

TRIBHUVAN UNIVERSITY  
INSTITUTE OF ENGINEERING  
**Examination Control Division**  
2082 Chaitra

| Exam.       | Regular |               |
|-------------|---------|---------------|
| Level       | BE      | Full Marks 80 |
| Programme   | BEL     | Pass Marks 32 |
| Year / Part | IV/ II  | Time 3 hrs.   |

**Subject:** - Applied Photovoltaic Engineering (Elective II) (EX 76502)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.



1. a) Define solar constant. Explain how the solar spectrum changes as it passes through the Earth's atmosphere. Find the altitude angle and azimuth angle for the sun at 2:00 P.M. solar time in Kathmandu, Nepal (latitude 27.67°) on June 1 (Day number = 152). [2+2+4]
  - b) Draw the equivalent circuit of a solar cell (four-parameter model). Explain the effect of series resistance ( $R_s$ ) and shunt resistance ( $R_{sh}$ ) on the I-V characteristic curve of a PV cell. [8]
2. a) Differentiate between monocrystalline and polycrystalline silicon solar cells regarding their production process and efficiency. Briefly explain what Tandem cells are and why they have higher efficiency. [4+4]
  - b) What are the key factors to consider when selecting a battery for a PV system? Briefly explain the phenomena of sulfation and stratification in lead-acid batteries. [8]
3. a) Explain the working principle of a buck converter with necessary circuit diagrams and mathematical derivation. Why is Maximum Power Point Tracking (MPPT) necessary in PV systems? [6+2]
  - b) What is "islanding" in a grid-connected PV system? Explain the difference between single-stage and two-stage grid-connected PV configurations. [4+4]
4. a) Estimate the size of the PV array, battery bank, charge controller, and inverter required to electrify a remotely located health post with the load details given below (system operating at 220V, 50Hz). Also, provide a realistic cost estimate for the project based on current market prices in Nepal. [10]

| SN | Load            | Quantity | Watts/Unit | Hours of use/day |
|----|-----------------|----------|------------|------------------|
| 1  | LEB Bulbs       | 15       | 10         | 10               |
| 2  | Refrigerator    | 1        | 150        | 24               |
| 3  | Laptop/Computer | 2        | 60         | 6                |
| 4  | Ceiling Fans    | 4        | 60         | 5                |
| 5  | Water Pump      | 1        | 1 HP       | 2                |
| 6  | Medical device  | 1        | 100        | 4                |

- b) Explain the process of recycling the PV modules. [6]
5. a) Discuss the technical issues related to high penetration levels of PV systems into the distribution grid, specifically focusing on voltage profile and protection coordination. [8]
  - b) Explain the working principle of the "Perturb and Observe" (P and O) MPPT algorithm. Draw the complete flowchart for this algorithm and explain how it handles a sudden decrease in solar irradiance. [8]

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| Level       | BE      | Full Marks | 80     |
| Programme   | BEL     | Pass Marks | 32     |
| Year / Part | IV / II | Time       | 3 hrs. |

**Subject:** - Applied Photovoltaic Engineering (*Elective II*) (EX76502)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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1. a) Define the term: Irradiance, Insolation, Peak sun, Air mass. [4+4]  
b) What are the maximum and minimum noon altitude angle for the location 27 degree 40 minute latitude?
2. a) Compare the IV curve of solar panel with characteristics curve of a normal diode. Also draw solar equivalent circuit at ideal condition. [4+4]  
b) Explain the effect of shading and its mitigation.
3. a) Explain thin film solar cell. [4+4]  
b) Explain silicon purification method for the construction of solar cell.
4. Explain the topologies of inverter with its advantage and disadvantage. [8]
5. What is MPPT? Explain Incond MPPT algorithm. [2+6]
6. a) Describe recent development in batteries. [4+4]  
b) What are the components of solar water pumping systems?
7. Discuss the technical issues related to high penetration level on grid connected PV system. [8]
8. Estimate the size of PV array, charge controller, battery bank and inverter to electrify a remotely located school with following load operating 220V 50Hz AC supply. Also estimate the cost of the system. Assume suitable data where necessary. [10]

| SN | Load             | Quality | Watt/unit | Hours of use |
|----|------------------|---------|-----------|--------------|
| 1  | LED bulbs        | 10      | 12        | 8            |
| 2  | Wifi-Router      | 2       | 20        | 24           |
| 3  | Desktop Computer | 3       | 250       | 4            |
| 4  | Projector unit   | 1       | 300       | 2            |
| 5  | Water pump       | 1       | 1.5 hp    | 2            |

