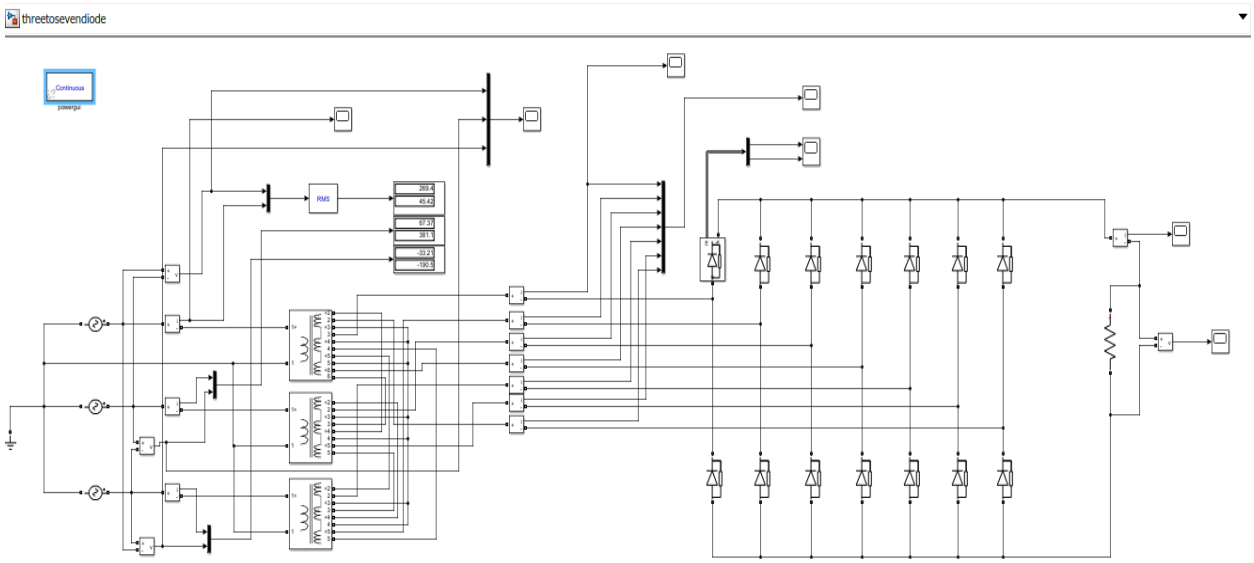


Figure (4) seven phase rectifier circuit

This rectifier consists of fourteen power diodes, where power electronics convertors fed by seven phase supply (three to seven phase transformer). Power electronics devises (D1 – D7) operate at the positive part of the wave and the devises (D8 – D14) operate at the other part of the wave .The voltage equations of the secondary transformer can be written as

$V_{pha1} = V_p \sin(wt)$ ------ (1)

$V_{pha2} = V_p \sin(wt-2\pi/7)$ ------ (2)

$V_{pha3} = V_p \sin(wt-4\pi/7)$ ------ (3)

$V_{pha4} = V_p \sin(wt-6\pi/7)$ ------ (4)

$V_{pha5} = V_p \sin(wt-8\pi/7)$ ------ (5)

