American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-10, Issue-8, pp: 96-101
www.ajer.org
Research Paper Open Access

Performance comparison of single-phase-to-single-phase converter and three-phase to three-phase converter with a resistive load.

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ABSTRACT
In industrial applications Speed control of induction motor is necessary. Cycloconverter are used in very wide variable frequency drives with ratings from few megawatts up to many tens of megawatts. A cycloconverter is controlled through the timing of its firing pulses, so that it produces an alternating output voltage. It can also be considered as a constant frequency changer and typically contains silicon-controlled rectifiers. The development of the semiconductor devices has made it possible to control the frequency of the cycloconverter according to the requirement and deliver a large amount of controlled power with the help of semiconductor switching devices like thyristors, in order to get alternating output of variable frequency, This paper reports the operation of a single-phase-to-single-phase converter and a three-phase to three-phase converter using Matlab/Simulink set of pulse generator were used to create pulse to trigger the SCRs in a dual bridge. The output of the simulation shows that the output frequency is 25Hz and the magnitudes of both input and output voltage remain the same, also for three phase to three phase cycloconverter, it was observed that the average value of output voltage is varied by varying the firing or delay angle of the SCRs conduction whereas the output frequency can be varied by changing the sequence of the firing of the SCRs, from the simulation results it can be observed that better output voltages and current are obtained using three phase to three phase cycloconverters as the multiple switching helps minimize output errors.
KEYWORDS: *single-phase-to-single-phase converter, three-phase to three-phase converter, Matlab/Simulink, Thyristor, Cycloconverter, resistive load, pulse generator.*

Date of Submission: 18-07-2021 Date of acceptance: 03-08-2021

I. INTRODUCTION

In industrial applications Speed control of induction motor is necessary. There are several methods for the speed control of induction motor. Cycloconverter are used in very wide variable frequency drives with ratings from few megawatts up to many tens of megawatts. A cycloconverter is controlled through the timing of its firing pulses, so that it produces an alternating output voltage. It can also be considered as a constant frequency changer and typically contains silicon-controlled rectifiers. The development of the semiconductor devices has made it possible to control the frequency of the cycloconverter according to the requirement and deliver a large amount of controlled power with the help of semiconductor switching devices like thyristors, in order to get alternating output of variable frequency [1]. The quality of the output waveform improves if more switching devices are used. Split- phase induction motors are widely used in many applications due to their energy efficient characteristics. Improvements in its performance mean a great saving in electrical energy consumption. Thus, a cycloconverter has the facility for continuous and independent control over both its output voltage and frequency. This paper reports the operation of a single-phase-to-single-phase converter and a three-phase to three-phase converter using Matlab/Simulink set of pulse generator were used to create pulse to trigger the SCRs in a dual bridge.

Traditionally we use the converter and inverter to vary the AC supply frequency (i.e., it converts AC to DC by using converter and then inverter for DC to AC) to change the frequency which is very costly and complicated. Due to this switching of AC to DC and DC to AC the noise produces also the harmonics creates so the sensitive electronic devices may get damaged, if the input and output waveforms is small then sub harmonics also get produced and this limitation is overcome by using the cycloconverter i.e., Intermediate DC stage is not used in this conversion.

Cycloconverter is used to convert the AC supply frequency from one input frequency to another output frequency. Cycloconverter is used for high power applications for driving induction and synchronous motor. So, cycloconverter is used for providing a variable frequency due to its 4-quadrant operation. Intermediate DC stage is not used in this conversion. In cycloconverter power flow is bidirectional.

Most literatures explain a Cycloconverter as a converter that constructs a lower frequency alternating voltage wave from a fixed high frequency alternating voltage wave form and this is done through some switching arrangements SCRS (silicon control rectifiers) or thyristors [2-6, 9-12]. Cycloconverters are mainly used in VVVF (variable voltage variable frequency) ac drives, which are used for running the ac motors of cement and steel industry. Beside this, these types of cycloconverters are also used in aircraft and naval ships industry where motors are driven at variable speed but at constant speed.

