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Closed Loop Control of BLDC Motor in Aircrafts for Flap Angle Applications

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ABSTRACT: Actuator systems, which feature a combination of motors, actuators, and auto transformer rectifier units, are used in aircraft applications such as landing gears, flaps, and rudder systems. The frequency of these systems is 400Hz. These are AC to DC converters that are used in aircraft systems to provide consistent DC power to motors, which then control actuators. These converters are different depending on the pulses, such as 12 pulses, 18 pulses, and so on. A 12-pulse and 18-pulse AC to DC converter was proposed for 400Hz and 50Hz in this study for BLDC Motor. The results were shown in MATLAB/Simulink for both 12 pulse and 18 pulse ATRU.

I. INTRODUCTION

The source (AC generator or DC generator – battery source), conversion units (AC to DC converters, also known as ATRU system), and load are the three primary components of an aircraft system (which are usually an AC or DC load). The system in traditional aircrafts used to run on 28V DC power, but in more contemporary technological systems, the aircraft systems now run on 115V of AC electricity at 400Hz. When compared to conventional systems, the 115V three phase AC voltages require less winding, resulting in a compact system that produces the same amount of energy as a 400V system while being more efficient. Because weight has such a large impact on aircraft, these technologies are thought to be more reliable than others. The diagram shown below represents the ATRU in aircraft.

