WPC: Wind Power Converter

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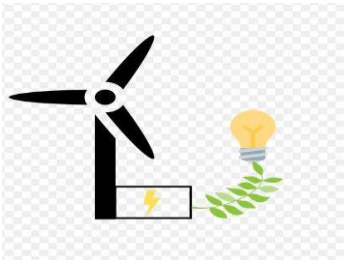

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Introduction:

Wind turbine is one of the cleanest renewable energy, and it's one of the fastest growing industrial among the renewable energy. Wind turbine convert the mechanical energy that caused by the wind to an electrical energy. That electrical energy can be used in resident area like house, or it can be used in business area like supply the malls with electricity. In order to convert from those two types of energy, a device called "converter" is used. Converters are usually made with rectifier (converter AC to DC) and inverter (converter DC to AC). the reason for using converter is to control the energy that enter the grid. Since wind is unpredictable and it change with time, and that caused the generator to produce different values of voltage and frequency, so the converter changes the voltage and frequency that produced from the generator to a fixed voltage and fix frequency. Fixed voltage and fixed frequency mean that the voltage and frequency do not change over time even if the turbine run with different speed.

The team task is to build and test an NPC (Neutral Point Clamped) converter. NPC converter consider as a three-level converter, which means the output has three stage, which increase the efficiency and reduce the power losses. NPC converter made with rectifier and inverter, the rectifier is used to convert the AC voltage that produced from the generator to DC voltage then convert that DC voltage to AC voltage with fixed voltage and fixed frequency. Since the wind is unpredictable, the team will not be able to test the converter unless it is windy. In order to fix that problem, a motor is used as a wind source, and that motor is controlled by AC drive, which control the motor speed and frequency. The motor shaft is attached to the generator, so when the motor run at different speed and frequency, the generator will produce the same voltage and frequency as the motor.

WBS Charts:

Mohammad's WBS:

	Activity	Description	Deliverables	Completion	Dependence on group member
Sub. 1					
	MATLAB Coding	Calculate the speed of the motor/generator.	-Create with Simulink. -Simple and easy to understand (for the client)	Finished	Non
Sub. 2					
	Soldering Gate Drive	Control and modify the signal from the IGBTs/Diode.	-6 Gate Drive. -Place component correctly.	In Progress (03/01/2019)	Non
	Testing	Testing the voltage sensor	-Accurate reading for the voltage. -Small offset. -Accurate reading for the voltage. -The light turns on when the voltage sensor is on.	Finished	Hamad
Sub. 3					
	Testing	Testing the Rectifier, which is used to converter AC to DC	-Change the value from AC to DC -The IGBTs/Diode are evenly spaced. -Easy to access.	Finished	Fahad
Final Design					
	wiring	Wiring the Rectifier, Gate Drives, and Interference board	- Strong/Tight wiring - Easy to track	In Progress (03/08/2019)	Sub. 2 and Sub. 3: (Hamad and Fahad)

Hamad's WBS:

	Activity	Description	Deliverables	Completion	Dependence on group member
Sub. 1					
	MATLAB Coding	measure the output for the motor/generator	create a Simulink code	Finished	Non
Sub. 2					
	Soldering PCB board	Measure the voltage across the IGBTs/Diode	Soldering the voltage sensors	Finished	Non
	Testing	Gate Drive is controlling the IGBTs/Diode	Testing 6 Gate Drives	In Progress (03/06/2019)	Mohammad
Sub. 3					
	Testing	Testing the Inverter	Change the voltage from DC to AC	Finished	Abdullah
Final Design					
	Wiring	Wiring the Inverter to the Gate Drive then to the Interference board	Connect properly	In Progress (03/08/2019)	Sub. 2 and Sub. 3: (Mohammad and Fahad)

Abdullah's WBS:

	Activity	Description	Deliverables	Completion	Dependence on group member
Sub. 1					
	Testing	Testing the speed of the motor and generator	Speed of the motor is the same as generator speed.	Finished	Mohammad & Hamad
Sub. 2					
	Soldering Gate Drive	Circuit isolation	6 Gate Drive	In Progress (03/01/19)	Non
	Testing	Testing Current sensors	accurate reading with a small current offset	Finished	Fahad
Sub. 3					
	Drilling	Drilling the heatsink	Even spaces between the IGBTs	Finished	Non
Final Design					
	Testing	Check connections based on the schematic	Correct connections	In Progress (03/11/19)	Mohammad

Fahad's WBS:

	Activity	Description	Deliverables	Completion	Dependence on group member
Sub. 1					
	testing	Compare the values from the AC drive to Simulink	The speed of the motor matched the speed of the generator	Finished	Mohammad and Hamad
Sub. 2					
	Soldering PCB board	The current sensor used to measure the current across the IGBTs/Diode	Soldering the Current sensors	In Progress (03/01/2019)	Non
	Testing	Gate Drives gives circuit isolation and control over the IGBTs/Diode	Testing 6 Gate Drives	Finished	Abdullah
	Drilling	The stander that would hold the Gate Drives	The height of the stander matches the height of the heatsink.	Finished	non
Sub. 3					
	Drilling	Drilling holes for the IGBTs/Diode	The spacing between the IGBTs/Diode are evenly	Finished	Fahad
Final Design					
	Testing	The Inverter is connected to the Gate Drive	The Inverter is connected correctly	In Progress (03/11/2019)	Hamad

WBS Discussion

For the WBS the team decided that every team member should contribute in each subsystem in order to understand all the concept of the project. The way we divided the work was that every team member should participate in building and testing, if two members is working on building the other two is testing their work. Below we will go deeper in explaining each subsystem and mention each team member tasks.