Cycloconverters are extensively used for driving large motors like the one used in Rolling mills, Ball mills Cement etc. The out frequency of a Cycloconverters can be reduced up to zero which helps us to start very large motors with full load at minimum speed and then gradually increase the speed of the motor by increasing the output Frequency. Before the invention of Cycloconverters, these large motors have to be unloaded completely and then after starting the motor it has to be loaded gradually which results in time and man power consumption [7].

This thyristor controlled cycloconverter drive can be used in industrial and domestic application such as the machine which have single-phase motor can be drive through this drive. This thyristor controlled cycloconverter drive can be used in vacuum cleaner, washing machine and water pumps. This drive can be used for controlling the speed of drill machine because some time we have required low speed and high torque for this purpose this is best drive. This drive can also be used for the speed control of cement mill drives, Ship propulsion drives, rolling mill drives, Scherbius drives, Ore grinding mills and mine winders. This thyristor-controlled drive is less costly and efficient and compared to the other motor drives [8].

The advent of high-power ratings power electronics has brought about great improvement in the technology of power conversion. Before this time, to convert from AC to AC, there must be conversion from AC to DC first and then the DC be inverted back to AC. This always involves more components. Nowadays, AC can be converted directly to AC without passing through any intermediate step of DC. This has been a good improvement in the field of power electronics. Note that this is a two-stage process with an intermediate dc stage. A cycloconverter is a type of power controller in which an alternating voltage at supply frequency is converted directly to an alternating voltage at load frequency without any intermediate D.C stage. A cycloconverter is to be controlled through the timing of its firing pulses, so that it produces an alternating output voltage [6]. By controlling the frequency and depth of phase modulation of the firing angles of the converters, it is possible to control the frequency and amplitude of the output voltage. Cycloconverters are simply the direct type converters used in high power applications. They are used in driving induction and synchronous motors. They are usually phase-controlled and they traditionally use thyristors due to their ease of phase commutation. Thus, a cycloconverter has the facility for continuous and independent control over both its output frequency and voltage. This frequency can normally be converted up to a magnitude less than 1/3 of the input frequency. The quality of the output voltage wave and its harmonic distortion also impose the restriction on this frequency. The distortion is very low at low output frequency. Traditionally, AC-AC conversion using semiconductor switches is done in two different ways: firstly, in two stages (AC-DC AND THEN DC-AC) as in dc link converters secondly in one stage (AC-AC) cycloconverters. Figure 1 and 2 shows the block diagram conversion.

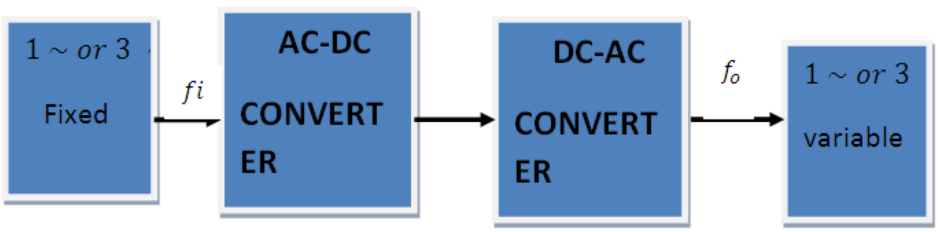

Figure 1: Traditional Converter

Figure 2: Cycloconverter

II. MATERIALS AND METHODS

1. Materials

The single phase to single phase and the three-phase to three-phase cyclo-converters would be modeled in Matlab/Simulink so as to observe the behavior of the cyclo-converter. The Simulink blocks required includes,

- A detailed thyristor (SCR)
- Voltage and current measurement
- Load (resistive)
- Pulse generator
- Ac voltage source
- Wye connected load
- Powergui (discrete)

The thyristors will be connected back-to-back to form a positive and negative converter, powered by the single ac voltage source for a single phase to single phase cyclo-converter.