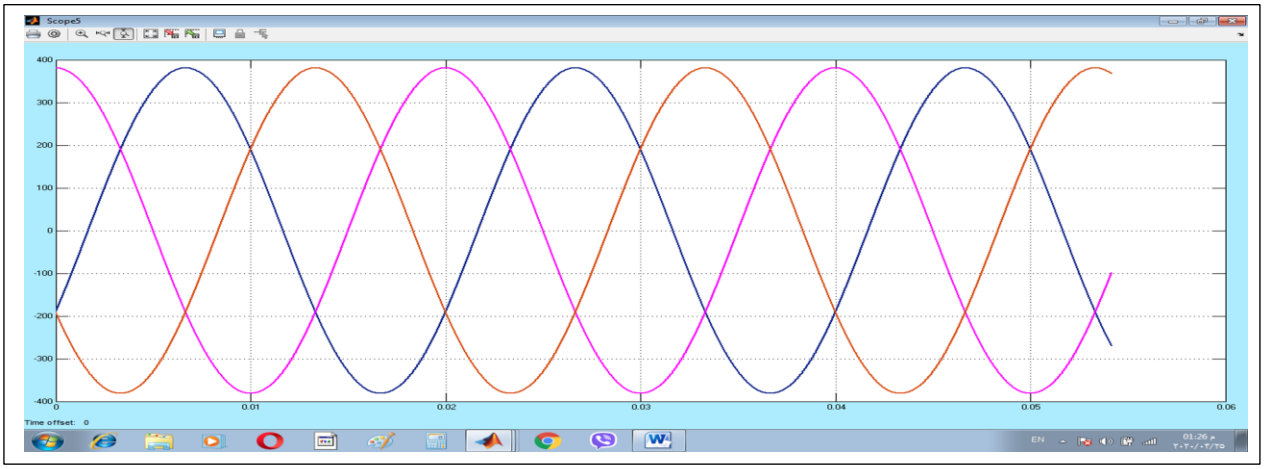
$V_{pha6} = V_p \sin(wt-10\pi/7)$ ------ (6)

$V_{pha7} = V_p \sin(wt-12\pi/7)$ ------ (7)

Where V_p is the peak value of the input phase voltage to neutral with respect to neutral.

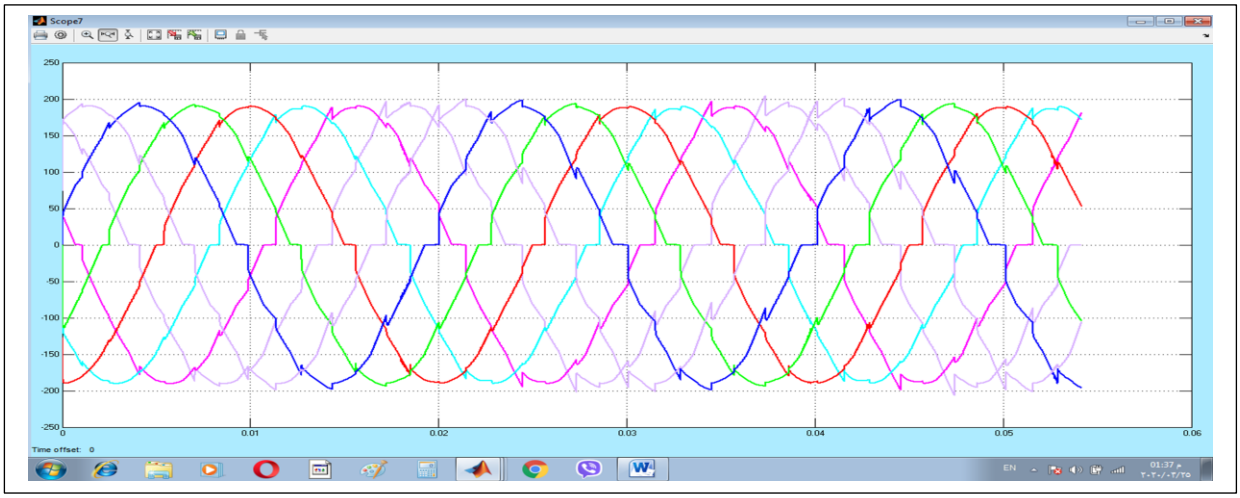
(1, 2, 3, 4, 5, 6, and 7) refereed to phase number. [3,4]

Fig (5) illustrates the waveforms of the three phase input voltages with respect to neutral point to fed three transformer.



