Registration No.: ....

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

School of Electrical Skills

Session: 2021-22 (Winter Semester)

Ph.D. Program, 3rd Semester,

End-Sem. Examination

Course Code: ELE 4102 **Time: 2 Hours**

Course Name: Microgrid: Operation and Planning with Renewable Energy Sources **Max. Marks: 50**

Instruction: All questions are compulsory. Each question carries one mark in section A. Each question carries five marks in section B.

Section – A

30x01 = 30 Marks

Q.1. A localized group of energy generations, storages and loads is referred to as:
(a) Micro Grid
(b) Macro Grid
(c) Virtual Grid
(d) Traditional Grid

Q.2. What is the full form of DR in context of DC microgrid?
(a) Delivery Rate
(b) Delivery Response
(c) Demand Rate
(d) Demand Response

Q.3. Which of the following factor should be identical for two alternators running in parallel:
(a) Voltage
(b) Frequency
(c) Vector Group
(d) All of the above

Q.4. Maximum power in a synchronous machine is obtained when the load angle is:
(a) 0 Degree
(b) 90 Degree
(c) 180 Degree
(d) 360 Degree

Q.5. If excitation of an alternator from parallel operation with other alternators is changed, then its:
(a) Power Factor Changes
(b) Reduces Speed
(c) System Collapses
(d) Change Frequencies

Q.6. In modern electronic loads, when they are connected to the isolated AC microgrids having PV as the single source of energy, which of the following losses are natural?

(a) AC-DC-AC
(b) AC-AC-AC
(c) DC-DC-DC
(d) DC-AC-DC

Q.7. The frequency of a microgrid system controls the:

(a) Active Power
(b) Apparent Power
(c) Reactive Power
(d) Power Factor

Q.8. Demand Response is performed at:

(a) The Consumer Side
(b) The Utility Side
(c) On Both Sides
(d) None of the Above

Q.9. Which of the following is the key control variable in DC microgrid?

(a) Frequency
(b) Voltage
(c) Load Current
(d) Active Power

Q.10. ACCB stands for:

(a) Alternating Current Circuit Breaker
(b) Air Current Circuit Breaker
(c) Alternating Circulating Current Breaker
(d) Air Circulating Current Breaker

Q.11. In SPMW, the modulating signal is:

(a) Square
(b) Sinusoidal
(c) Saw-tooth
(d) None of the Above

Q.12. The only factors used in a DC power flow study are:

(a) Voltage and Current
(b) Power and Current
(c) Voltage and Frequency
(d) Load angle and Voltage

Q.13. In Voltage Source Inverters (VSIs), the amplitude of the output voltage is:

(a) Dependent on the Loads
(b) Dependent only on L Loads
(c) Independent of the Loads
(d) None of the Above

Q.14. Which one of the following is merit of the Master-Slave microgrid system?
(a) Difficult to Apply in Large Systems
(b) Needs Multiple Communication Channels between different Controllers
(c) Implementation has Strict Requirements for Communication and Supervisory Control
(d) None of the Above

Q.15. The values of a fuzzy set are represented by:
(a) Discrete Set
(b) Degree of Truth
(c) Probabilities
(d) Both (b) & (c)

Q.16. How many types of random variables are available in fuzzy logic?
(a) 1
(b) 2
(c) 3
(d) 4

Q.17. A method which helps to achieve zero steady state error to step input in state feedback controller design is:
(a) Derivative Control
(b) Integral Control
(c) Proportional-Derivative Control
(d) Proportional-Integral Control

Q.18. Dual converters handle ________ during no load:
(a) Very High Temperatures
(b) Only Circulating Currents
(c) No Current
(d) Load Current

Q.19. Which one is the most desirable features of the Microgrid Converters?
(a) High Input or Output Current Ripples
(b) Low Resistance for Switching Surges and Lightening
(c) Possibility of External Control
(d) All of these