9. a) Draw single line diagram of grid connected PV system. [4+4]  
b) Explain about the IEEE standard for integration of distributed system in grid.
10. What are the socio-economic impact of solar PV in rural areas of Nepal? [6]

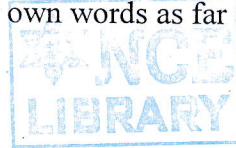
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TRIBHUVAN UNIVERSITY  
INSTITUTE OF ENGINEERING  
**Examination Control Division**  
2079 Chaitra

| Exam.       | Regular |            |        |
|-------------|---------|------------|--------|
| Level       | BE      | Full Marks | 80     |
| Programme   | BEL     | Pass Marks | 32     |
| Year / Part | IV / II | Time       | 3 hrs. |

**Subject: - Applied Photovoltaic Engineering (Elective II) (EX 76502)**

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt **All** questions.
- ✓ All questions carry equal **Marks**.
- ✓ Assume suitable data if necessary.



1. a) What are the factors affecting spectral distribution and intensity of a solar radiation? Find the optimum tilt angle for a south facing PV module in Satdobato (27.65° latitude) at solar noon on Feb.4 ( day number, n = 35) [4+4]
- b) Draw I-V and Power curve of solar cell. Explain how irradiance and temperature affects the performance of solar cells. [4+4]
2. a) What are tandem cells? Explain thin film solar cells with advantages and disadvantages. [2+6]
- b) Draw a suitable control block diagram of a PV water pumping system and explain briefly about each components involved. [8]
3. a) Estimate the size of PV array, charge controller, battery bank and inverter to electrify a remotely located school with following load operating 220V 50 Hz AC supply. Also estimate the cost of the system. Assume suitable data where necessary. [10]

| SN | Load             | Quantity | Watt/unit | Hours of use |
|----|------------------|----------|-----------|--------------|
| 1  | LED bulbs        | 12       | 12        | 8            |
| 2  | Wifi- Router     | 2        | 20        | 24           |
| 3  | Desktop Computer | 3        | 250       | 5            |
| 4  | Projector unit   | 1        | 300       | 3            |
| 5  | Water pump       | 1        | 1.5 hp    | 3            |
| 6  | Fans             | 2        | 60        | 4            |
| 7  | Printer          | 2        | 800       | 3            |

- b) Explain the process of recycling the PV modules. [6]
4. a) Explain the working principle of a buck-boost converter with necessary mathematical derivation and figures. [8]
- b) Differentiate between single and multi-stage grid connected PV system. Mention the advantages and disadvantages of transformer-less integration of PV into the grid. [4+4]
5. a) Discuss the technical issues related to high penetration level on grid connected PV system. [8]
- b) What are the codes and standard applicable to PV systems? Discuss about the IEEE 1547 Standard that addresses the issue associated with grid connected PV system. [8]

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2079 Shrawan

| Exam.       | Level   | Full Marks | Time |
|-------------|---------|------------|------|
| BE          | BE      | 80         |      |
| Programme   | REL     | 72         |      |
| Year / Part | IV / II | 3 hrs.     |      |

**Subject:** - Applied Photovoltaic Engineering (Elective II)(EX76502)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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1. a) Estimate the amount of direct and diffuse radiation falling on a collector/module at solar noon on a clear day in Kathmandu (latitude  $27.67^\circ$ ) on April 7 ( $n=97$ ) if the clear sky beam isolation was found to be  $1000 \text{ W/m}^2$ . The collector is faced  $8^\circ$  towards southeast and its angle is  $30^\circ$ . [8]  
 b) Difference between NOCT and STC for a solar module. [4]  
 c) Explain the IV curve of a solar cell in dark and on illuminated condition. [4]
2. a) What are thick and thin film cells? Why does Tandem cells have highest solar conversion efficiency? [4+4]  
 b) Differentiate between tubular and flat plate batteries. What factors should be chosen while choosing battery for a PV system? [4+4]
3. a) Explain about the Socio and Economic Implications due to PV systems. [6]  
 b) Determine the size of PV array, charge controller, battery bank and inverter to electrify a remotely located school with following loads operated by 220V/50 Hz ac supply. Also estimate the overall cost of project and draw the necessary circuit layout. Assume suitable data where necessary. [10]