Figure(5) three phase voltage waveforms supplied to transformer

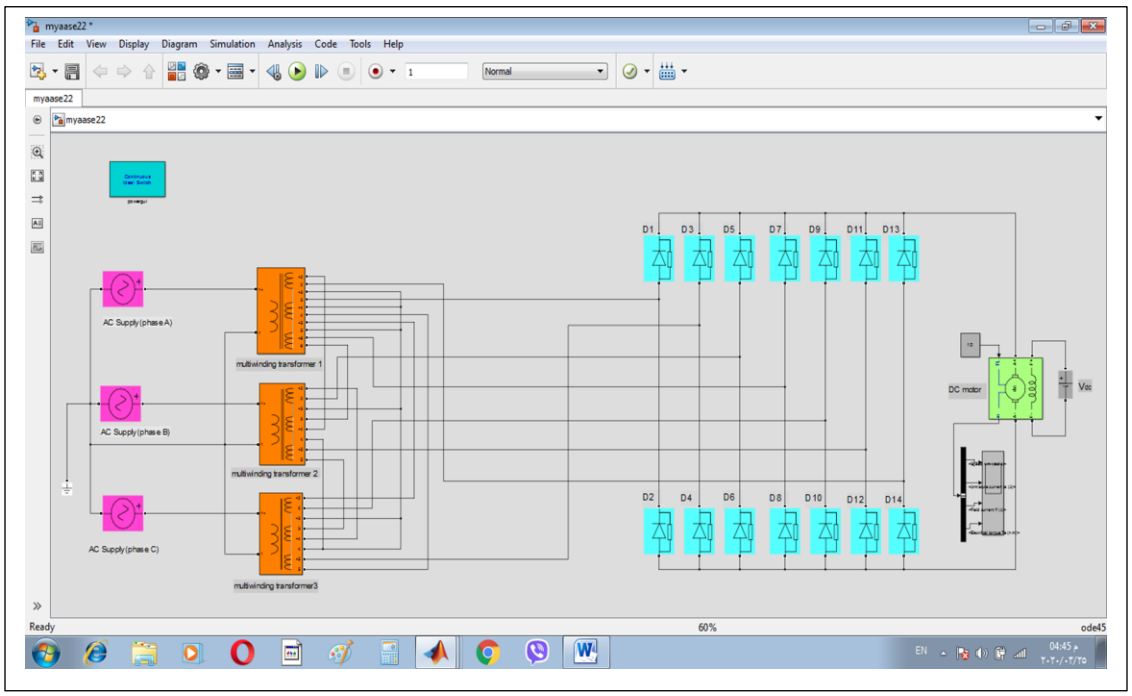
The aim of the special connection in fig (4) is to rise the number of the voltage phases from three to seven. These voltages represent the input of the seven phase rectifier. The waveforms of these voltages are distorted due to high reactance of the transformers. Fig(6) introduces this phenomena



figure(6) output voltage of transformer suppling converter

5- load of converter

There are many types of load can be connected to rectifier circuit depending on their application. In this state a dc motor is connected to converter as a load with specific characteristic to obtain the effect on multi-phase rectifier and novel method for converting conventional phases to more than it on its performance. Fig(7) shows the complete circuit of driver .



Fig(7) complete circuit of drivers

6-Simlation results

The proposed model was tested when the load of the multi-phase rectifier was DC motor. It can be notice that the simulation results representing all wave forms deals with driver witch show its performance under loaded circuit. it can be classify results into three parts : three phase power supply, three to seven phase modified transformer , and dc motor as a load

6-1- Part one : supply side

Figure (8) shows the waveform of the current in phase A (one of the three supply phases). Fig (9) represents the waveforms of output currents for the multi-windings transformer which provide the multi-phase rectifier