Subsystem 1:

In subsystem 1 we are supposed to build a MATLAB code using Simulink to test the motor/generator speed and since the subsystem 1 have two tasks we let two of the team members work on one task the first task is to build a MATLAB code, which Hamad and Mohammad worked on it for three days, since the motor/generator is our power source Abdullah and Fahad tested the motor/generator at different speeds and frequencies as the

second task, building and testing the motor/generator toke a week and the team already finished it.

Subsystem 2:

For the subsystem 2 all the requirements are based on soldering PCB boards, and every team member need to build at least one PCB board, Mohammad and Abdullah are working on solder six Gate drives for each of them, Hamad is working on soldering the voltage sensors, and Fahad is soldering the current sensors, we did not finish all the tasks on subsystem 2, we finished the voltage and current sensors but we are still working in the Gate drive, as for the testing tasks Mohammad and Abdullah tested the voltage and current sensors, and Hamad is waiting for Mohammad and Abdullah to finish the Gate drives to test them.

Subsystem 3:

For the subsystem 3 the team required to build the Neutral point clamped converter (NPC) that has three outputs. The NPC converter is a combination of rectifier and inverter, rectifier contributes in converting the AC power getting from the generator to DC power, and the inverter is converting the DC power to an AC before sending it back to the grid. In this subsystem we divided the work as follows Fahad and Abdullah will be drilling the two heatsinks which one will be used as a rectifier and the other one will be used as an inverter. After Abdullah and Fahad get done with drilling the heatsinks and placing the IGBTs/Diodes, both Hamad and Mohammad will be working on testing the components to ensure that they are working properly before going ahead to the final design. This subsystem status is completed, and the duration of this subsystem was 3 days, and we are waiting for subsystem 2 so we can work on the final design.

Final Design:

The final design will be building our final step which is the NPC converter by getting all the subsystems together and wiring them. The final design is depending on all the subsystems, so we have to get done with all the subsystems and make sure that they are working properly before we get them all together. The estimation we set for finishing this part is before the spring break and we will be devoting the rest time for testing and debugging the final design before the day of presenting it.

Risks, Challenges, and Resolutions:

The team started working on the project since last term, but the deliverables for this project changed based on the client (Dr. Yaramasu) request. The first challenge was the power model that the team is using to build the rectifier and inverter changed. Power module is containing IGBTs and Diodes, so the team had to study the new power module and understanding the connection that inside the power module. The team found the data sheet for that module and studied it and drew a schematic of the connection for each pin in the power module.

The second challenge is the size of the board that the team must install all the device on it. The team started with 50x50 inches board to 58.5x22 inches board, and the board need to be display vertically. So, with the first board the team had the size to space out the devices with some space between each device, but with the new board, the space between the devices reduced, which some devices have less than half inch between them. Having no space between the devices makes it hard to connect them together and the board get messy with wiring, so the team chose to use different colored wires, and run some of the wires on the back of the board.

The Final challenge the team is facing as of today is the gate drive in the second subsystem. First, the team needed a heat gun to solder the gate drive, but the heat gun did not arrive in time, so the team delayed the soldering by one week. After receiving the heat gun, the team was supposed to work on them, but the soldering got delayed another week due to bad weather conditions. Lastly, the team was planning on working on the soldering the gate drives last week, but some components were missing, so the team discussed that issue with the client, and they would be provided this week, so the team moved to the final design until the components arrive.

Conclusion:

The wind power converter is one of the great examples of renewable energy nowadays and we should focus on it more. This explains why Northern Arizona University offering such of this project showing how important the wind power converter is. The estimation of completion the project was set before the spring break (March 16) if everything goes as planned. Unfortunately, subsystem 2 was delayed due to the heat gun was damaged and luck of PCP boards for soldering the gate drives, but the good thing that we have been told by the client that the gate drives will be provided by him soon. The current status of our project is we attached every components in the board and we have attached the wires to the converter and start working on wiring the inverter and rectifier, and we have set the wires for the gate drives and we have drilled their space in the board so as soon as we get the gate drives we can attach the wires to the gate drives. The reason we have set the project to be done before the spring break is that we will have a big gap in the week after the spring break till the day of presenting the final project, so we will use this gap for testing and debugging and if any issues shows up during the process we still have a time to go back and resolve the issue.