Analysis of Harmonic Free Voltage Regulator with Simulation Technique.

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ABSTRACT: The Demand for a stabilized & harmonic free supply voltage (clean supply) is increasing these days, this is because some of today's loads such as computers are classified as power supply sensitive loads, and this means that they require a clean & stabilized power supply.
In order to meet the requirements of the sensitive loads, fixed voltage supply power is required. Voltage Regulator is one of the most used solutions to achieve the requirements of sensitive loads by supplying sensitive loads with fix voltage regardless the input supply variations.
Each method of voltage regulators used earlier has its own advantages & disadvantages; in order to create a voltage regulator model combines all the advantages and none of the disadvantages, to achieve these qualities like: low-cost, high response, no moving parts, linear & produce pure sinusoidal waveform at the output of the regulator, so a new model will be introduced. The goal of this article is to provide a better way of getting clean and stabilized power supply by using voltage regulator and studying it by the help of MATLAB prog.

Keywords: ***Voltage Regulator, Clean Supply, Harmonic Analysis, MATLAB***

I. Introduction

Voltage regulator is a circuit which maintains a desired voltage quantity at a predetermined level usually by comparison with a reference value. A voltage regulator must be an ideal one to produce the desired output without having any harmonics in the output waveform[1]

An ideal voltage regulator must possess the following characteristics:

1. Wide range of input voltage variations.
2. Pure sinusoidal voltage wave at the output of the regulator.
3. Very high response time to the variation of the input voltage.
4. Frequency Independent.
5. Low power self consumption.

Now in this article we are studying to make a voltage regulator having the advantages of all the other regulators and by leaving the disadvantages and try to make the desired output.
For that first of all were studying some of the advantages and disadvantages of other regulators.

II. List of some of voltage regulators with advantages & Disadvantages:

2.1 Electromechanical Voltage Regulators:

Advantages:
1- Sine-wave Output (No-Harmonics).
2- Can provide output higher than the supply.
3- Easy to understand.
4- Low losses.
5- Robust.

Disadvantages:
1- Require circular maintenance.
2- High Weight.
3-Low Response (Because of presence of an electromechanical contactors).
4- Require Cooling System.
5- Has a Limited number of taps.
6- High Cost.

2.2 Static Voltage Regulators

Advantages:
1- Low cost.
2- Reduced Size.
3- Easy to modify the frequency & the amplitude of the output.
4-Generate small harmonics compared with the other electronics regulators.
5-Require small transformers (because of high frequencies, the size of the transformer can be reduced without reaching the limit of saturation).

Disadvantages:
1- High frequencies mean greater distortion of the main supply.
2- High losses in conductors due to the skin effect.
3- Still has harmonics at the output.
4- Require Complex controlling system.[2]

III. Condition for the Design of Regulator:

The main idea of the Regulator is the summation or subtracting of two sinusoidal waves to produce a sine-wave without any harmonics, so, if the regulator add or subtract a certain value of a sine-wave as needed to the input voltage supply, the regulation will be done perfectly.

Figure (3.1) shows the addition and substraction of two sine waves as a general example:

