Computer Engineering and Intelligent Systems
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol.9, No.6, 2018

Optimal Combination of Solar Energy and Diesel Fuel in a System Used in Remote Areas

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Abstract
Regarding importance of security and safety in all countries around the world, the work of the security men requires the use of all means of communication wired or wireless to surveillance and monitor the security situation around the clock. So, there are remote sites belonging to the Ministry of the Interior such as deserts, mountains and maritime islands takes a long time to arrive to it after trouble and hardship. At those locations, towers and communication devices working on generators that work by diesel but the main problem is the sudden interruption for these generators causing disrupted communication devices. And the period of interruption may be an opportunity for intruder to entry across borders or for terrorist person in carrying out his plans. So, we had to resort to renewable energy for a stable and sustainable energy working permanently to nurture communication devices while backup generators in case of a defect in a renewable energy system.Through the renewable energy will decrease many problems including sudden interruption of communication devices that may cause security problems, reducing the cost of fuel, the cost of spare parts. The research interested in using optimal combination of solar energy and diesel fuel in a system used in remote areas, the system can provide the electrical power all time without any trip because it works in completed way when the diesel fuel ends the system will use the electrical power which produced by solar energy in automatically.
Keywords: Simulation, Optimal combination, solar energy, diesel fuel and remote areas.

Introduction

The need for using renewable energy is increasing in continuously at many fields from houses, companies, factories, observation towers and other areas of life. renewable energy is important method to get electrical power because it free and permanent energy. The solar panels are the most common methods used in many countries but it is expensive that make problems for many cities to use so the research attend to study other method to create electrical power form solar power such as solar chimney. The protection system use diesel to provide the system with need energy but that not enough because when any fault occurred the system will stop worked. When we talk about protection and surveillance systems that mean we need the electrical power all time, so in this study will improve new system used optimal combination of solar energy and diesel fuel in a system used in remote areas. the main idea from this method that providing the system with power for all time when the diesel fuel ends the system will use the electrical power which produced by solar energy in automatically.

Literature review

In the 1860s, an electrician called Willoughby Smith was testing underwater telegraph line for faults using a material called selenium. By chance, he discovered that electricity travelled through selenium very well when it was in light [1].

In the late 1870s, two American scientists, William Adams and Richard Day, became interested in this new discovery. They soon discovered that the sun's energy creates a flow of electricity in selenium [2].

At 1880s, Charles Fritts invented the first PV cell by putting a layer of selenium on a metal plate and cover it with gold chips and place it in the sunlight, this cell creates even more electricity but not enough to be useful [3].

At 1931, Bruno Lange, a German scientist, built a solar cell panel out of selenium. But Lange had the same problem as Fritts. His panel generated such a tiny amount of electricity, it wasn't very useful. Another problem was that the selenium cells didn't last long in strong sunlight. For those reasons, some experts thought PV cells would never be a good way to create electricity. It wasn't until the 1940s that people became interested in solar electricity generation again [4].

In the early 1950s, Calvin Fuller and Gerald Pearson, two scientists who worked at the Bell Laboratories in the USA, tried to improve silicon transistors for electrical equipment. By accident they created a PV cell that also generated electricity when it was placed in light. It was made out of two different kinds of silicon that had different metals mixed in [5].

In 1953, another Bell scientist called Daryl Chapin was tried to make selenium cells better at generating electricity. But he did not have much success. After Pearson told Chapin about his accidental silicon PV cell,

Chapin started to look into it straight away. The Bell scientists were excited to find that silicon PV cells made nearly five times more electricity than selenium cells [6].

The Bell scientists spent a whole year experimenting with the silicon cells so they could make enough electricity to be useful. Finally, after many disappointments, they succeeded. They did this by mixing tiny amounts of different chemicals into slices of silicon crystals. The PV cells they invented were 50 times more efficient at generating electricity than the selenium cells had been 20 years earlier [7].

Soon after this, US military scientists started to investigate if they could use PV cells to give power to satellites that were in orbit. Those scientists thought that because PV cells could make electricity for years they would be better than the batteries that ran out of power after a few weeks [8].

By 1972, approximately 1000 satellites were running on solar power. This meant more money was spent on improving PV cells. So, the cells became lighter, more durable, and better at generating electricity [9].

By the mid-1970s, PV cells were being used for power in remote places where it was too expensive to use electric cables. These were the kind of places where it was difficult or expensive to bring in new batteries or fuel for electricity generators and this is our focus, is to feed our telecommunication towers in Rafhaa at which it is much expensive to use the utility grid to power it [10].

The solar panel is a light metal plate consist of cells that produce electrical power. There are many types from solar panel such as; monocrystalline silicon which mean the cell consist from silicon crystal, in this type the power absorption ratio ranging from 11-17 % , it is the best type because it absorbs large amounts of solar energy; If a light falls by 1000w, the board's energy absorption rate is 110-170 w. other type called polycrystalline silicon, the cell consists from more than crystalline silicon, the absorption rate ranges from 3-7% that mean If a light falls by 1000w, the board's energy absorption rate is 30-70 w. Other type from solar panel is the lowest quality from it called molecules, it is used to produce only 10 w or 20 w [11].