2. Methods

Single Phase to Single Phase Cyclo-Converter

The single phase to single phase cyclo-converter is simply a frequency changer, changing ac power from one frequency to ac power on another frequency, with the magnitude of both the ac voltage and current remaining the same. In this single phase to single phase cycloconverter, 200V ac voltage at 50Hz frequency are set in ac voltage source block and one pulse generator is used with every leg of this cycloconverter. Each pulse generator gives the trigger pulse to every leg in such a way that on one thyristor switched on simultaneously. 20% duty cycle and 60Hz frequency have been used in every pulse generator. figure 3 shows the Simulink model of the single phase to single phase cycloconverter. From the model, the converter is seen to contain two converters as have been explained in chapter two of this paper, one half of the converter conducts current in the positive direction, while the negative converter conduct current in the negative direction. the gate terminal of both sets of thyristors in each half's are triggered by a set of pulse generators fired at different firing angles so that the thyristors are switched on simultaneously

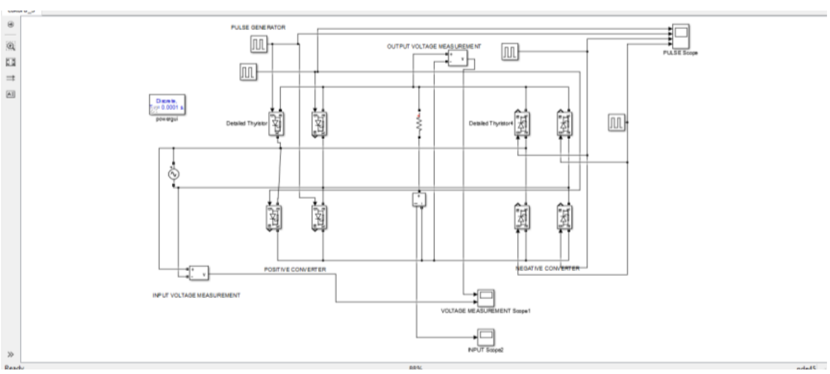

Figure 3: Simulink model of single phase to single phase cycloconverter

Three-Phase to Three-Phase Cycloconverter

This converter consists of six groups of converters circuits where three groups are called positive groups while other three are negative group. During each positive half cycle, a positive group carries the current and during negative half cycle, negative groups carry the current. the duration for conduction of each group of thyristor determines the desired output frequency, also the average value of output voltage is varied by varying the firing or delay angle of the SCRs conduction whereas the output frequency can be varied by changing the sequence of the firing of the SCRs.

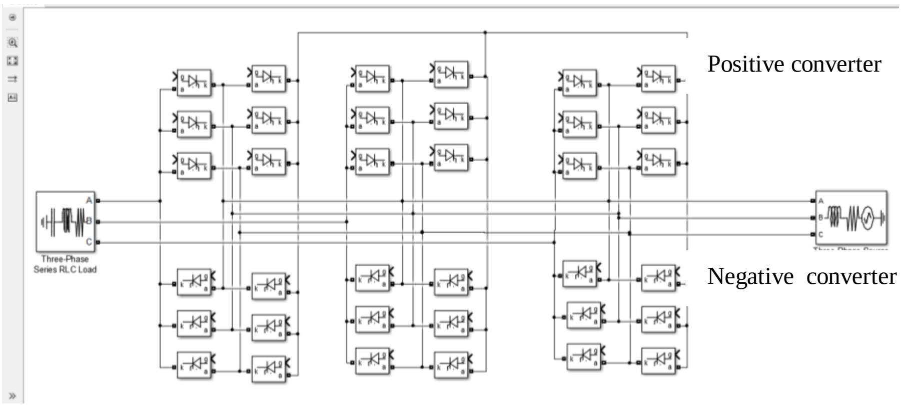

Figure 4: Simulink model three phase to three phase cycloconverter.

The neutral connection is no longer necessary with a balance load and hence this connection can be omitted.

Three phase cycloconverters are more popular than single phase types as these can handle very large currents and produce smooth output waveform.

III. RESULTS

The results obtained show the switching pulses of the firing generators, the input and output voltages of the single phase and three phase cycloconverters.