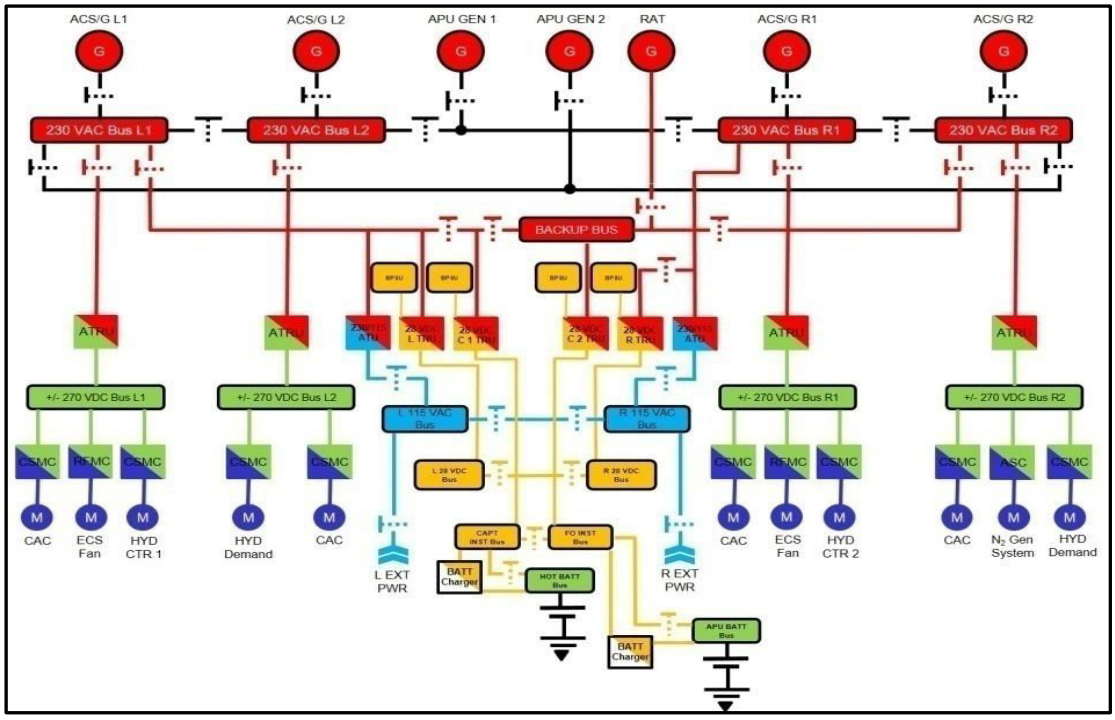

Figure.1 Aircraft Power Distribution System

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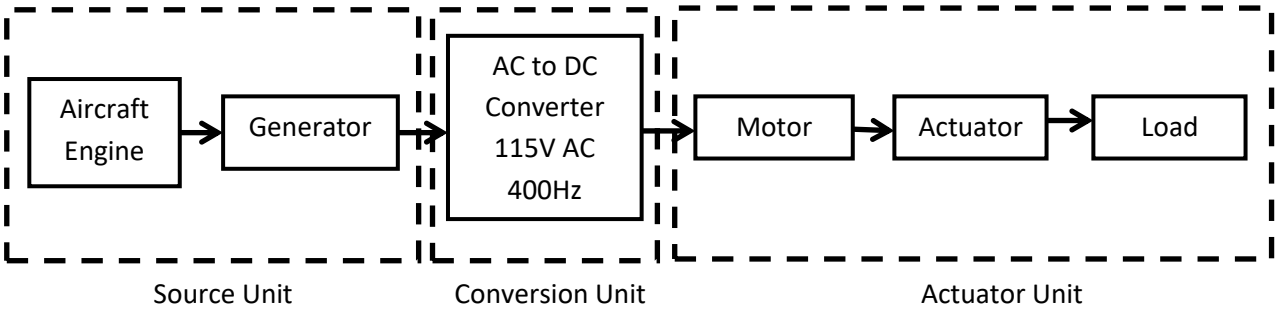

Figure.2 Block diagram of Aircraft Actuator System

The electricity is generated by a 115V AC 400Hz source unit. This is fed into the conversion unit, which transforms the AC power into 270V DC power. This is fed into the motor, which controls the actuator system that controls the load. In traditional aircrafts, the actuator systems were hydraulic or pneumatic, but in today's world, aircrafts use Electrohydrostaic Actuators (EHA) or Electromechanical Actuators (EMA) that combine the functions of a motor with hydraulic or mechanical actuators.

II. SYSTEM MODEL

12 PULSE

The twelfth pulses in a 12-pulse ATRU are formed by merging two six-pulse diode rectifiers, which are linked to phase-shifting transformers to achieve the appropriate phase shift of 0° and 30°. The block diagram of a 12-pulse ATRU using a three-phase delta linked input autotransformer is shown below.

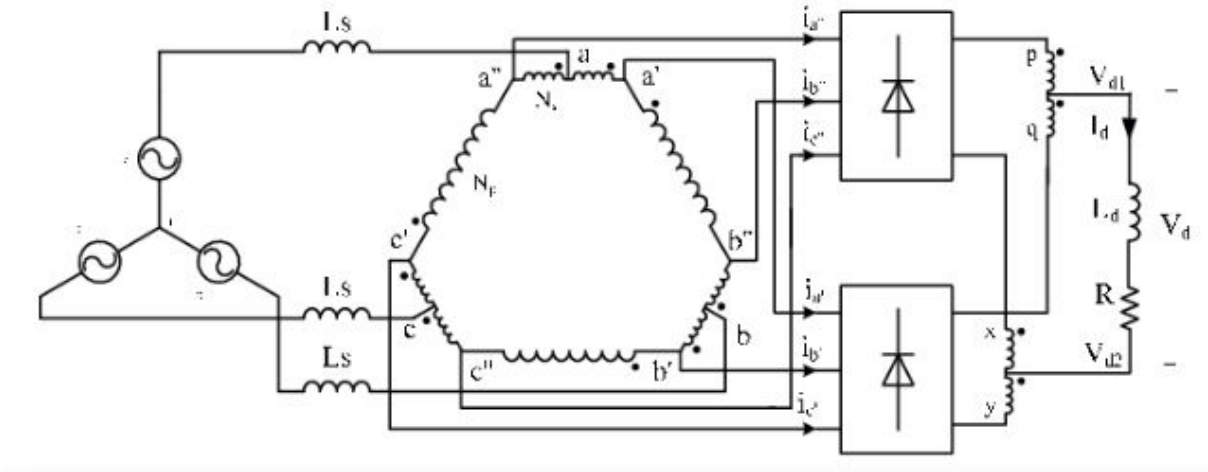

Figure.3 12Pulse ATRU system

18 PULSE

Eighteen pulses are generated in an 18-pulse ATRU by combining three six-pulse diode rectifiers, which are coupled to phase-shifting transformers to achieve the appropriate phase shift of 40°, 0°, and -40°. The block diagram of an 18-pulse ATRU with an input three-phase delta linked autotransformer is shown below.