Batteries are units used to store electrical power in security way. The solar energy is used to produce the electrical power but it depends on the sun so it is work in in the daytime and stop at night so need to batteries which store the electrical power [12].

The solar hybrid power systems are modern system include two system one depends on solar energy and other system using other energy sources such as diesel, which is considered one of the oil derivatives, this technology used in many fields to provide power all time and avoid the suddenly cutting of the electric power in the system [13].

The thesis interested in show how to use optimal combination of solar energy and diesel fuel in a system used in remote areas. The thesis study power system depends on electrical power from main grid which based on diesel fuel for producing electrical power also it uses backup batteries store electrical power which generate it from solar energy, the main aim for this project is to cover people's needs of electrical power and face any error occur in the system with all security way. In the remote areas the electrical operation and maintenance are more important event because it is far away from the services and need more time to arrive it.

Research importance

Since the sun is sustainable source of energy, so we can use it to power any loads especially in the remote areas, also solar cell is more stable, efficient and available. The study interested how use solar cell to produce electrical power and store it in solar batteries to use it in necessity cases.

Research aims

- Identify how use optimal combination of solar energy and diesel fuel in a system used in remote areas.
- Investigate the performance of electrical energy which produced by optimal
- Combination of solar energy and diesel fuel in a system used in remote areas.
- Investigate the advantages and disadvantages for using optimal combination
- of solar energy and diesel fuel in a system used in remote areas and identify
- The efficiency of apply it in (Kingdom of Saudi Arabia) KSA.
- Obtain a constant energy continuous in order to feed the surveillance
- Equipment in remote areas.
- Protect the devices from the sudden interruption of the current.
- Reduce the fuel cost, the maintenance and spare parts cost.

Research methodology

To design effective optimal combination system, need to identify the main steps to apply the idea, there are details about it:

- Demand Assessment: Identify the demand load from electrical power; to cover the building system from the electrical power need to know how much from electrical power will need to operate the all electrical devices in the system.

- Resource Assessment: from the available energy power sources must identify how much can produce electrical power for each source to Check the ability to provide the required amount of electrical power.
- Barriers and Constraints: identify the barriers and constraints such as employment, net present cost, annual electricity demand, environmental factors and reliability.
- Solar power Demand: identify the mount which must provide it using the solar power source, this demand is important to support all resources which need to cover the electrical power need which will be used in necessity cases.
- Technology assessment: Once resources have been identified, the appropriate technological options for these sources must be identified to apply the project in effective way.
- After identify all demand system the suitable optimization technical will be selected to provide the electrical power with effective way.

Result

To apply the project idea for building hybrid system contains solar energy and diesel generator must use appropriate program to build the model and test it, MATLAB program have been used to apply the project idea. The project simulation includes two cases:

1) First case based in diesel generator as the main source to generate the electrical power then used the PV as backup generator.
2) Second case based in PV as the main source to generate the electrical power then used the diesel generator as backup generator.

To apply these case, the main model is created using MATLAB, the figure below show it:

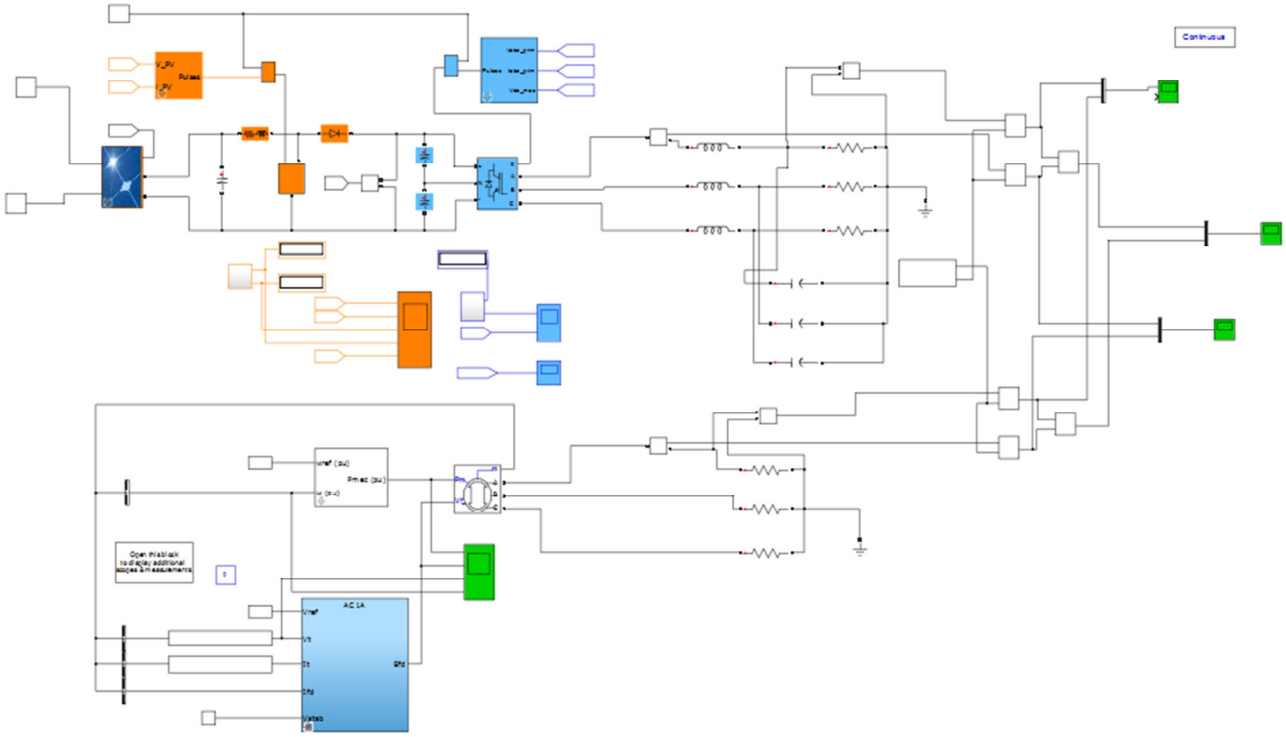

Figure 1:Matlab model for hybrid system

Output:

Case1: Diesel generator then PV

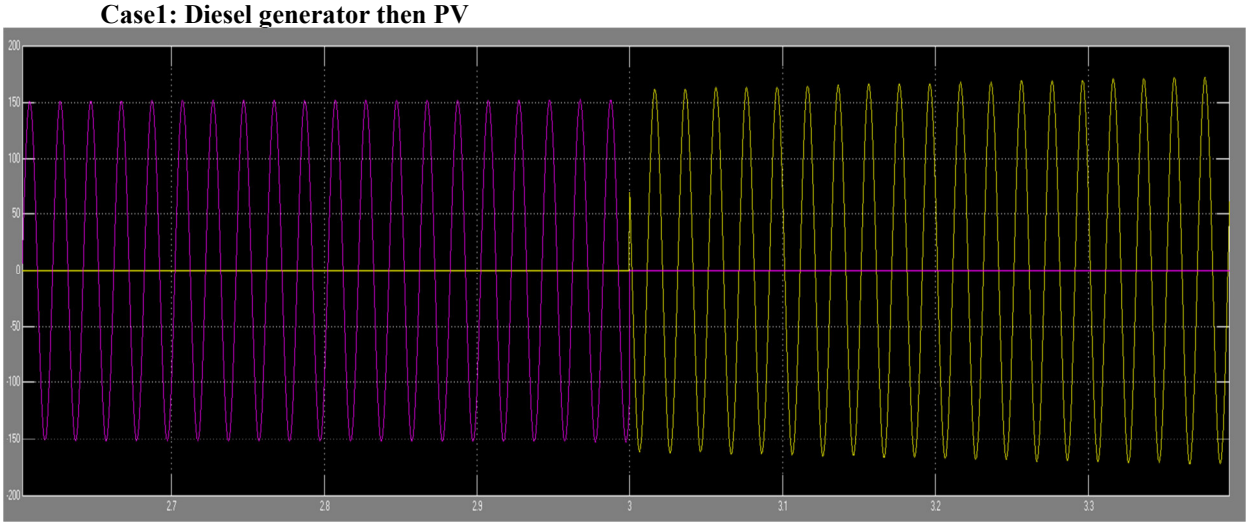