| SN | Load                     | Quantity | Watts/unit | Hours of use |
|----|--------------------------|----------|------------|--------------|
| 1  | Fluorescent lamp         | 8        | 40         | 6            |
| 2  | LED bulbs                | 12       | 15         | 8            |
| 3  | Desktop computers        | 5        | 100        | 4            |
| 4  | Printer / photocopy      | 2        | 800        | 1            |
| 5  | Fan                      | 8        | 60         | 2            |
| 6  | Projector units          | 3        | 150        | 3            |
| 7  | Communication equipments | 2        | 30         | 8            |

4. a) What are grid tie and grid interactive inverters? Explain different types of inverter based on its mode of operation. [8]  
 b) What are bi-directional inverters? Explain its working principle with necessary diagrams. [8]
5. a) What are the different grid connections issues related to the PV integration into the distribution network? Explain any two of the issues. [6]  
 b) What are the applicable codes and standards of a PV system? Explain about IEEE standard for integration of distributed system into the grid. [5]  
 c) Draw a single line diagram of grid connected PV system without battery backup. [5]



TIRHUVAN UNIVERSITY  
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Examination Control Division  
2079 Jestha

| Exam. | Level | Programme | Year / Part | Back | Full Marks | Pass Marks | Time   |
|-------|-------|-----------|-------------|------|------------|------------|--------|
| BE    | BE    | IEL       | IV / II     |      | 80         | 32         | 3 hrs. |

**Subject: - Applied Photovoltaic Engineering (Elective II)**

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Define solar constant. What are the factors affecting the spectral distribution and intensity of solar radiation? [1+3]
- b) Find the altitude angle and azimuth angle for the sun at 1:00 P.M. solar time in Kathmandu, Nepal (latitude 27.67°) on June 6 (Day No = 157). [4]
- c) What are the different performance parameters of a solar cell? Draw a four parameter model of a solar cell and explain its IV curves on dark and on illuminated condition. [2+6]
2. a) What are the Tandem cells? Explain its significances. Present a comparison between a thick and thin film PV cells. [4+4]
- b) Differentiate between MPPT and PWM charge controllers. Also mention their advantages and disadvantages. [4+4]
3. a) What is Linear Current booster? Draw some of the common topologies implemented for solar water pumping system. [2+4]
- b) Estimate the size of PV array, charge controller, battery bank and inverter to electrify a remotely located government school with following loads operated at 220 V/50 Hz AC supply. Provide a realistic cost estimate of the project based on current market prices in Nepal. Also draw the necessary layout. Assume suitable data where necessary. [10]

| SN | Load              | Quantity | Watts/unit | Hours of use |
|----|-------------------|----------|------------|--------------|
| 1  | Fluorescent lamp  | 7        | 40         | 6            |
| 2  | LED bulbs         | 12       | 15         | 8            |
| 3  | Wifi-Router       | 3        | 15         | 24           |
| 2  | Desktop computers | 5        | 250        | 4            |
| 3  | Printer/photocopy | 2        | 1000       | 1            |
| 4  | Fan               | 6        | 80         | 2            |
| 5  | Projector Units   | 2        | 300        | 2            |
| 6  | Water Pump        | 2        | 1.5 hp     | 3            |

4. a) Differentiate between single and multi-stage grid connected PV system. Mention the advantages and disadvantages of transformer-less integration of PV into the grid? [4+4]
- b) What are bi-directional inverters? Explain the operation of basic type of BDC with necessary circuit diagrams and operating waveforms. [2+6]
5. a) Draw a single line diagram of a grid connected PV system? What functions should a modern smart grid connected inverters offer in-order to contribute for grid stability? [4+4]
- b) Explain the features of IEEE 1547-2003. What changes are implemented in the new IEEE 1547-2018. [5+3]

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| Exam.       | Regular |            |        |
|-------------|---------|------------|--------|
| Level       | BE.     | Full Marks | 80     |
| Programme   | BEL     | Pass Marks | 32     |
| Year / Part | IV / II | Time       | 3 hrs. |

**Subject:** - Applied Photovoltaic Engineering (*Elective II*) (EX76502)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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- ✓ Assume suitable data if necessary.