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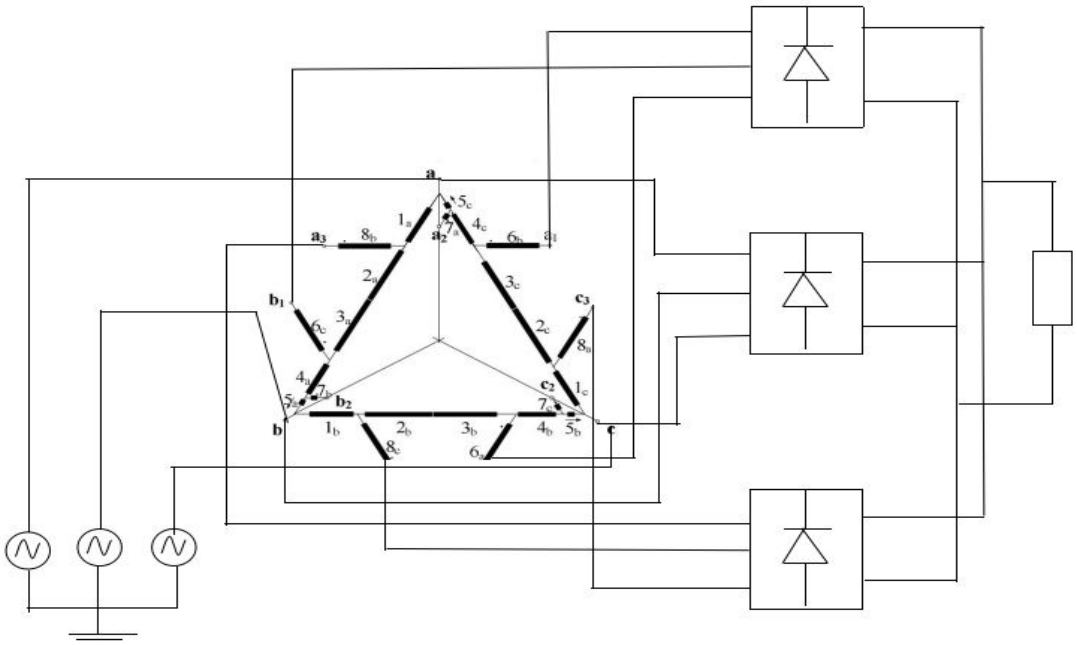

Figure.4 18 Pulse ATRU system

Secondary three-phase voltages are converted to three dc voltages using three uncontrolled 6-pulse rectifier bridges. The uncontrolled bridge rectifiers' DC outputs are coupled in parallel to the load to give a DC voltage of 270V with a ripple frequency of 7200 Hz for 18 pulses.

III. SIMULATION SYSTEM

The simulation system for 12 pulse ATRU has shown in figure. The system is simulated in MATLAB/Simulink consists of Three phase AC source, Auto transformer with star and delta connection respectively. A rectifier circuit which converts three phase AC to DC to the motor which is BLDC motor in this case.