Figure 2:volte simulation result case1

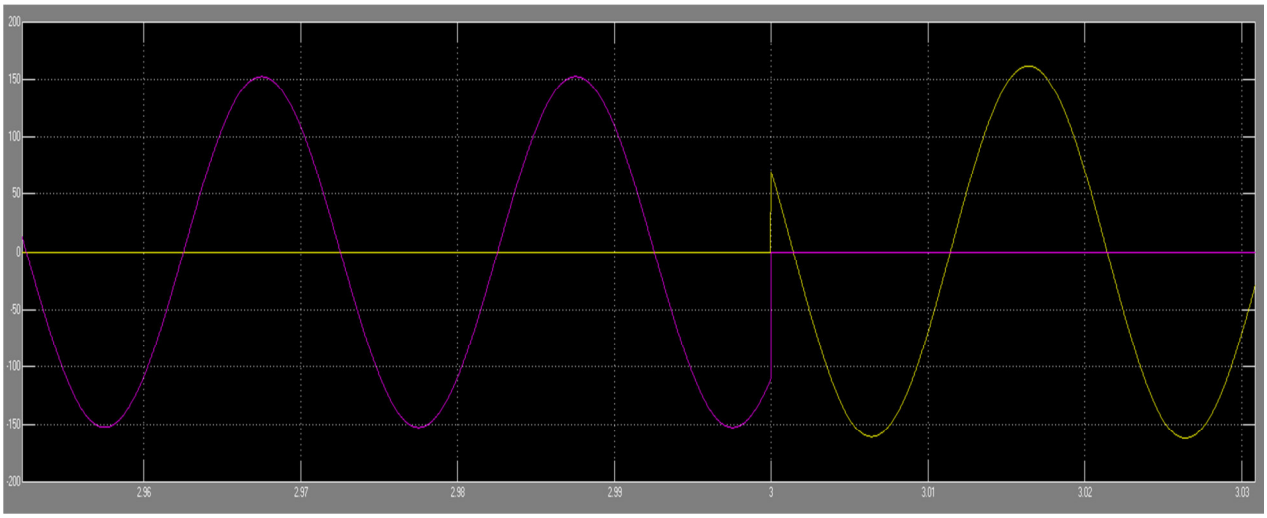

Figure 3:Volt-The moment of transition from the diesel generator to PV system case1