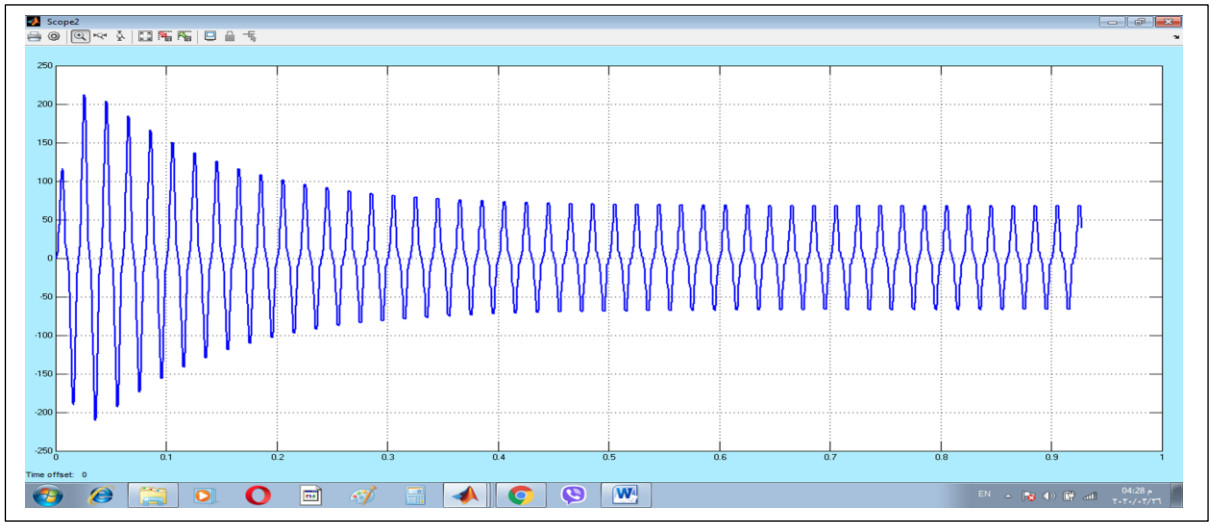


Fig (8) represent current of source phase (A) on of three phase supply

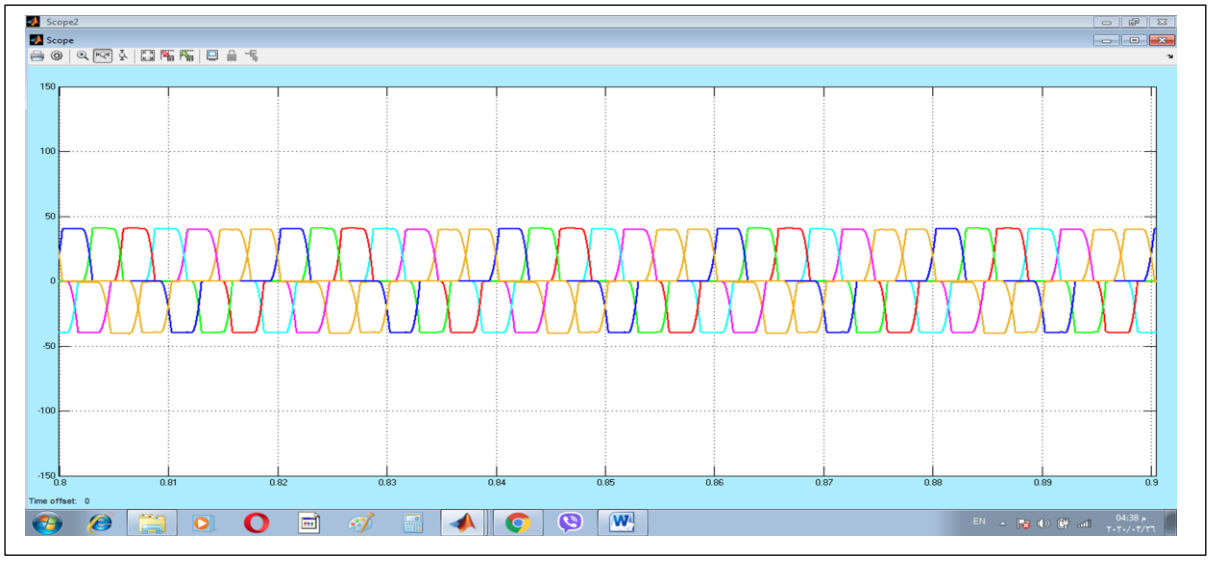


Fig (9) waveforms of transformer output current

Voltage wave form of power supply and transformer are introduced above ???