Q.20. Which one of the following configurations types the DC bus is interfaced with an AC Grid at one end and power flows along a single path towards the loads?
(a) Radial Configuration
(b) Ring or Loop Configurations
(c) Interconnected Configurations
(d) Both (b) and (c)

Q.21. How one can check the transient stability of a power system?
(a) By Checking Variation in Load Angle
(b) By Checking Variation of Real Power with Load Angle
(c) By Checking Variation in Load Angle and Real Power

(d) By checking Variation in Load Angle or Real Power

Q.22. How can we improve the steady state stability of the synchronous generator for a better performance?
(a) Increasing the Excitation
(b) Increasing the Reactance
(c) Decreasing the Moment of Inertia
(d) Increasing the Moment of Inertia

Q.23. The sending end voltage of a transmission line controls the:
(a) Active Power
(b) Reactive Power
(c) Apparent Power
(d) Alternator Speed

Q.24. Stability of a system implies that:
(a) Small changes in system input does not result in large changes at system output
(b) Small changes in system parameters does not result in large changes at system output
(c) Small changes in initial conditions does not result in large changes at system output
(d) All of the Above

Q.25. Which one of the following is used to improve the power system transient stability?
(a) Improved Steady State Stability
(b) High Speed Fault Clearing
(c) Single Pole Switching
(d) All of the Above

Q.26. The torque developed by a motor in case of an armature-controlled DC servomotor is:
(a) Proportional to Field Current & Armature Current
(b) Proportional to Air-gap Flux & Armature Current
(c) All of the Above
(d) None of These

Q.27. Converse Lyapunov Criterion gives necessary and sufficient condition of stability for:
(a) Linear System
(b) Non-Linear System
(c) Both of Them
(d) None of Them

Q.28. In the state space analysis, the stability depends upon:
(a) Both A & B
(b) Both C & D
(c) Only C
(d) None of the Above

Q.29. In hybrid storage systems, which of the following device helps to compensate for high frequency switching transients?
(a) Super Capacitors
(b) Super Resonators

(c) Super Inductors
(d) Battery Banks

Q.30. Which of the following hierarchal control facilitates an economically optimal operation?
(a) Load Control
(b) Secondary Control
(c) Central Emergency Control
(d) Global Control

Section – B

04x05 = 20 Marks

Q.1. Explain IEEE 1547: Standard for Interconnection and Interoperability of Distributed Energy Resources with associated Electric Power Systems Interfaces.

Q.2. Compare Centralized with Decentralized control approach of Microgrid.

Q.3. Discuss the Microgrid polices and regulation in Asia.

Q.4. Expalin the designing and modelling of a Standalone DC-Microgrid for Off-Grid building in rural areas.