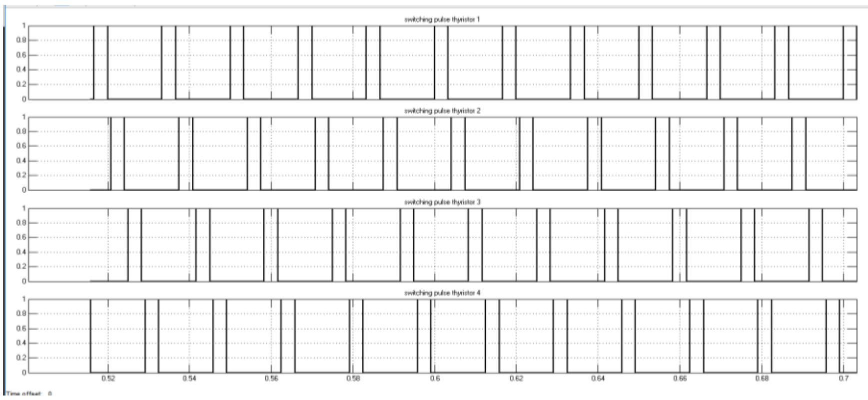

Figure 5: Thyristor switching mode

The switching modes in figure 5 shows that, not any two or three thyristors are switched on simultaneously. They are switched on after one another. This is the main technique which have been used in this single-phase-to-single-phase cycloconverter.

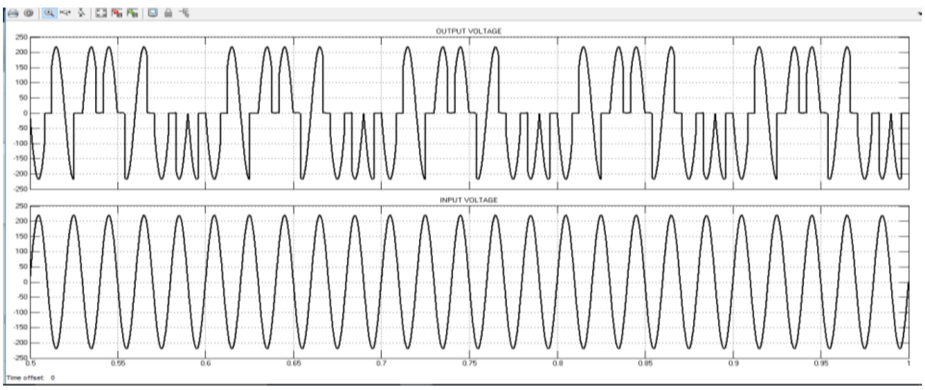

Figure 6: Voltage input and output waveform for resistive load single phase to single phase cycloconverter.

for α =60°, the cycloconverter produces one-fourth of the input frequency. Here, for the first two cycles, the positive converter operates and supplies current to the resistive load.it rectifies the input voltage and produces unidirectional output voltage as we can observe four positive half cycles in the figure. and during the next two cycles, the negative converter operates and supplies load current. Here one converter is disabled if another one operates, so there is no circulating current between two converters.

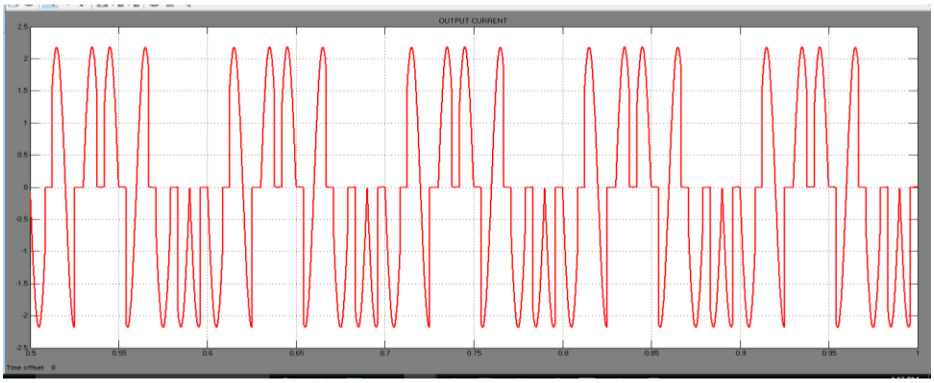

Figure 7: The current waveform of a single phase to single phase cycloconverter with resistive load

The waveform exactly follows the voltage waveform because a resistive load was used.