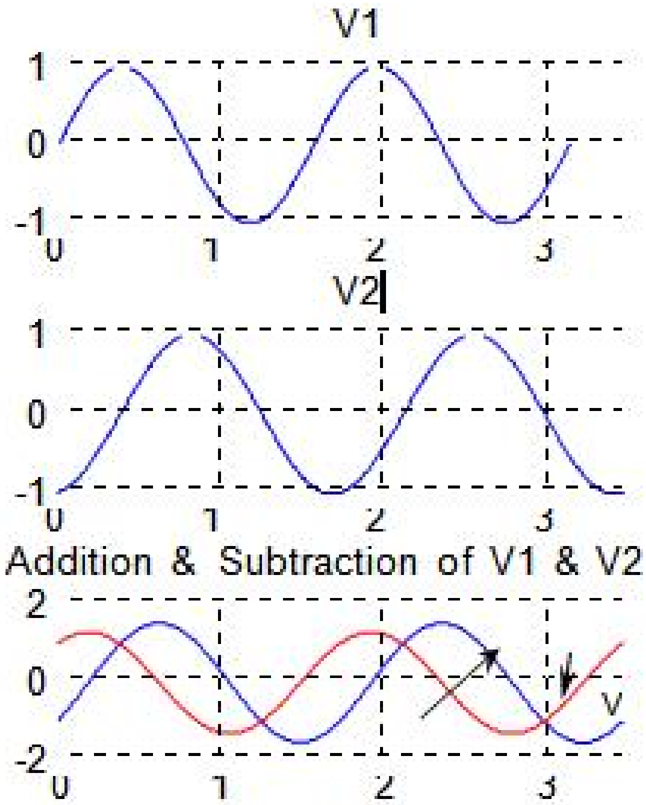

Figure (3.1)

IV. ProposedModel BlockDiagram:

In order to meet the requirements of the sensitive loads (such as computers), a very wide range of voltage regulation is required, very high response time, pure sinusoidal waveform at the output & low self power consumption.

The electronic devices in general have the advantages of high response time, low self power consumption, low cost & light weight. For these reasons the traditional electromechanical devices & switches are replaced by electronics especially power electronics in power engineering field.[3]

The main concept of this project is to replace the motor drive systems(Electromechanical) by electronic control circuits(Electronics), the autotransformer & tap-changer transformer will be replaced by power electronics rectifier & inverter, the stair case regulation process in the traditional voltage regulators will be done linearly(smoothly) by the electronic circuits .

The main block diagram of the electronic linear voltage regulator is shown that can replace the electromechanical devices with solid state devices only.[4]

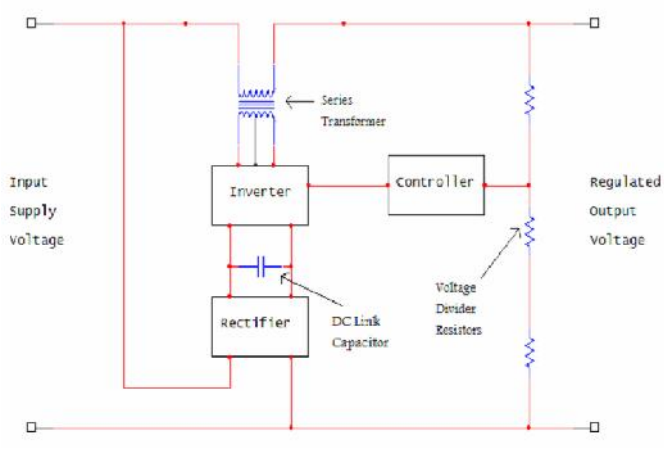

Figure (4.1)

V. HarmonicAnalysis

In order to judge that the proposed model has the advantages of the ideal regulator or not the harmonic analysis can give the appropriate comparison between the proposed model and the ideal regulator.

In this section, the output harmonics few the proposed models, at different input voltages will be discussed and compared with the output harmonics from the other methods used for voltage regulation.

The first thing that must be introduced is the computer program that gives the required harmonics at different input voltages. Firstly, the program is written in MATLAB programming language for performing the operation of the proposed regulator using PWM technique, in this program the operation of the regulator is achieved under ideal conditions, because the main purpose for this program is studying the harmonics of the model NOT the dynamics of it.[5]

So by IDEAL MODEL the following assumption are taken into consideration:

1. The Rectifier is modeled as an ideal rectifier, which means that the output DC voltage is pure DC without any ripple voltage & the used components are ideal, or there are no voltage losses in the rectifier. according to the above assumption the output DC voltage is equal to the peak of the input voltage as shown in the following relation :

$$V_{DC} = \sqrt{2} * V_{in}$$

Where:

V_{dc}: The output DC voltage from the rectifier

V_{in}: The input RMS voltage to the regulator

2. The Inverter is modeled with ideal components, or there are no losses in it.

3. The Transformer is modeled as an ideal transformer with no losses (winding resistance losses, eddy current, leakage inductance & core losses) with a transformation ratio equal to 60/230.