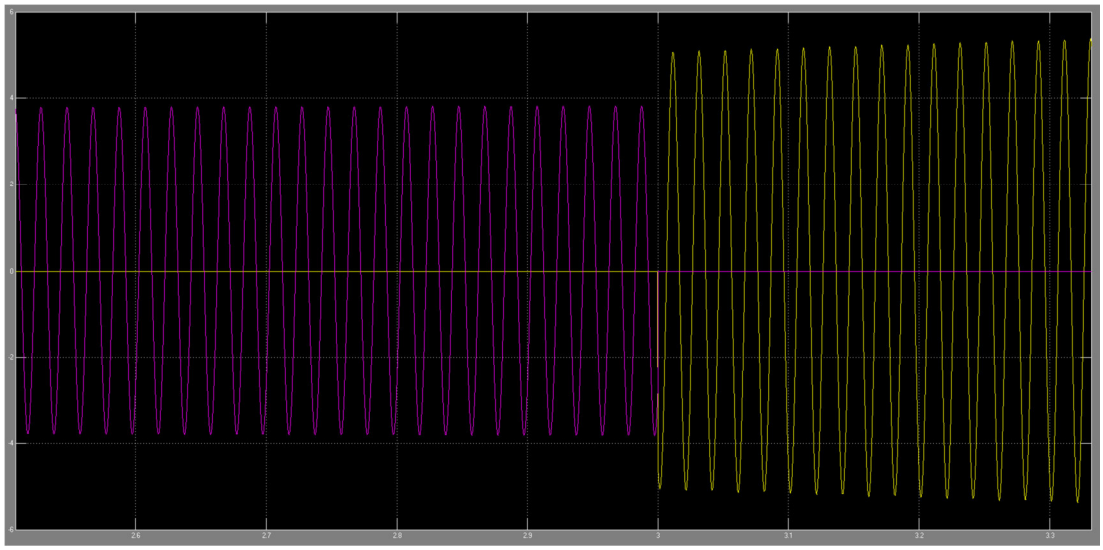

Figure 4:current simulation case1

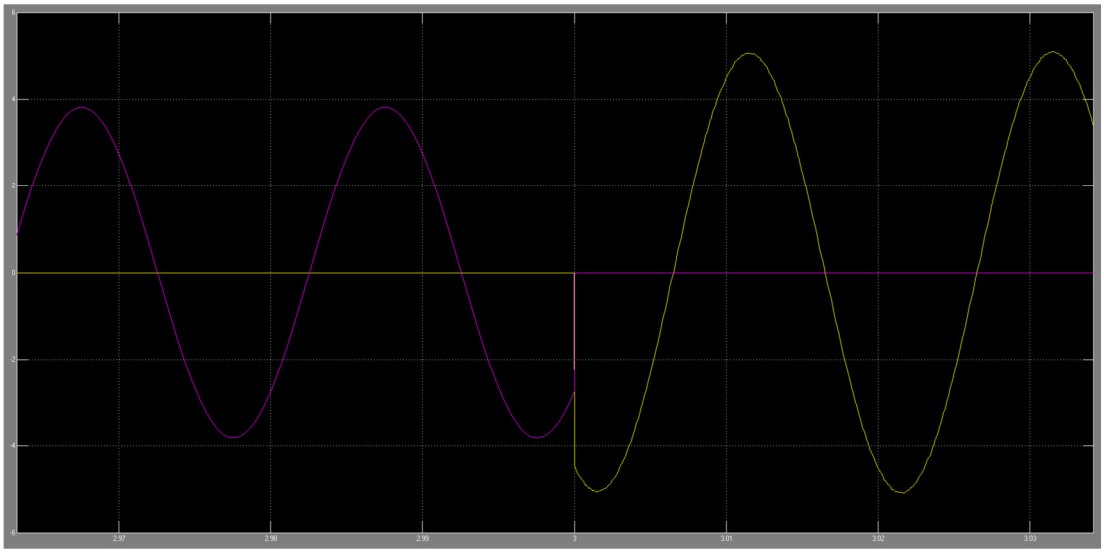

Figure 5:current-The moment of transition from PV to diesel generator case1

Case2: PV then diesel generator

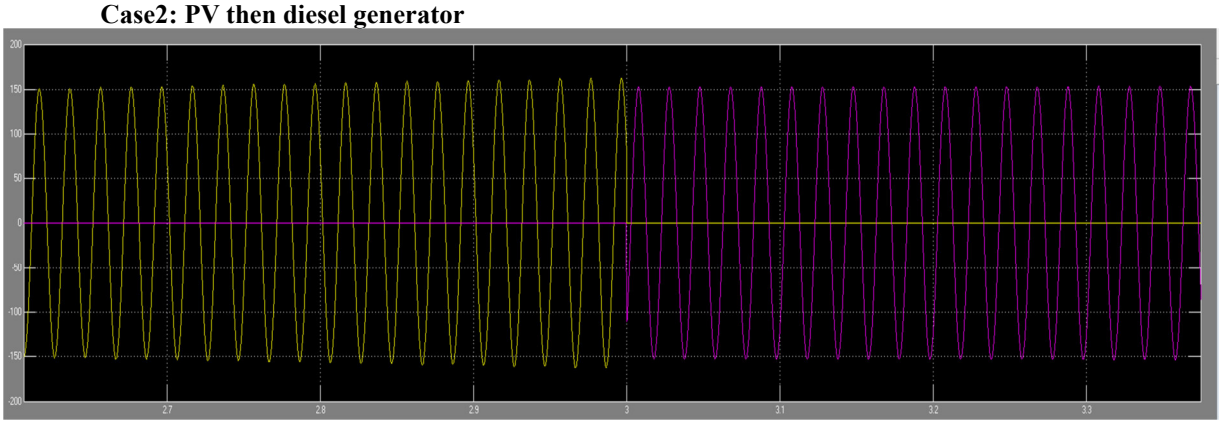

Figure 6: volte simulation result case2

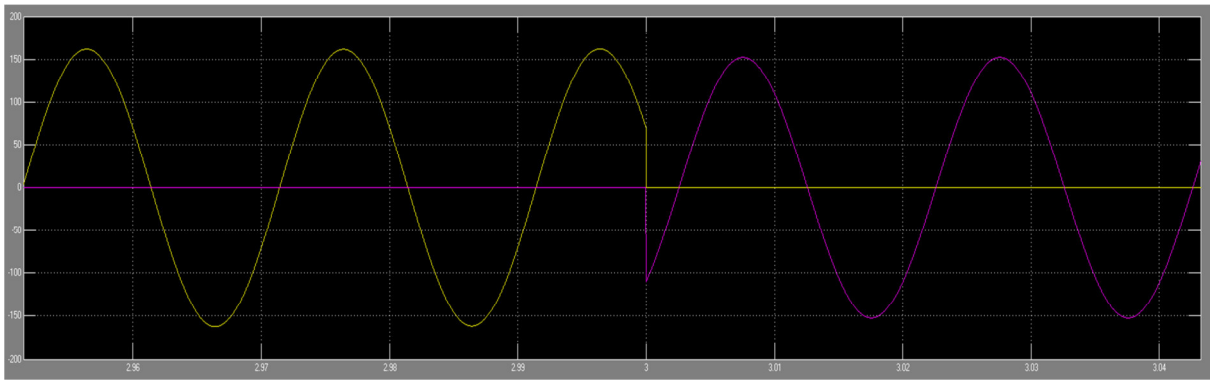

Figure 7: volt-The moment of transition from PV to diesel generator case2

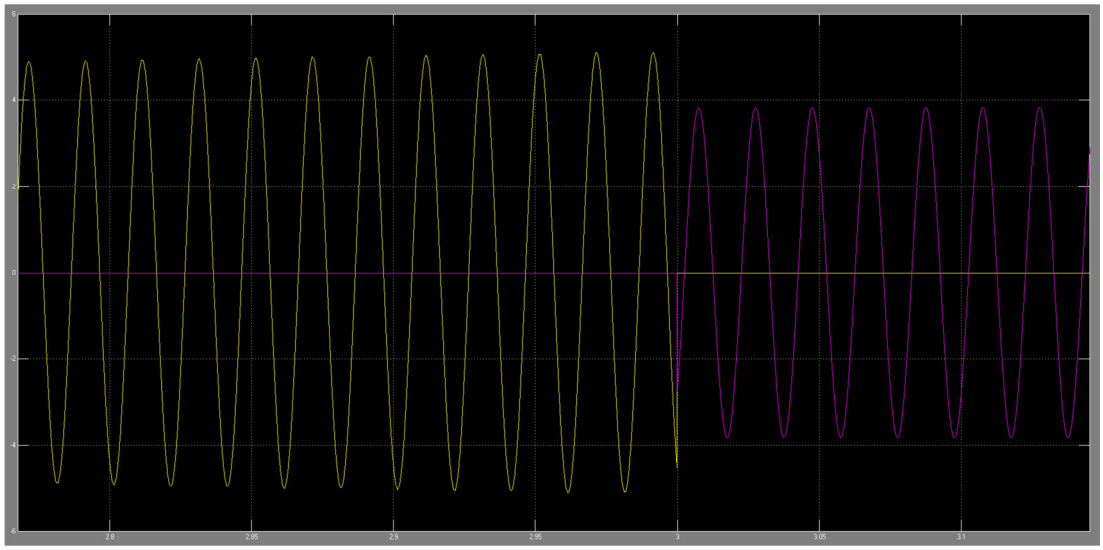

Figure 8:current simulation result case2

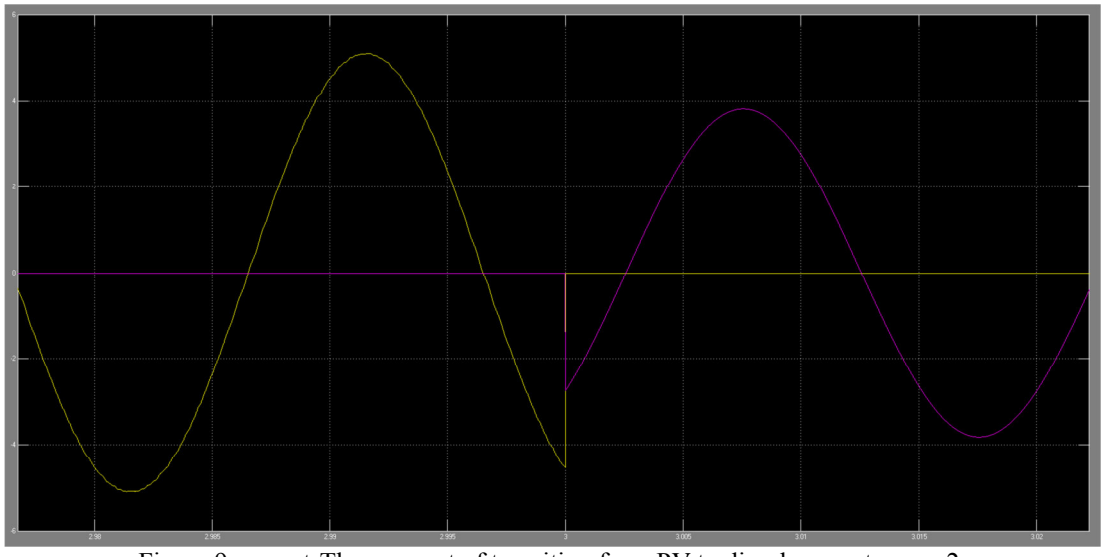

Figure 9:current-The moment of transition from PV to diesel generator case2

The last figures show two problems:

- The first problem related to the output current and voltage, there are difference in the resulting values. To solve this problem I take the model which operate PV system then diesel generator then add filter to PV system and manage the filter value to get the best result.
- The second problem related to synchronization, because the PV and diesel generator are different system not synchronized, as shown from the last figures simulation. To improve the project need to synchronize the generated power when move from diesel generator to PV in case 1 and synchronize the generated power when move from PV to diesel generator in case2. The improvement system is interested in operating the first solar PV then diesel generator.

To solve the synchronization problem, AST system idea will used to manage transfer from solar PV to diesel generator by making the solar panel system effected in radiation if it less than 500 that will be convert to diesel generator without delay. so that system will operate the solar panel in the day and separated at night direct without any problem in delay time. But the last system used timer to transfer from one power generator to other which created delay problem.