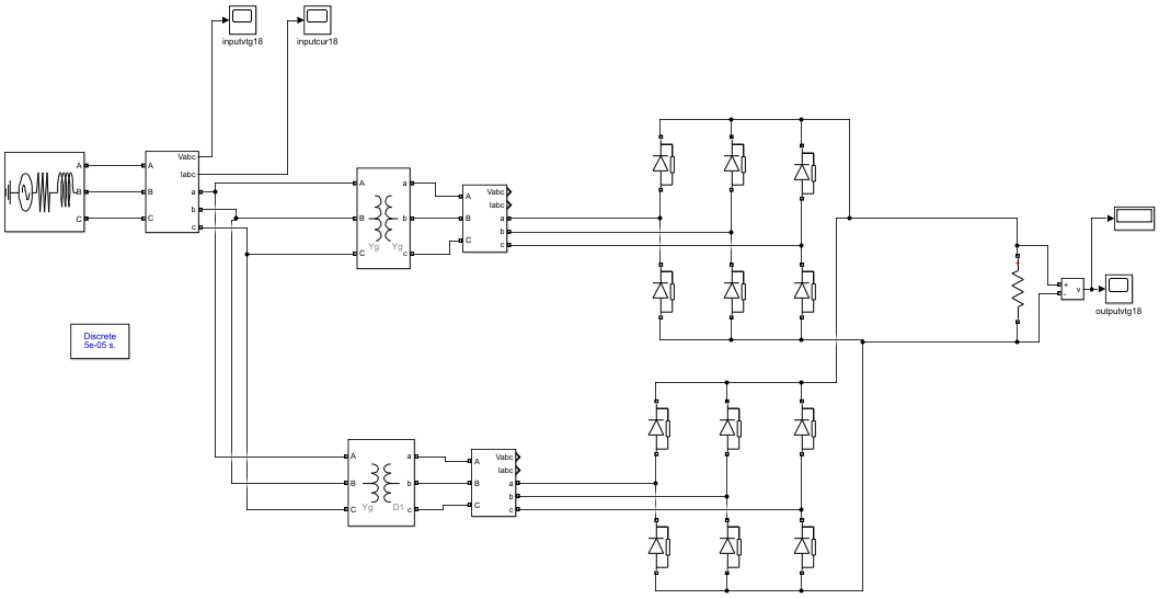

Figure 5 Simulation system for 12 Pulse ATRU

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The figure shows the 12 pulse ATRU with the BLDC motor in the closed loop using the SPWM methodology. The BLDC motor is used for the actuators in the aircrafts for the flap angles.

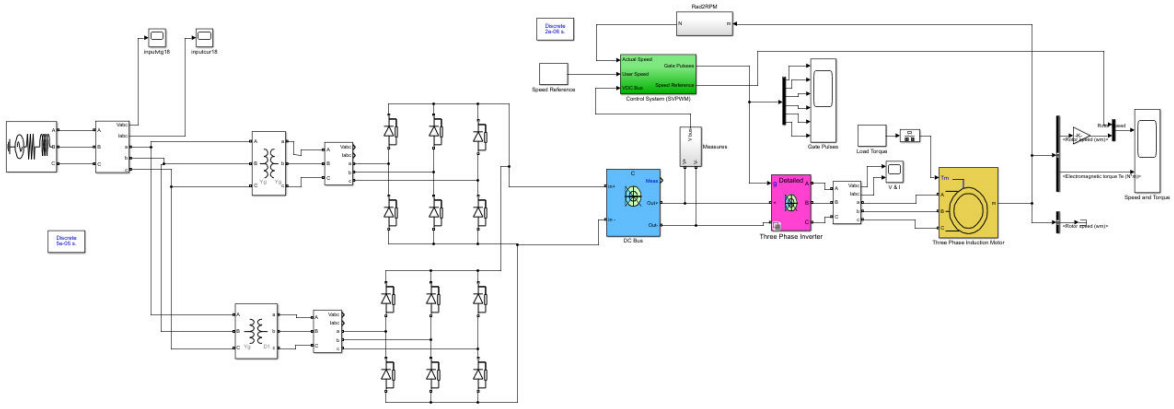

Figure.6 Simulation system for closed loop operation of BLDC motor for Actuator System using 12 Pulse ATRU

The closed loop control of BLDC motor is done for the 1000RPM. The actual speed and the user speed coincide. For the control purpose the speed and the rotor angles are taken for the change of pulses in inverter.
The input AC is passed through the auto transformer unit which is in both star and delta form. The AC voltage is passed through the rectifier to receive the DC supply. This power is given to the input of the inverter through the DC bus. The inverter again changes the DC power to AC power for the BLDC motor. The motor in closed loop runs according the user speed given in the constant block.