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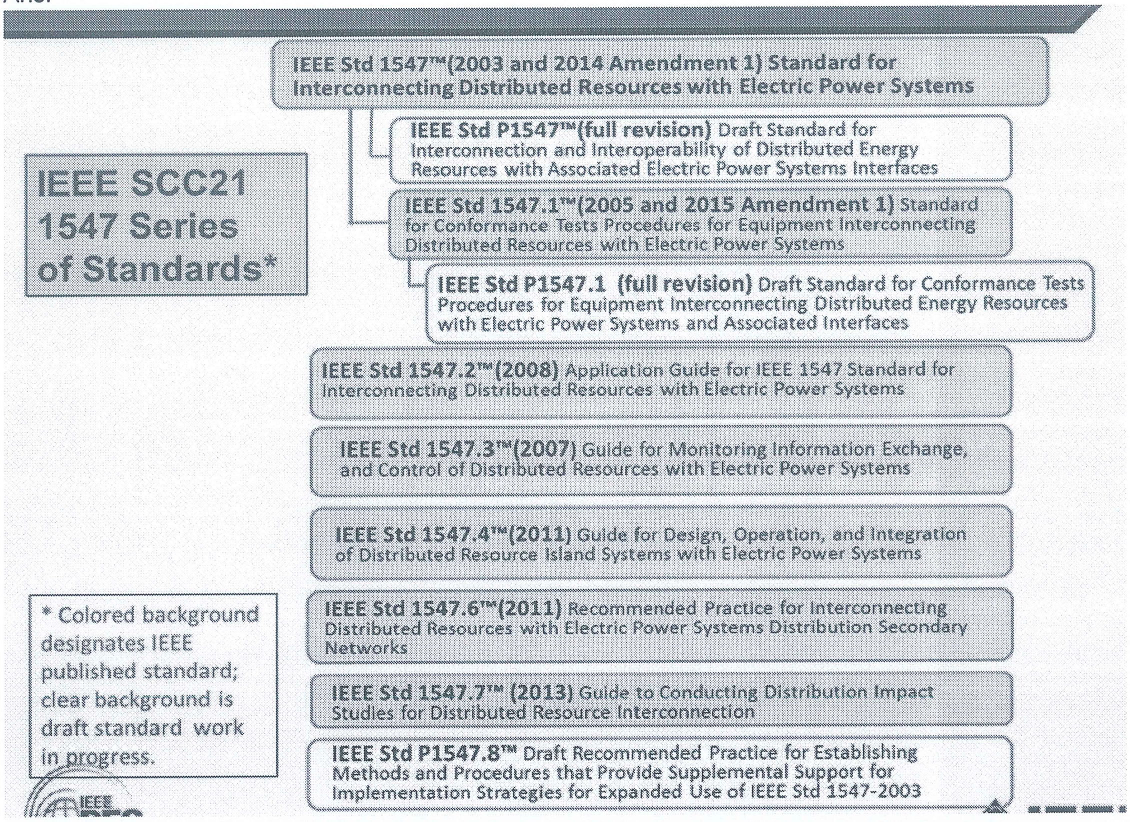
Ans. 1: (a)
Ans. 2: (d)
Ans. 3: (d)
Ans. 4: (b)
Ans. 5: (a)
Ans. 6: (d)
Ans. 7: (a)
Ans. 8: (c)
Ans. 9: (b)
Ans. 10: (a)
Ans. 11: (b)
Ans. 12: (a)
Ans. 13: (c)
Ans. 14: (d)
Ans. 15: (b)
Ans. 16: (c)
Ans. 17: (b)
Ans. 18: (b)
Ans. 19: (c)
Ans. 20: (a)
Ans. 21: (c)
Ans. 22: (a)
Ans. 23: (b)
Ans. 24: (d)
Ans. 25: (d)
Ans. 26: (b)
Ans. 27: (d)
Ans. 28: (d)
Ans. 29: (a)
Ans. 30: (d)