6-2- Part two: converter and power electronics device

Figure (9) illustrates the waveforms of the current and peak inverse voltage for the diode, while figure (10) represents the waveform of output voltage for the rectifier which represents the load voltage. Figure (11) explains the output current wave form of the rectifier (the load current).

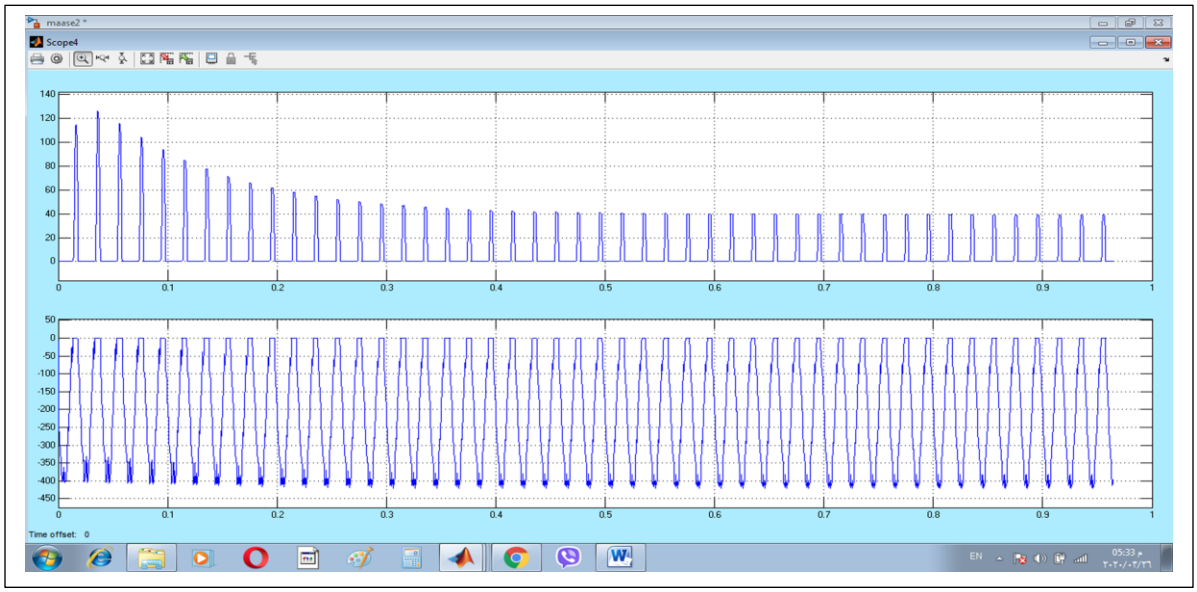