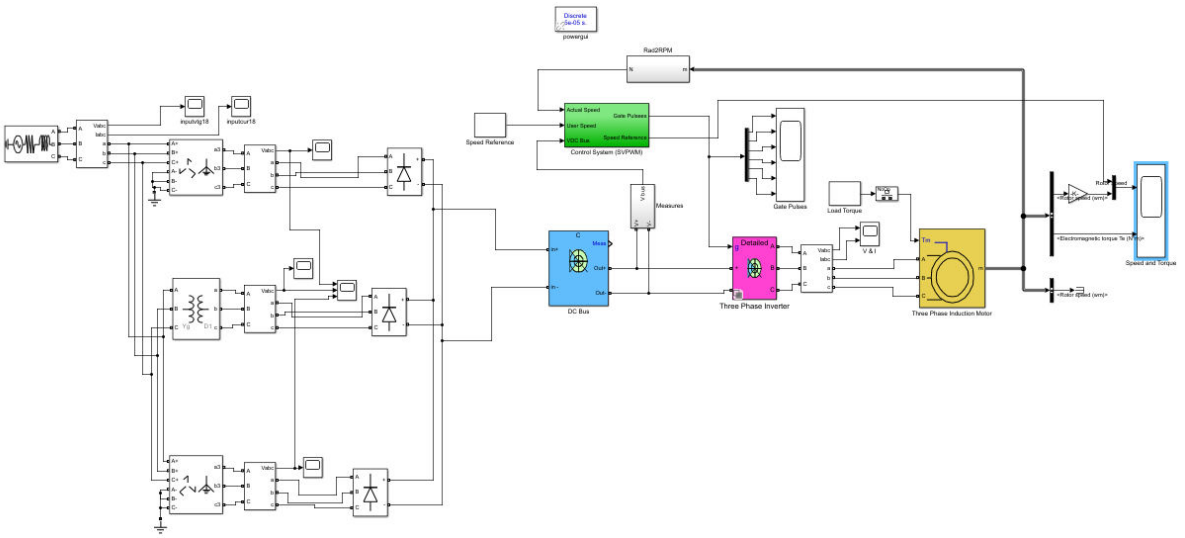

Figure.7 Simulation system for closed loop operation of BLDC motor for Actuator System using 18 Pulse ATRU

The above figure represents the closed loop control of BLDC motor in aircrafts for 18 pulse ATRU for flap angle applications. This system is same as the above system but only difference is this system uses 18 pulse ATRU.

IV. SIMULATION RESULTS

The input and output voltages for the 50Hz systems, respectively, were noted down for the simulation systems. The input voltages and currents are also utilised to determine the system's THD. As can be observed from the results, the simulated system's input voltage matches that of the hardware system. In the simulated system, the input voltage is shown for three phases.

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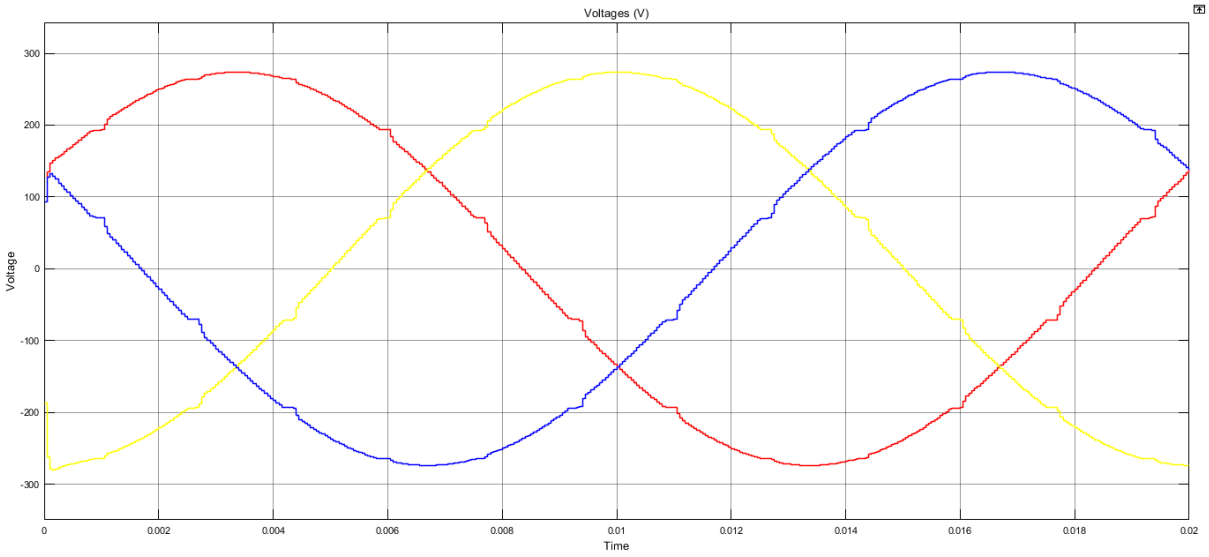

Figure.8 Three phase voltage system

The simulation results for the proposed system using the BLDC motor is shown below. The system first produces 12 pulses in the time cycle of 20ms. This is shown in figure.