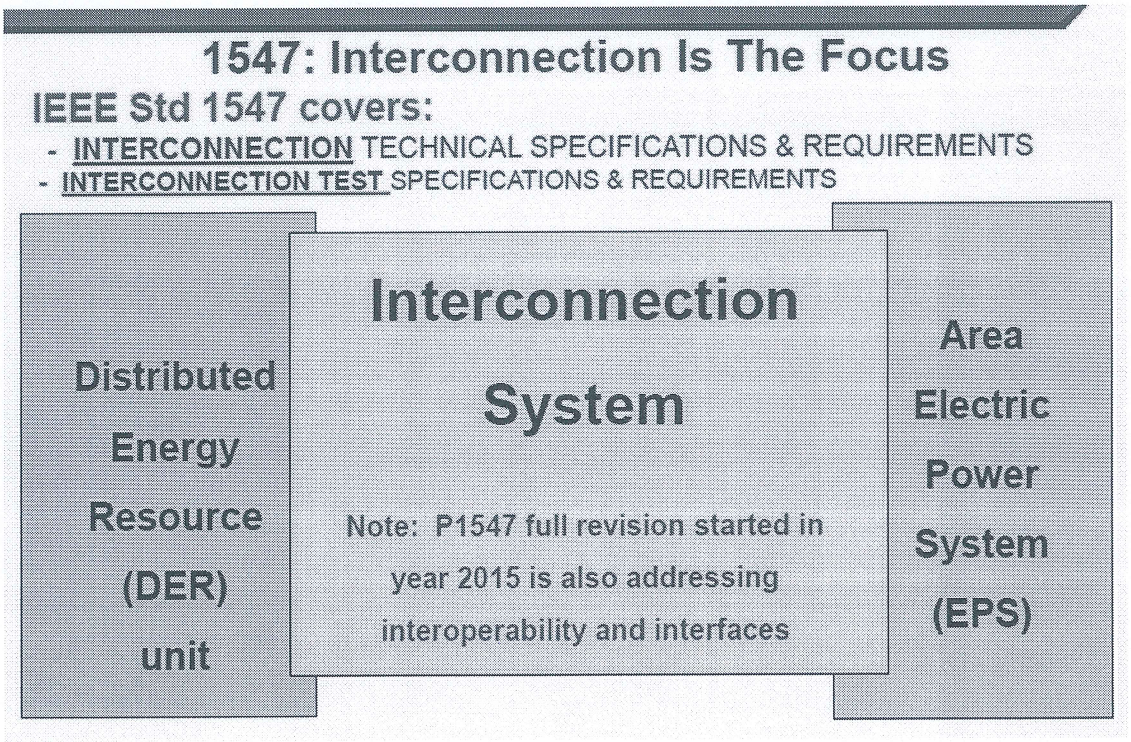
Section – B

04x05 = 20 Marks

Q.1. Explain IEEE 1547: Standard for Interconnection and Interoperability of Distributed Energy Resources with associated Electric Power Systems Interfaces.

Ans:


IEEE SCC21
1547 Series
of Standards*
IEEE Std 1547™(2003 and 2014 Amendment 1) Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE Std P1547™(full revision) Draft Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE Std 1547.1™(2005 and 2015 Amendment 1) Standard for Conformance Tests Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
IEEE Std P1547.1 (full revision) Draft Standard for Conformance Tests Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces
IEEE Std 1547.2™(2008) Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE Std 1547.3™(2007) Guide for Monitoring Information Exchange, and Control of Distributed Resources with Electric Power Systems
IEEE Std 1547.4™(2011) Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems
IEEE Std 1547.6™(2011) Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks
IEEE Std 1547.7™ (2013) Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection
IEEE Std P1547.8™ Draft Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Std 1547-2003
* Colored background designates IEEE published standard; clear background is draft standard work in progress.


1547: Interconnection Is The Focus
IEEE Std 1547 covers:
- INTERCONNECTION TECHNICAL SPECIFICATIONS & REQUIREMENTS
- INTERCONNECTION TEST SPECIFICATIONS & REQUIREMENTS
Distributed Energy Resource (DER) unit
Interconnection System
Note: P1547 full revision started in year 2015 is also addressing interoperability and interfaces
Area Electric Power System (EPS)

IEEE 1547 IS:

- A Technical Standard – Functional Requirements For
  - the interconnection itself
  - the interconnection test
- Technology neutral, e.g., does not specify particular equipment nor type
- A single (whole) document of mandatory, uniform, universal, requirements that apply at the PCC or Point of DER Connection.
- Should be sufficient for most installations.

IEEE 1547 Is NOT:

- a design handbook
- an application guide
- an interconnection agreement
- prescriptive, e.g., does not address DR self-protection, nor planning, designing, operating, or maintaining the Area EPS.