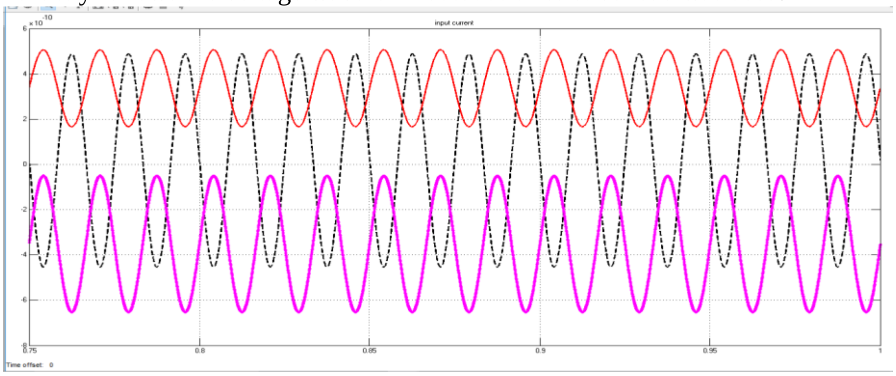

Figure 8: Simulink result of three-phase to three-phase cycloconverter

The three-phase input currents result shows that the three phase currents are out of phase.

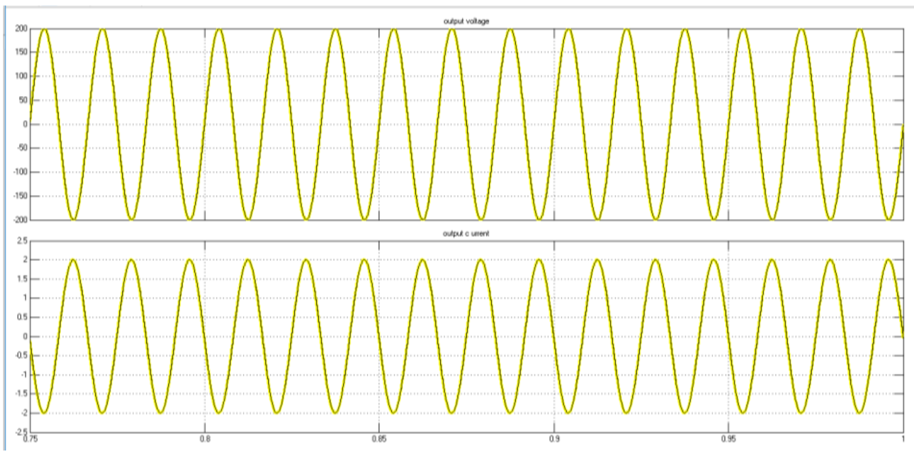

Figure 9: Simulink result of three-phase output voltage and current

The result shows that the phase voltages and currents are all in phase.

IV. CONCLUSION

The single-phase to single-phase and the three-phase to three-phase cycloconverters have been designed using Matlab/Simulink software. The output of the simulation shows that the output frequency is 25Hz and the magnitudes of both input and output voltage remain the same, also for three phase to three phase cycloconverter, it was observed that the average value of output voltage is varied by varying the firing or delay angle of the SCRs conduction whereas the output frequency can be varied by changing the sequence of the firing of the SCRs, from the simulation results it can be observed that better output voltages and current are obtained using three phase to three phase cycloconverters as the multiple switching helps minimize output errors. In conclusion, a constant voltage variable frequency cycloconverter has been designed for usage in low frequency demand.

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Irokwe, N. V, et. al. "Performance comparison of single-phase-to-single-phase converter and three-phase to three-phase converter with a resistive load.”*American Journal of Engineering Research (AJER)*, vol. 10(8), 2021, pp. 96-101.