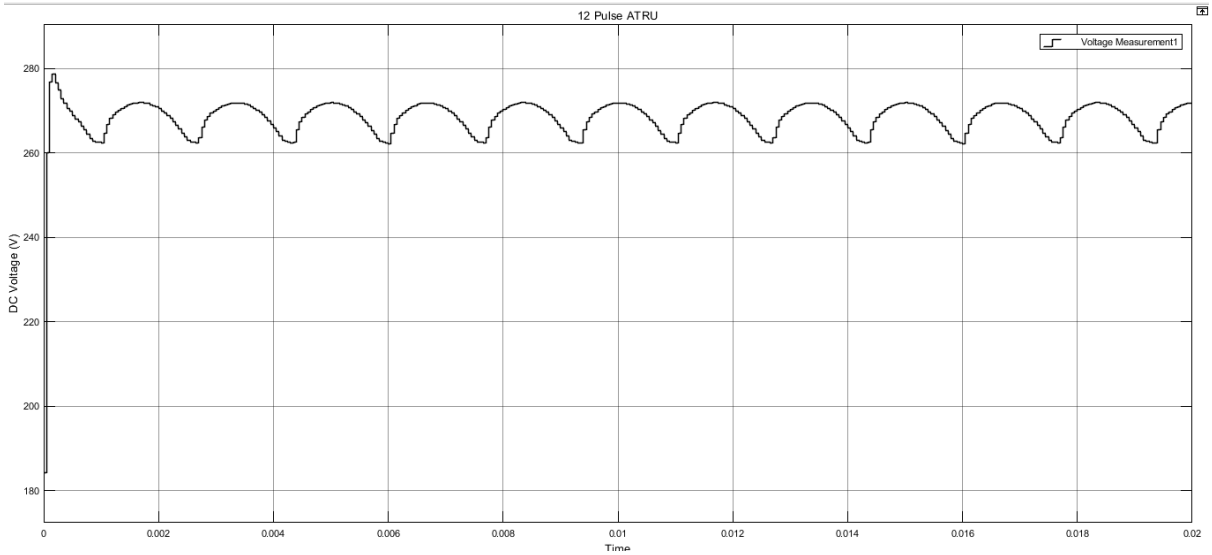

Figure.9 12 pulse rectifer output

The defined and the actual speed of the motor is shown in the system of BLDC motor which coincides with other. The results shows torque and speed of the BLDC motor in closed loop system.

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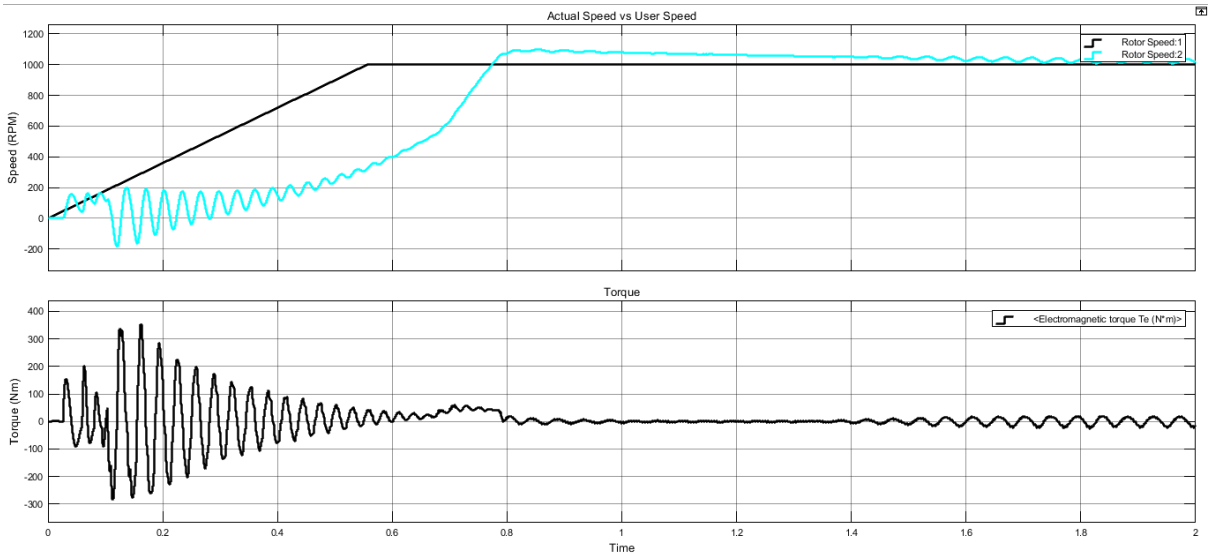

Figure.10 Comparison of user and actual speed in actuator system

The torque is disturbed at the beginning as the speed has to reach the defined speed. Once the defined and actual speed matches the torque almost becomes equal to zero and becomes steady. The defined speed by the user in this system is 1000RPM. In the above figure the actual speed matches the user speed after 1.2 time cycle.