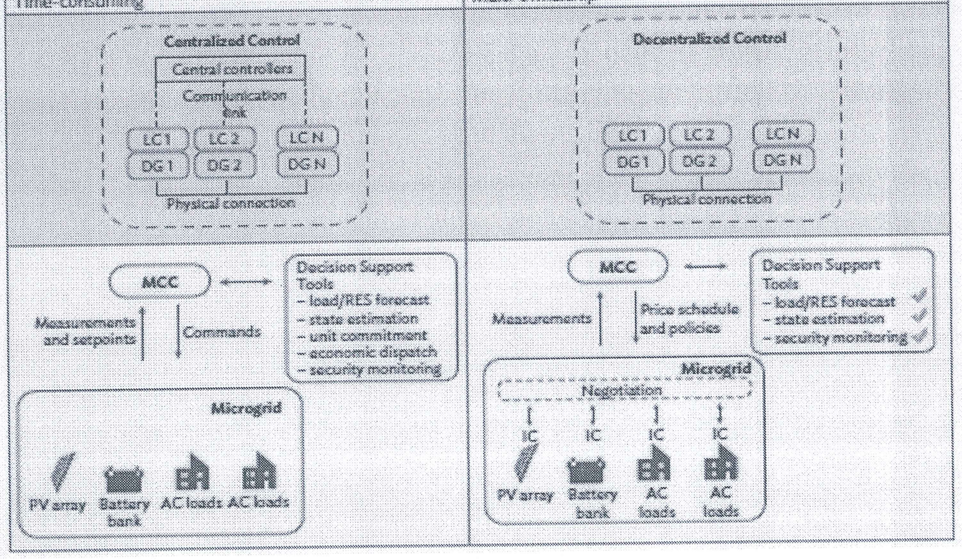
IEEE 1547.1 is:

Test Procedures for Conformance to1547

Q.2. Compare Centralized with Decentralized control approach of Microgrid.

Table 4: Key Differences between Centralized and Decentralized Microgrid Control

Centralized Control	Decentralized Control
Advantages: Global solutions Easy grid connection	Advantages: Reliable Expandable
Disadvantages: Expensive Time-consuming	Disadvantages: Complex Multi-ownership



Q.3. Discuss the Microgrid polices and regulation in Asia.

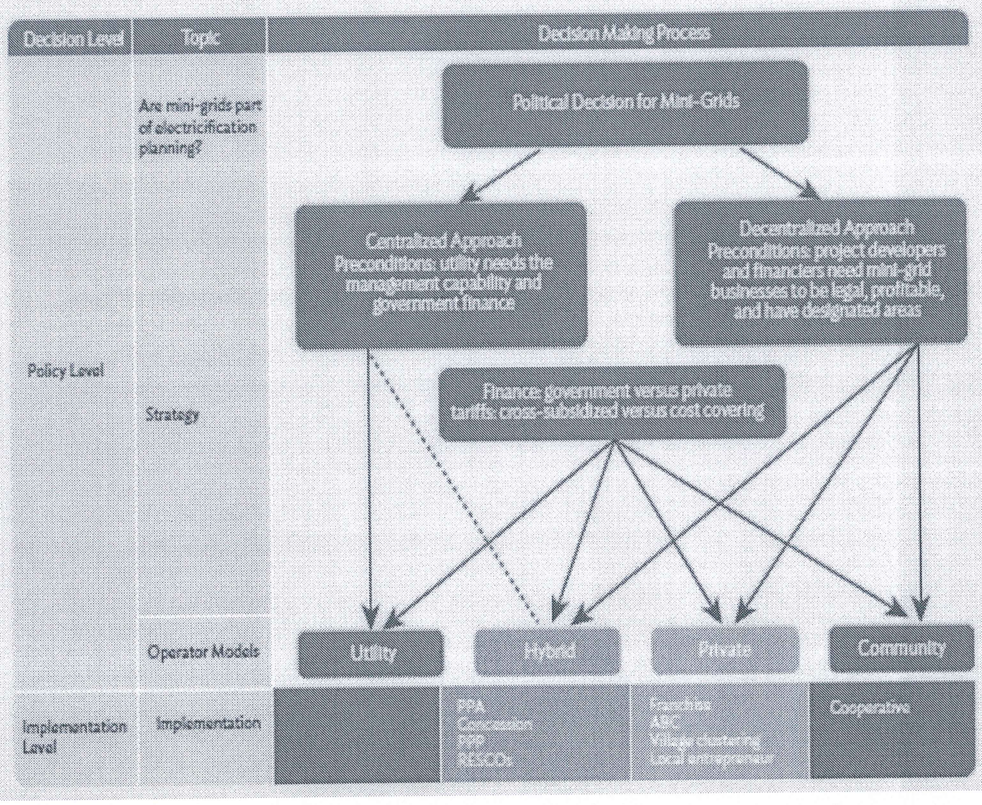
2.5 Microgrid Policies and Regulations in Asia