fig (10) current and peak inverse voltage waveform of diode

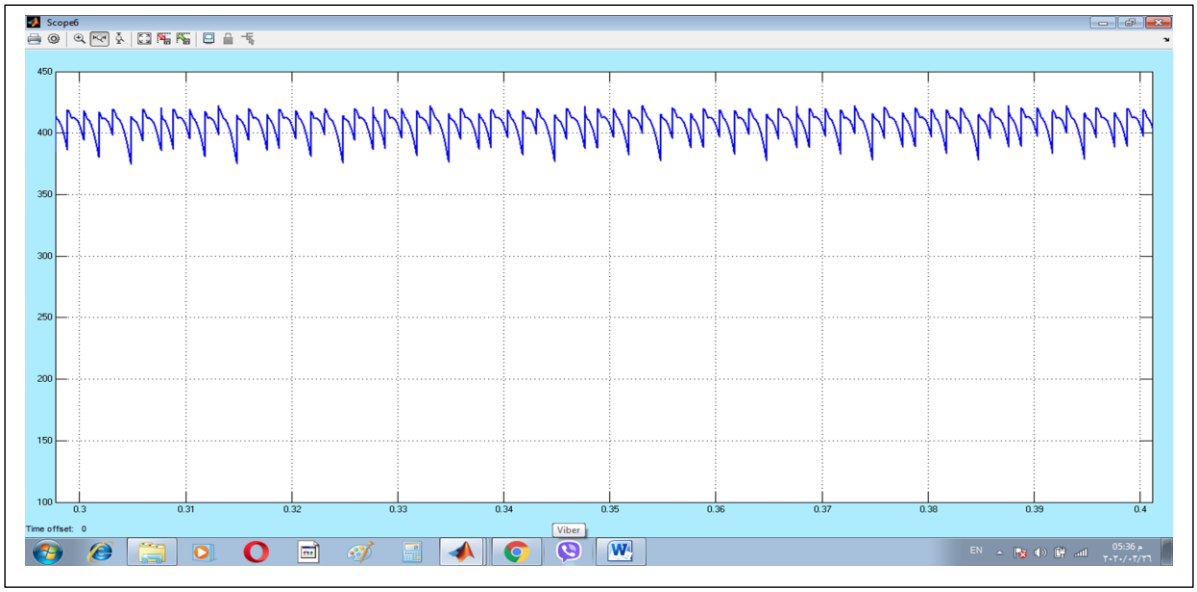


fig (11) output voltage waveform of the rectifier

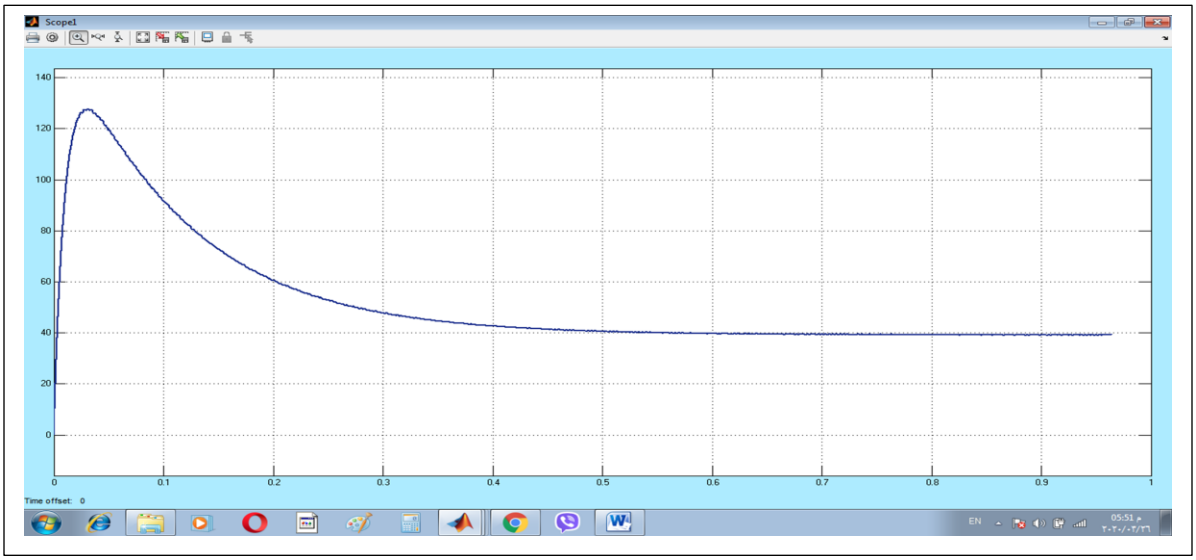


fig (12) output current wave form of rectifier supplying load

6-3-part three load side

Figure (13) shows the waveforms for the (speed, armature current, field current and electrical torque) which represent the characteristics for the DC motor.