1. a) What is solar constant? How does the solar spectrum get changed before reaching the surface of the earth? How are direct and diffuse solar radiations measured? [2+3+3]
- b) Explain the need of bypass diodes and blocking diodes with figures. [3]
- c) Draw solar cell equivalent circuit. What factors limit the output of a solar cell? [5]
2. a) Differentiate mono crystalline and polycrystalline solar cell regarding performance and production process. [8]
- b) Why are inverters considered a major component in a PV system? What factors should be considered while selecting battery for PV-system? [8]
3. a) Explain with diagrams the different types of DC-DC converters. [8]
- b) Explain the potential environmental impact of use of solar PV system. How solar PV helps to uplift the rural life standard? [6]
4. a) What do you mean by islanding effect in Grid connected PV system? What is the effect of PV integration on voltage profile of a feeder? [8]
- b) Estimate the sizes of solar array, battery bank, inverter and other components needed to operate an academic block with 220 V / 50 Hz loads as listed below. Also provide a realistic estimate of the cost based on current market prices in Nepal to install such a system. Assume suitable data if required. [10]

| S. No. | Load                    | Quantity | Watts | Hours of Use |
|--------|-------------------------|----------|-------|--------------|
| 1      | LED Bulbs               | 13       | 9     | 4            |
| 2      | Laptops                 | 3        | 40    | 3            |
| 3      | Desktop Computer        | 1        | 120   | 4            |
| 4      | Printer                 | 1        | 1000  | 2            |
| 5      | Projectors              | 3        | 200   | 3            |
| 6      | Wi-Fi Router            | 1        | 10    | 16           |
| 7      | Communication Equipment | 1        | 20    | 12           |
| 8      | Water Pump              | 2        | 1 Hp  | 3            |

5. a) What are the main provisions outlined in IEEE 1547-2003 regarding the grid connected PV system? What changes are implemented in the new IEEE 1547-2018? [4+4]
- b) Draw a single line diagram of grid connected PV system? What factors should be implemented in the modern smart grid connected inverters for grid-stability? [4+4]

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INSTITUTE OF ENGINEERING  
**Examination Control Division**  
2075 Bhadra

| Exam.       | Regular |            |        |
|-------------|---------|------------|--------|
| Level       | BE      | Full Marks | 80     |
| Programme   | BEL     | Pass Marks | 32     |
| Year / Part | IV / II | Time       | 3 hrs. |

**Subject:** - Applied Photovoltaic Engineering (Elective II) (EX76502)

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1. a) Describe the spectral distribution of the blackbody radiation from Sun. How are direct and diffuse solar radiations measured? [5+3]
- b) How does shading affect the performance of a PV cell? How can these effects be mitigated? [5]
- c) A PV module is made up of 36 identical cells, all wired in series. With 1-sun insolation ( $1 \text{ kW/m}^2$ ), each cell has short-circuit current  $I_{sc} = 3.4 \text{ A}$  and at  $25^\circ\text{C}$  its reverse saturation current is  $I_0 = 6 \times 10^{-10} \text{ A}$ . Parallel resistance  $R_p = 6.6 \Omega$  and series resistance  $R_s = 0.005$ . Find the voltage, current and power delivered when the junction voltage of each cell is  $0.50 \text{ V}$ . [3]
2. a) What are Epitaxial thin films? Describe the structure of GaAs cell and its characteristics. [3+5]
- b) Why are inverters considered a major component in a PV system? What are their major performance parameters? Describe square wave inverters with diagrams. [2+2+4]
3. a) What is the concept of Maximum Power Point (MPP) tracking? Compare 'Perturb and Observe (P&O)' and 'Incremental Conductance' algorithms employed for MPP tracking. [4+4]
- b) What is the effect of PV integration on the voltage profile of a feeder? How is the short circuit analysis done after the PV integration? [4+4]
4. a) Estimate the sizes of solar array, battery bank, inverter and other components needed to operate an academic block with  $220 \text{ V} / 50 \text{ Hz}$  loads as listed below. Also provide a realistic estimate of the cost based on current market prices in Nepal to install such a system. Assume suitable data if required. [10]

| S.No. | Load                    | Quantity | Watts | Hours of Use |
|-------|-------------------------|----------|-------|--------------|
| 1     | LED Bulbs               | 13       | 9     | 4            |
| 2     | Laptops                 | 3        | 40    | 3            |
| 3     | Desktop Computer        | 1        | 120   | 4            |
| 4     | Printer                 | 1        | 1000  | 2            |
| 5     | Projectors              | 3        | 200   | 3            |
| 6     | Wi-Fi Router            | 1        | 10    | 16           |
| 7     | Communication Equipment | 1        | 20    | 12           |
| 8     | Fans                    | 4        | 60    | 4            |