Microgrid policies and regulations vary across Asia, and some countries, such as Japan, the PRC, and Thailand have supportive policies and/or pilot programs for urban and industrial microgrids whereas others have yet to introduce such policies. Several countries such as Bangladesh, Cambodia, India, Indonesia, Maldives, Myanmar, Nepal, and the Philippines have developed and implemented off-grid minigrid policies for increasing access to energy. Including grid-connected or off-grid microgrids as a policy within a country's power or energy system needs to be a strategic decision-making process (Figure 35).[34]

Some of the key policy and regulatory enablers for urban and industrial microgirds are:

(i) **Specific urban and industrial microgrid policy.** A specially defined policy for urban and industrial microgrids would help facilitate private and public sector investments, as well as provide stability for such microgrid. This policy should clearly define the goals of deploying urban and industrial microgrids, provide technical specifications and standards, identify eligible consumers, determine grid interconnection norms, tariffs, and licensing and documentation requirements. So far, only developed countries such as Japan and the Republic of Korea, and upper middle-income countries such as the PRC

Figure 35: Strategic Process for Microgrids



and Thailand have defined such policies or programs in Asia. Other developed countries such as the US and a few European countries have also defined such policies and programs.

(ii) **Net metering or gross metering policies.** Net metering or gross metering policies enable microgrids to be connected to the national grid and export excess electricity to the grid. Such policies enable urban and industrial renewable energy-based microgrids to use the grid instead of the expensive battery or energy storage solutions, to increase their autonomy. This will also improve their economics by supplying excess electricity to the grid for economic considerations (net or gross metered). While net or gross metering for stand-alone, single customer rooftop, or ground-mounted solar installations are available in many developed and developing countries in Asia, these have not yet been defined for microgrids in most countries.

(iii) **Technical standards and specifications for grid interconnection.** This would allow microgrids to design and plan according to specified technical standards and hence, manage grid interconnection technical design and costs more reasonably. While grid interconnection norms for stand-alone, single customer rooftop, or ground-mounted solar installations are available in many developed and developing countries in Asia, these have not yet been defined for microgrids in most countries.

(iv) **Open access or contestable consumer model.** Open access policies and regulations allow electricity consumers—typically only large C&I consumers (known as contestable consumers) —to choose their electricity service provider, rather than being confined to purchasing electricity from a government-owned or private monopoly utility. Such contestable consumers are often served by open access developers or merchant power plants that develop and install these assets either remotely or locally, as onsite rooftop solar or microgrid installations and using national grid T&D infrastructure to supply electricity. Countries such as India, the PRC, the Philippines, and Singapore have such regulations in place, whereas countries such as Viet Nam are in the process of introducing similar policies. Nevertheless, treatment of open access and/or contestable consumers by onsite microgrids is still not defined in most countries of Asia, and such clarity would enable more microgrid investments.

(v) **Simpler electricity generation and distribution licensing.** In many countries, electricity generation and distribution is still a highly regulated and licensed activity and requires complex documentation and approval process for microgrid developers to obtain such licenses. Simplifying these regulations would increase developers' interest in setting up microgrids.