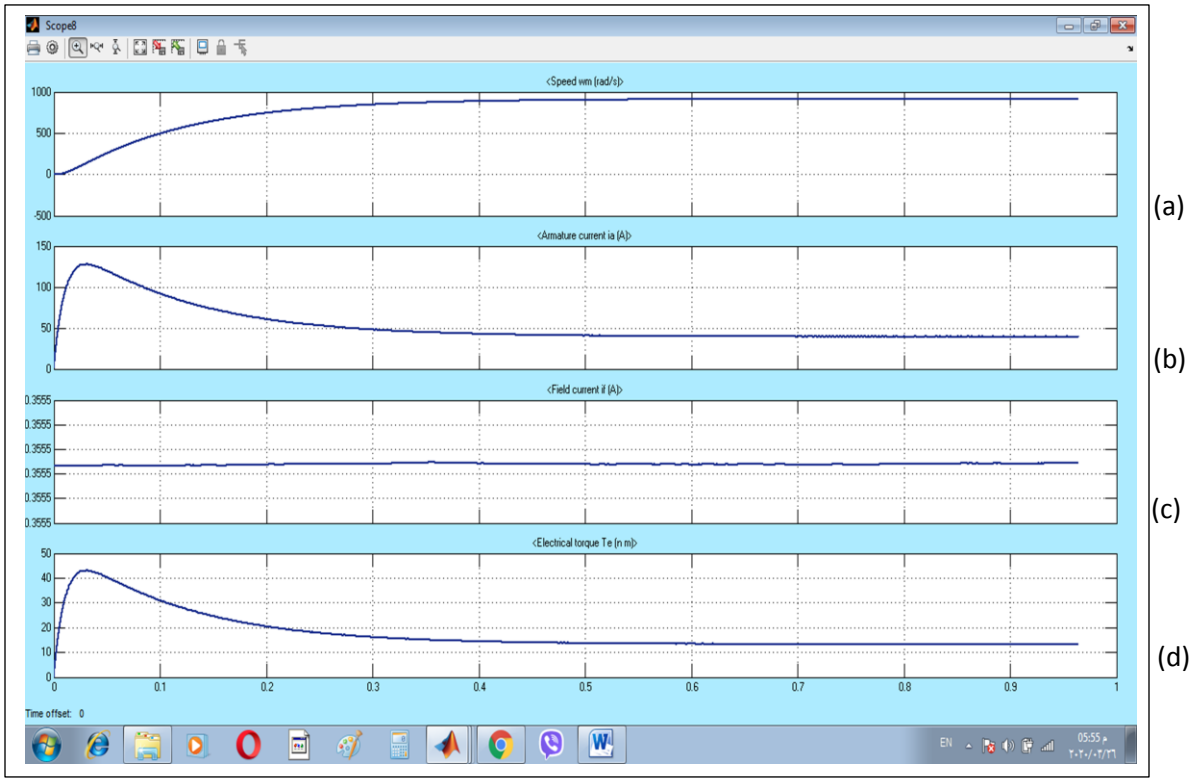


Fig (13) Waveforms of (speed, armature current, field current and torque) for the dc motor

The adjacent line voltage can be written as follow

$V_{dc}= (7/\pi) \int_{\pi/14}^{\pi/14} Vm \cos wt$ -------(8)

V_{dc} : dc voltage of one phase

$I_{dc} = (7/\pi) \int_{\pi/14}^{\pi/14} Im \cos wt$ -------(9)

$I_{dc}(7)$: dc current of one phase

(7)

The equation of the total harmonics distortion (THD) is:

THD % = $\sqrt{\sum_{i=2}^{n} I_n} / I_1^2$*100%

4-CONCLUSION

This paper introduced a novel seven phase rectifier with its analysis where a multi-phase system gets wide range of interesting in many application like wind energy system and sea marine, the results of circuit show the voltage and load current of resistive load where it can be notice good wave form for both voltage and currents for load and source sides also good total harmonics distortion compared with others circuits have phases less than proposed circuit. This circuit can be developed to with other application to make the modern power system more Reliable.

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