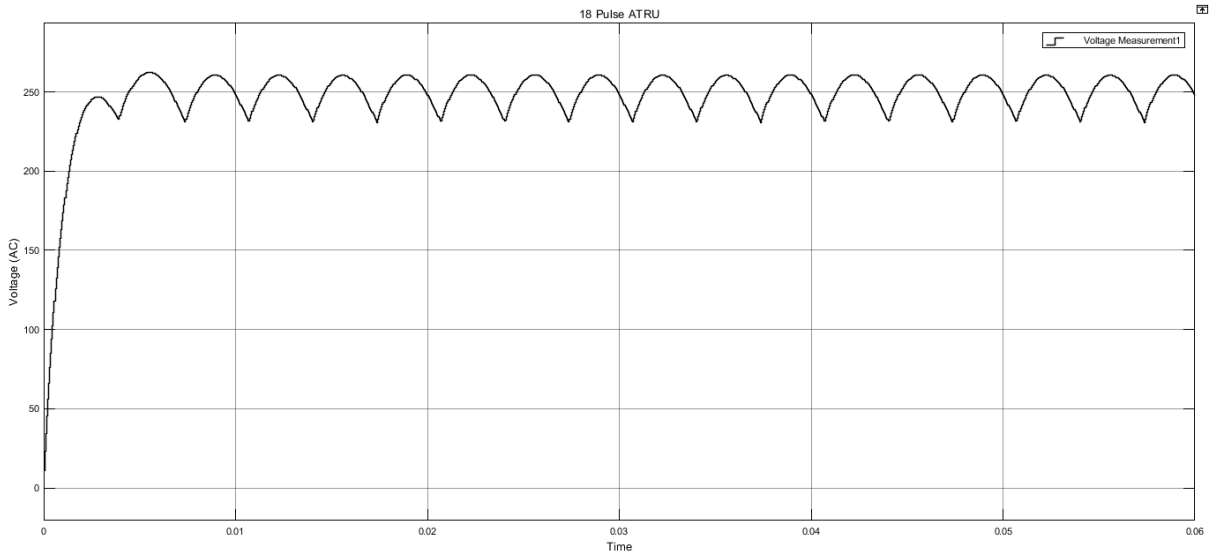

Figure.11 18 pulse rectifer output

The waveform shown is for 18 pulse ATRU output which is DC in nature. It creates 18 pulse in a cycle of 0.06

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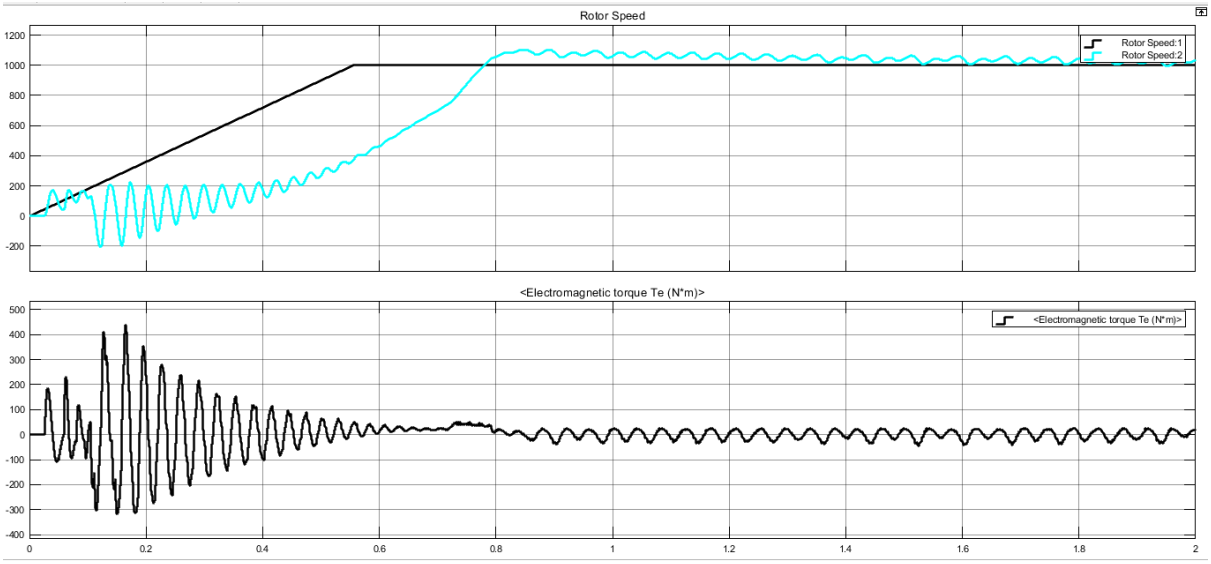

Figure.12 Comparison of user and actual speed in actuator system

This waveform represents the output speed control of the BLDC motor where user speed is 1000 RPM and the actual speed coincides with it.