4. The Controller is modeled as an ideal controller, in other words the Controller must produce the appropriate pulsing signals to the inverter. the program choose the suitable DC voltage to compare it with the triangle wave, the program is written to make the regulator produce an output fundamental voltage (at fundamental freq = 50.Hz) in the range of $229 \le Vo_{fundamental} \le 231$ where the input voltage is in the range $170 \le Vin \le 290$ because the main purpose of this program is to study the output harmonics under a perfect regulation process[6].

Figure (5.1) shows the ideal block diagram.

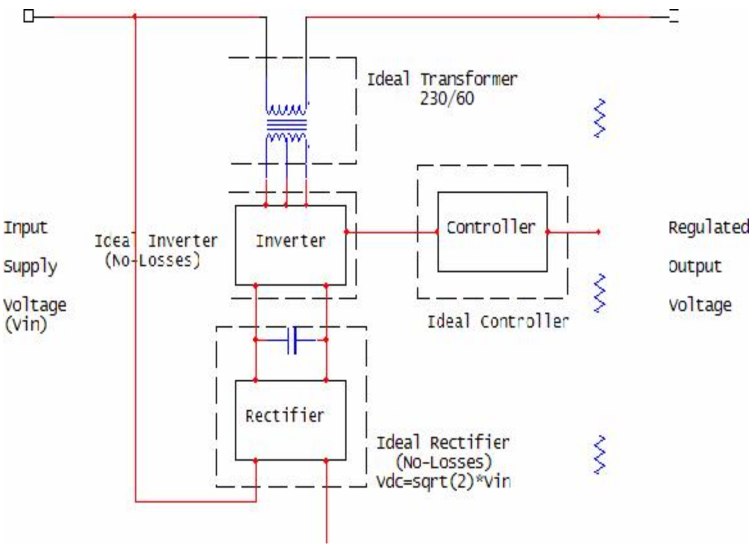

Figure (5.1)

5.1 The following results & figures are obtained from the program in case of under voltage

Enter the RMS Input Voltage [170 =< Vin =< 290]: 190

Performance Parameters

Modulation index (ma) is = 0.5800

Rectifier Output DC Voltage =

Vdc = 268.7006V

The RMS Voltage of the Secondary Winding of the Transformer

Vrms(ideal) = 47.4214

The Fundamental RMS Voltage of the Secondary Winding of the Transformer =

Vrms(fundamental) = 40.3353

The RMS Voltage of the Output Waveform:

Vo(ideal) = 231.6813

The Fundamental RMS Voltage of Output Waveform = Vo(fundamental) = 230.3353

Total Harmonic Distortion (%THD) of the Output Voltage =

%THD = 10.83

From the above results, it can be noted that the fundamental output voltage is in the appropriate range or in other words the percentage voltage regulation error is less than 0.5%. And the required %THD we get is less than 18% (which is the max. value to produce the regulated output).

The following figures show the whole process of the program.