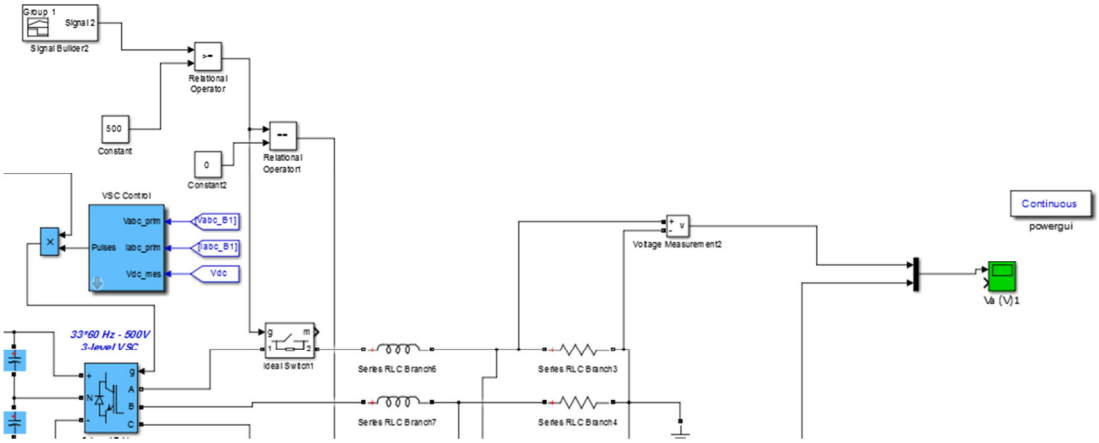

Figure 10: Radiation Control using ATS system

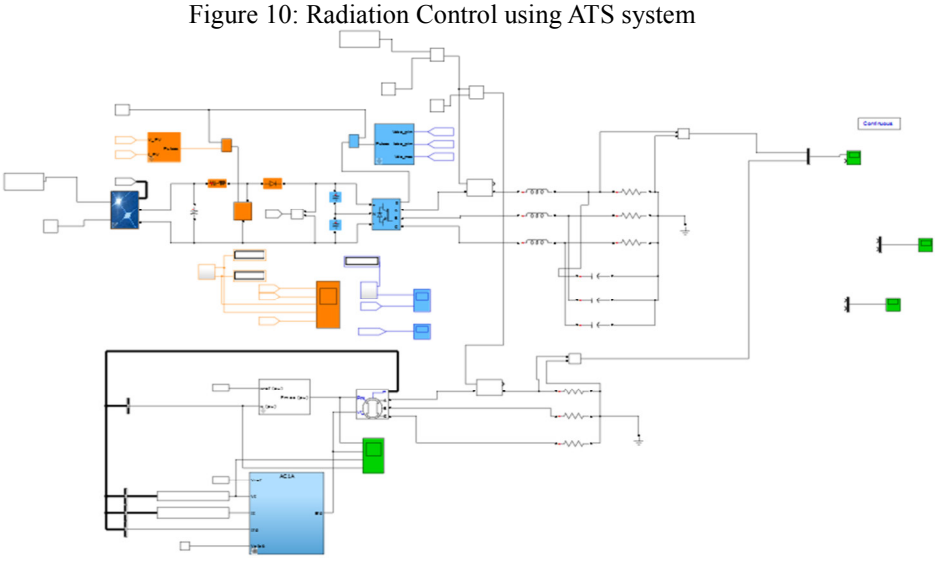

Figure 11: improved system

Output result:

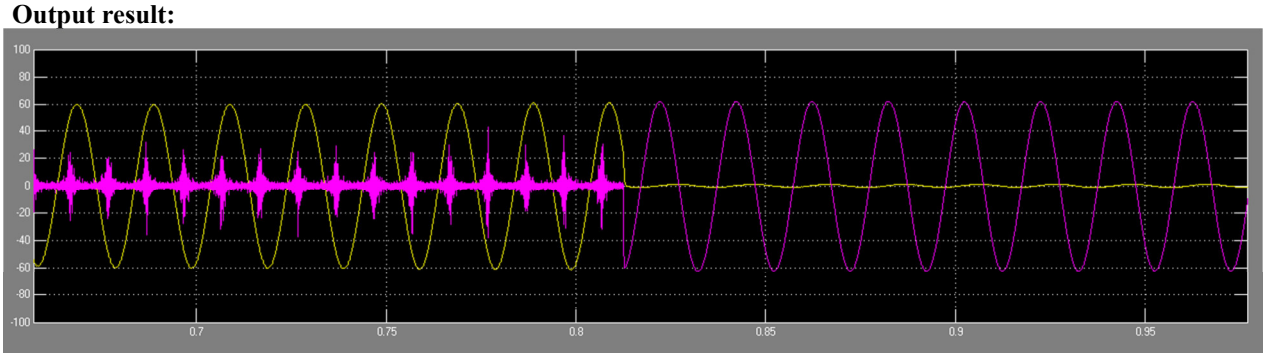

Figure 12:volt-PV improved system

Comparison between system1 and system2:

Table 1:comparison between system1 and system2

Characteristics	System1	System2
Control mechanism	Timer	ATS
Max voltage	79-190 volts	79-79volts
Total operating time	10 second	2 second
Transition time	At 5 second	When the radiation < 500
Synchronizations voltage problem	(-150)-100 Period 100	(-60)-0 Period 0

The last table show the main features for system1 and 2 which formed the hybrid electrical system to provide electrical power. System1 incudes PV solar and diesel generator which managed by timer operate the PV

for specific time then transfer to diesel generator to produce the power. But the second system based on ATS system which effected by the changing in voltage value to change the generator, the voltage value effected by radiation change. In each system can manage the voltage value from tools parameters to get voltage value which need.

The Synchronizations voltage problem which occurred when transfer from power source to other the system need some time to get the original load. In system1 occurred from (-100) to 100 values but in system2 occurred in (-60) to 0 that show how the ATS system help to solve the synchronization problem at positive side from output simulation.