V. CONCLUSION

A 12-pulse and 18-pulse AC to DC converter was designed for 50Hz (in simulation) in this work. The system was design in MATLAB/Simulink. The input and output voltages of the simulated and modelled systems match, resulting in an efficient and dependable model for the applications.

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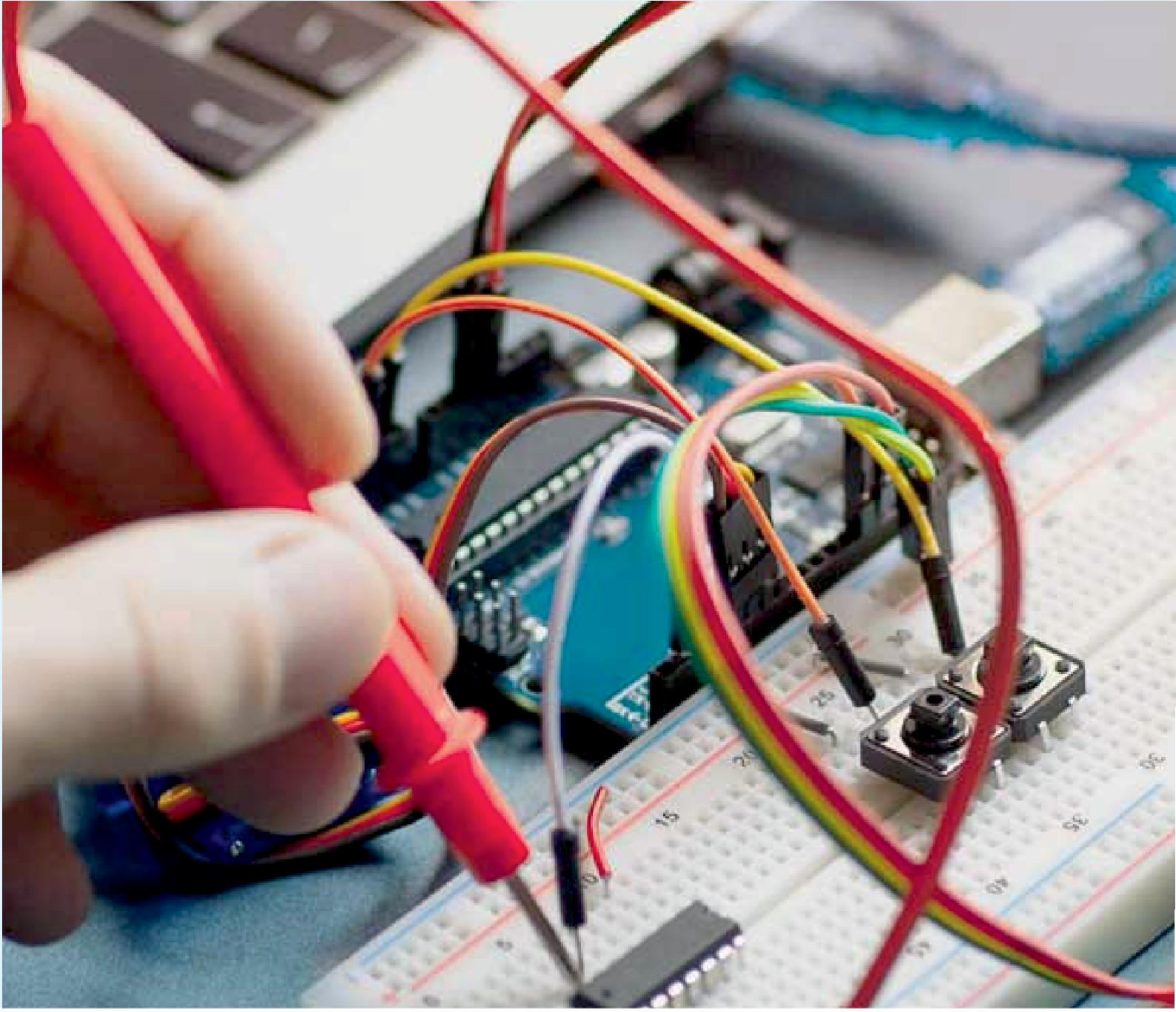

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