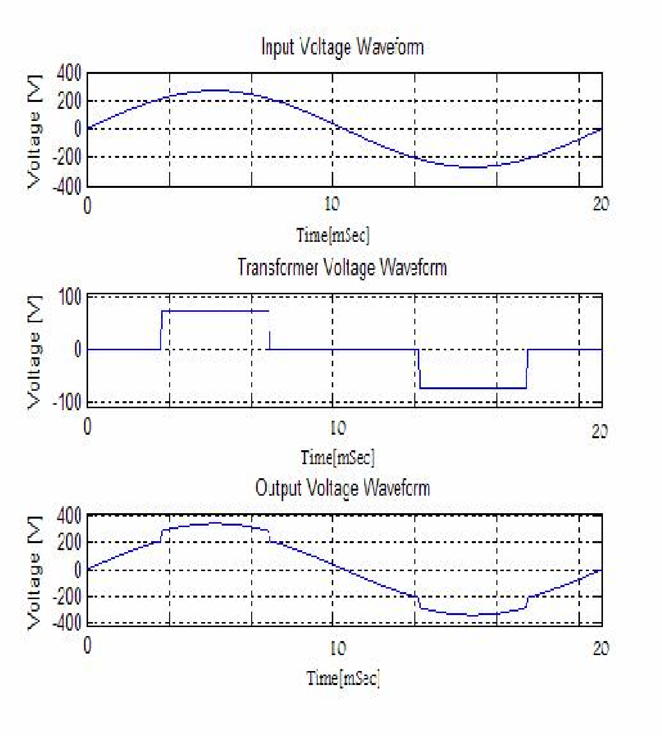

Figure (5.2)

5.2 In case of over voltage, the following results & figures are obtained:

Enter the RMS Input Voltage
[170 =< Vin =< 290]: 260

Performance Parameters:

Modulation index (ma) is = 0.7800

Rectifier Output DC Voltage =

Vdc = 367.6955

The RMS Voltage of Secondary Winding of the Transformer =
Vrms(ideal) = 46.9020

The Fundamental RMS Voltage of the Secondary Winding of the Transformer =
Vrms(fundamental) = 30.4159

The RMS Voltage of the Output Waveform =
Vorms(ideal) = 232.3436

The Fundamental RMS Voltage of Output Waveform =
Vorms(fundamental) = 229.5841

Total Harmonic Distortion (%THD) of the Output Voltage =
(%THD) = 15.5509

The following figures shows the whole process of the program

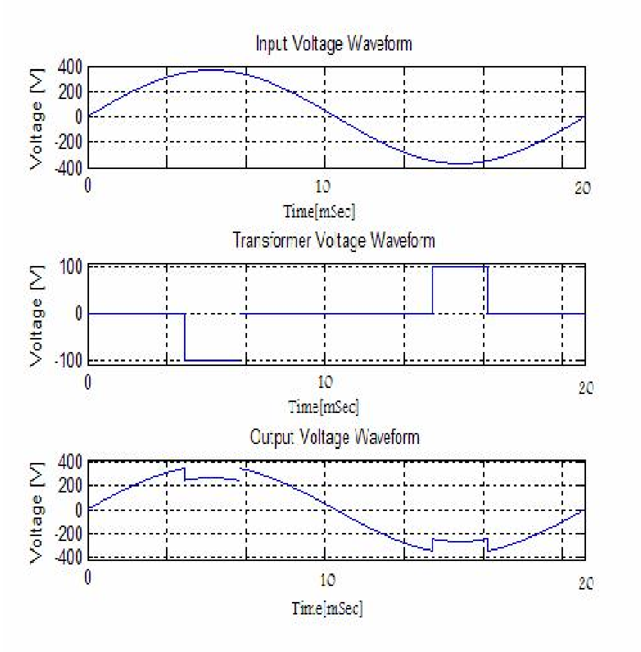

Figure (5.3)

5.3 Summary

From the above done analysis we had found that the output voltage contains a maximum %THD less than 18% (which is the maximum value of %THD for regulated output voltage) which means that the proposed model in harmonic analysis point of view is acceptable.[7]

VI Conclusion

As the above studied model of VOLTAGE REGULATOR, we can say that the Model of the Voltage Regulator we are designing is giving the value %THD in range to give a clean Harmonic free output voltage.

As it is made up by using a series transformer that's why the cost of this voltage regulator is less and the advantages are far more as we compared to the other voltage regulators.

It is a multipurpose Voltage regulator which can be designed on a low scale proposes like for Computers or other devices and instruments or it can be designed for the large scale industries just changing the size of the transformer used.

VII References:

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