(vi) **Feed-in-tariffs and other financial incentives.** Tariff support and other financial incentives such as subsidies and tax benefits for microgrids would enable developers to deploy microgrids even for consumers where financial viability without such incentives is a barrier.

(vii) **Risk-sharing mechanisms for debt financing.** Considering the limited understanding and interest from commercial banks and lenders in many developing countries to finance microgrids, any risk-sharing mechanisms, such as credit guarantees or blended finance structures, could help microgrid developers raise debt finance at affordable interest rates.

Q.4. Expalin the designing and modelling of a Standalone DC-Microgrid for Off-Grid building in rural areas.

3.3. System Modeling and Design Using MATLAB/Simulink

Figure 9 presents a typical schematic design of DC microgrid containing a solar panel and battery storage system. It also contains the solar charger and load controllers/DC-DC converter, which controls the voltage coming from the solar panel and the battery as well as going to the battery to charge it and to the load. Compared with the conventional AC microgrids, DC microgrids have a simplified schematic design since they do not require many power electronics like inverters to convert the DC current to AC current or vice-versa. Moreover, the absence of much power electronics in the system makes the system more efficient by avoiding power losses and more reliable. Furthermore, it has the potential to be integrated with the grid with the addition of power electronics to link with it. Additionally, the application range is not only specified for schools rather it can be used for large community energy needs and other service centers including health centers and refugee camps.

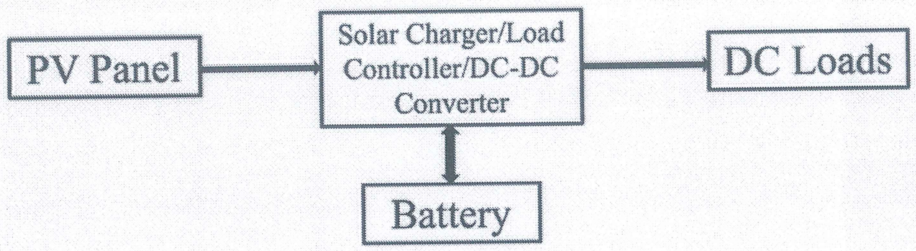
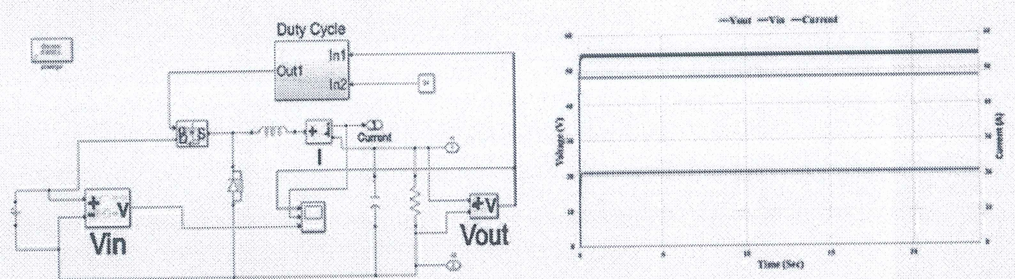


Figure 9. Schematic design of DC Microgrid composed of Solar PV, System Controller and Battery.

The proposed DC microgrid includes a PV system, DC-DC converter, and a battery and was modeled using MATLAB/Simulink. The DC-DC converters are used in conjunction with the PV system and the battery to control the power flow, as well as stabilize the voltage and generate maximum power. The type of DC-DC converter used in this system is a DC-DC buck converter, which reduces the input voltage since the voltage of most of the appliances and the battery is about 24 V and it is necessary to control the voltage coming from the PV system. Figure 10 presents the DC-DC buck converter modeled in MATLAB/Simulink and the simulation output of the converter. The simulation output indicates that the designed DC-DC buck convertor controls and reduces the input voltage from 48 V (assuming that the nominal voltage of the PV system is 48 Volts) to about 22 V, implying that the selected appliances are working in the range of 12–24 V.