- b) How can PV be employed in UPS system? Describe different charging schemes of UPS by PV and grid. [6]
5. a) What are the major aspects of IEEE 1547 standard for grid connected PV? [8]

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1. a) Define altitude and azimuth angle. Find the altitude angle and azimuth angle for the sun at 3:00 P.M. solar time in Kathmandu, Nepal (latitude  $27.67^\circ$ ) on March 1 ( $n=60$ ). [8]  
b) With the aid of IV curve of a typical PV cell, explain how the internal losses affect the performance of a PV cell. Also explain the impacts of temperature and insolation on its performance. [8]
2. a) Differentiate between MPPT and PWM charge controllers. Discuss also the effect of temperature on their performance. [8]  
b) What are thin film and thick film solar cells? Differentiate between conventional and thin film technology in the fabrication of solar cells. [8]
3. a) What are the different power electronic topologies implement in PV system? Explain the main features of each of them. [8]  
b) Draw a neat diagram of bidirectional dc to dc converter and explain its operational features. Briefly explain about its application in PV system. [8]
4. a) Draw a suitable control block diagram of a PV water pumping system and explain briefly about each components involved. [6]  
b) Estimate the size of solar array, battery bank, inverter and other components needed to electrify a remotely located public school with following loads operated by 220V/ 50 Hz ac supply. Also provide a realistic estimate of the cost based on current market prices in Nepal to install such system. Assume suitable data where necessary. [10]

| SN | Load              | Quantity | Watts/unit | Hours of use |
|----|-------------------|----------|------------|--------------|
| 1  | Fluorescent lamp  | 20       | 40         | 7            |
| 2  | Desktop computers | 10       | 100        | 5            |
| 3  | Printer/photocopy | 2        | 800        | 2            |
| 4  | Fan               | 8        | 60         | 4            |
| 5  | Projector Units   | 3        | 150        | 3            |
| 6  | Refrigerator      | 2        | 600        | 24           |
| 7  | Water pump        | 1        | 746(1hp)   | 2            |
| 8  | Microwave         | 1        | 1000       | 1            |

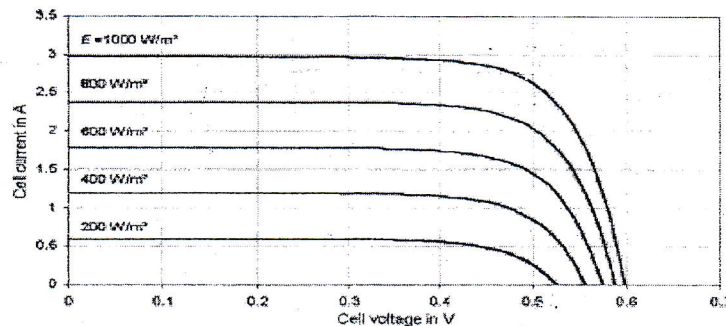
5. a) What are the codes and standards applicable to PV system? Discuss about the IEEE 1547 standards that addresses the issues associated with grid connected PV system. [8]  
b) Discuss the technical issues related to high penetration level on grid connected PV system. [8]

| Exam.       | Back     |            |        |
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1. a) What is solar spectrum? What are the factors that affect the solar radiation at earth surface? Describe the major equipments that are used to measure the solar radiation. [8]
- b) What are zenith angle, azimuth angle and tilt angle. Find the optimum tilt angle for a south-facing photovoltaic module in Kathmandu (latitude  $27.67^\circ$ ) at solar noon on March 1. [8]
2. a) Figure below shows the solar cell characteristic of a typical silicon PV-cell. If the maximum efficiency and fill factor of the cell are 18% and 0.9 respectively, determine the area of the cell. [8]