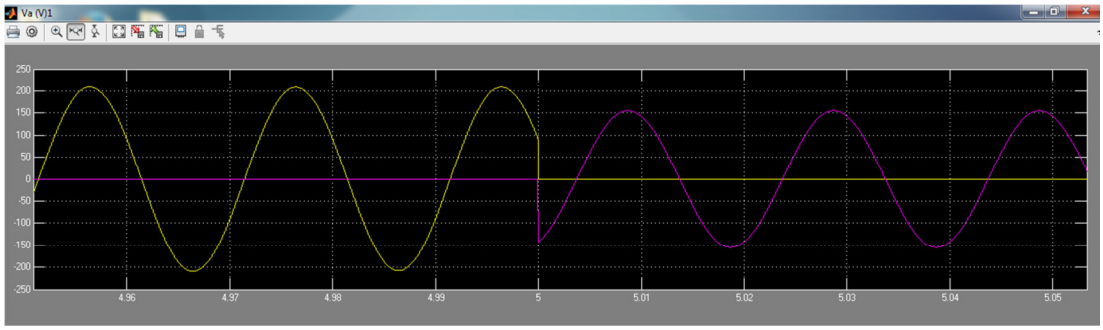

Figure 13:system1 voltage result

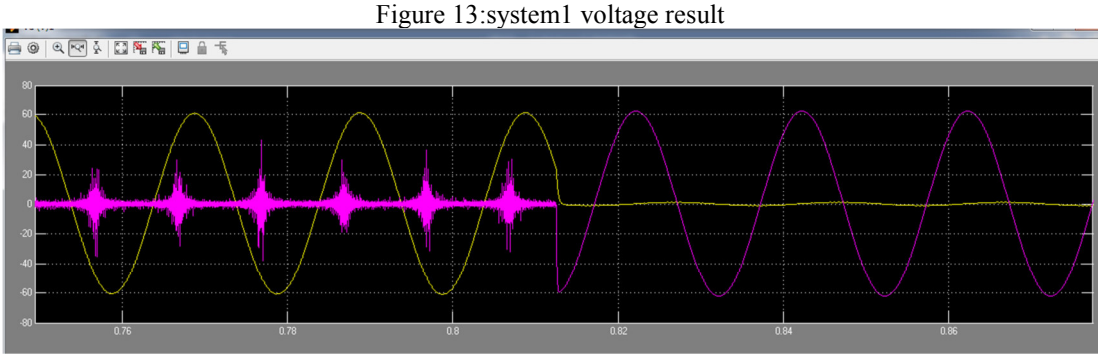

Figure 14:system2 voltage result

Conclusion

After studying and continuing work in this thesis, a number of important results has been reached such as:

The remote areas in Saudi Arabia suffers from breakdown in electrical power because of its distance from the main grid, so it is important to provide it with multiple of electrical power generator to support the system with load demand of electrical power and avoid any unexpected breakdown in electrical power.

The electrical power system in remote areas based on diesel generator to provide the system in load demand of electrical power, the cost of diesel is high and cause heavy load in money lost to support the diesel generator, so the thesis interested in study renewable source of power generation.

Solar energy has been selected as a renewable energy source for generating electrical power in remote areas, it is free and readily available in Saudi Arabia. The temperatures arrive to 40 Celsius degree, so it can used to provide electrical power with highly efficient.

Hybrid system is used to solve the research problem in providing the electrical power at remote areas with the least cost. The thesis study design hybrid system consists of solar energy and diesel generator, the hybrid system based on solar energy as mainly then diesel generator as secondary.

MATLAB program had been used to achieve the thesis idea in building hybrid system include PV system and diesel generator. MATLAB software used to design the system and simulate it to show the results and study the performance for the PV and diesel generator systems.

After had been operated hybrid system in project part 1 using MATLAB program the analysis result of PV and diesel system shown the difference between the result voltage of solar cells and diesel generator; the voltage in PV system equal 79 volt but in diesel generator system the voltage equal 190 volt. to solve this problem the configuration filter in diesel generator converter was controlled to get the load demand of electrical power in the system. In the project part 2 the voltage value was managed to get 79 volts in each system.

Table: The difference in the result voltage value between solar cells and diesel generator systems.

Project Level	PV system Max voltage	Diesel generator system Max voltage
Project-Part1	79 volts	190 volts
Project-Part2	79 volts	79volts

In MATLAB electrical model can manage the voltage value which must be generated from PV system by

controlling characteristics of solar cells such as type of PV, Number of series-connected modules per string (Nser) and Number of parallel string(Npar). the SunPower SPR-305-WHT type is used in the project. There are the main characteristics of solar cells which used in the project.

Table: the main characteristics of solar cells which used in the project.

Characteristics	Project-part1	Project-part2
Solar cell type	SunPower SPR-305-WHT	SunPower SPR-305-WHT
Npar	1	1
Nser	1	1
Radiation	1000 W/m^2	1000 W/m^2
Temperature	25 degC	25 degC
Total power	305 Watt	305 Watt

The synchronization which occurred when transfer from one source generator to other is one of the main problems which shown in the electrical model simulation; in the hybrid system the problem occurred when the system transfer from PV system to diesel generator for providing the load demand of electrical power.

The project was built in two phases; the first phase based on time system which make the electrical system transfer from PV source generator to diesel generator after a specified period, in this phase the synchronization problem is clearly shown in (-150)-100 voltage in period 100, but the second phase based on ATS system which help to solve the synchronization problem during a limited range (-60)-0 in period 0. that mean the ATS system can protect the voltage value from synchronization problem more than the timer system model.

Table: Main difference between project phase1 and project phase2

Characteristics	System1	System2
Control mechanism	Timer	ATS
Total operating time	10 second	2 second
Transition time	At 5 second	When the radiation < 500
Synchronizations voltage problem	(-150)-100 Period 100	(-60)-0 Period 0

Acknowledgement

I give all love for every one gives me any help in this thesis from my family, Dr. supervisor, my friends and team work.

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