(a) DC-DC Buck Converter Design in MATLAB/Simulink

(b) Simulation output

Figure 10. Design and simulation output of DC-DC buck converter design in MATLAB/Simulink: (a) DC-DC buck converter design; (b) simulation output.

Figure 11 presents the design of the proposed DC microgrid system with the PV system, battery and DC-DC buck converter which is connected with the loads. The battery controlling strategy which is encircled by red is also presented. The loads are connected with the supply system in a distributed mood over 24 h. The PV system is connected with the DC-DC buck convertor and the DC-DC buck converter is also connected with the battery and with the loads.

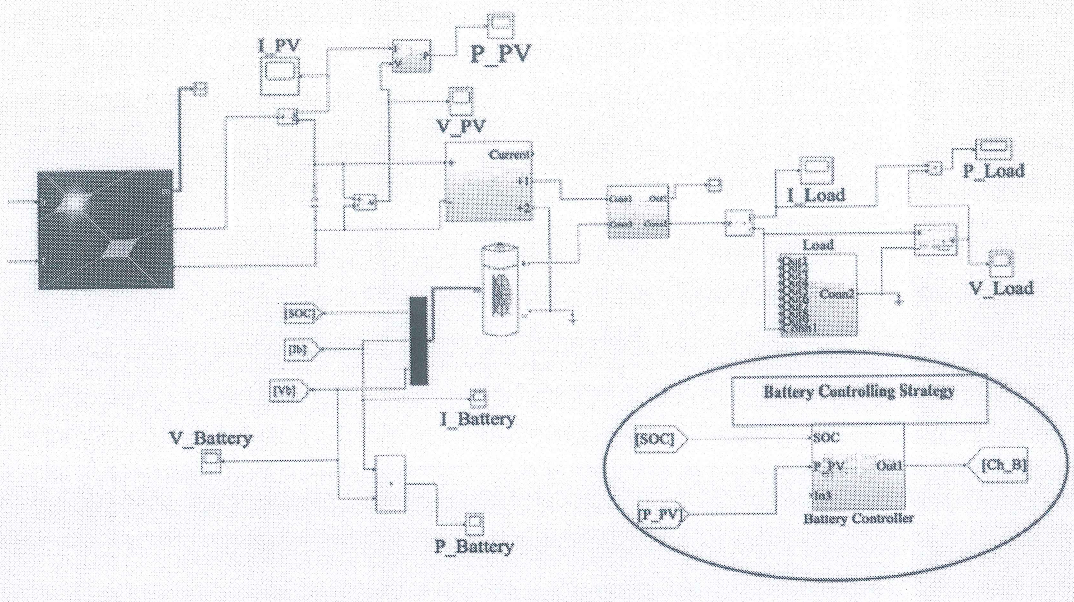


Figure 11. DC microgrid design using MATLAB/Simulink.

Figure 12 indicates the charge controller strategy in the developed DC microgrid (Figure 8). Most batteries are designed to operate in the state of charge range of 20–90%. Therefore, the strategy in the controller will check if the batteries are in the range of 20–90%. Besides that, the battery controller is depending on the power generation and load demand. If the power generated is higher than the required load power and the battery is at a low *SoC* below 90% the battery will be charged. However, if the load power is higher than the generated power load shedding should be taken into consideration to protect the safety of the battery. Similarly, if the generated power is greater than the power load and *SoC* is in the range of 20% to 90% the battery will be charged unless the battery should be discharged. The other scenario is if the *SoC* is higher than 90% up to a maximum of 100%, as well as if the DC microgrid generates power more than the required demand the current will be sent to a dump load (in the system controller) to avoid overcharging and prevent DC bus voltage increasing unless the battery will be discharged to supply power to the load.