- b) What is maximum power point tracking (MPPT) of Solar PV system? Explain Perturb and Observe method of MPPT tracking? [8]
3. a) A Solar Laboratory have installed a  $7.2 \text{ kW}_p$  photovoltaic array. How much energy will it produce in a year? The location receives an average insolation of  $5.25 \text{ kWh/m}^2/\text{day}$  air-mass-ratio (AM) = 1.5 and irradiance ( $G$ ) =  $1000 \text{ W}_p/\text{m}^2$ . [4]
- b) Classify Solar Cell on basis of generation. Differentiate between Monocrystalline and Polycrystalline Solar cells. [8]
- c) In the table given below, the energy used for a year by a city is given below. Determine the size in  $\text{kW}_p$  of PV to supply the energy for city. Given  $\eta = 16\%$  for PV, PSH = 4.5 hr. [4]

| Months   | Energy Used [Wh] | Months    | Energy Used [Wh] |
|----------|------------------|-----------|------------------|
| January  | 2432             | July      | 144000           |
| February | 2732             | August    | 119233           |
| March    | 4562             | September | 99083            |
| April    | 9500             | October   | 45540            |
| May      | 21900            | November  | 25540            |
| June     | 69958            | December  | 5350             |

4. a) With neat and clean figures, explain about the grid connected PV system. **[8]**

b) What does an inverter mean? What are the different types of solar inverter? Describe each briefly. **[8]**

5. a) Determine the size of PV array, battery and inverter size according to the load given in the table. Also provide relevant estimate cost of the system. Suggest ways to decrease the cost on basis of coincidence factor. Assume the relevant data required. **[10]**

| S.N | Load        | Quantity | Power    | Operation Hours /day |
|-----|-------------|----------|----------|----------------------|
| 1   | Fan         | 5        | 60 Watt  | 7                    |
| 2   | CFL         | 10       | 40 Watt  | 10                   |
| 3   | TV          | 2        | 100 Watt | 4                    |
| 4   | Laptop      | 1        | 70 Watt  | 8                    |
| 5   | Rice cooker | 1        | 800 Watt | 2                    |
| 6   | Water Pump  | 1        | 1 hp     | 1                    |

b) What are importance of major standards used in PV system? Discuss the relevant standards used in the PV system. **[6]**

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2073 Bhadra

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| Level       | BE      | Full Marks | 80     |
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1. a) What is solar constant? How does the solar spectrum get changed before reaching the surface of the earth? How are direct and diffuse solar radiations measured? [2+3+3]
- b) With the aid of IV curve of a typical PV cell, explain how the internal losses affect the performance of a PV cell. Also explain the impacts of temperature and isolation on its performance. [8]
2. a) Make comparison of monocrystalline and polycrystalline silicon solar cells regarding their production processes and performance. [8]
- b) Compare the performance of PV-Battery system with and without utilizing intermediate dc-dc converter. [2+2+4]
3. a) Develop two-stages power electronic interface schemes associated with grid-connected solar PV system. Explain the control feature of the PV side converter. [8]
- b) What is the effects of PV integration on the voltage profile and short circuit level of the distribution network? Explain with suitable examples. [8]
4. a) Draw a suitable control block diagram of a PV water pumping system and explain briefly about each components involved. [6]
- b) Estimate the sizes of solar array, battery bank, inverter and other components needed to operate an academic block with 220 V/50 Hz loads as listed below. Also provide a realistic estimate of the cost based on current market prices in Nepal to install such a system. Assume suitable data if required. [10]

| S.No. | Load                    | Quantity | Watts | Hours of Use |
|-------|-------------------------|----------|-------|--------------|
| 1     | LED Bulbs               | 13       | 9     | 4            |
| 2     | Laptops                 | 3        | 40    | 3            |
| 3     | Desktop Computer        | 1        | 120   | 4            |
| 4     | Printer                 | 1        | 1000  | 2            |
| 5     | Projectors              | 3        | 200   | 3            |
| 6     | Wi-Fi Router            | 1        | 10    | 16           |
| 7     | Communication Equipment | 1        | 20    | 12           |
| 8     | Fans                    | 4        | 60    | 4            |

5. a) What is the significance of interconnection standards? Discuss relevant standards applicable for grid connected PV systems. [8]
- b) Discuss the technical issues related to high penetration level on grid connected PV system. [8]