Enrollment No.....................................

Faculty of Engineering

End Sem (Odd) Examination Dec-2018

OE00013 Photovoltaic Systems

Programme: B.Tech.   Branch/Specialisation: All

Duration: 3 Hrs.   **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1   i.   Which one considered as renewable energy source   **1**
             (a) Coal   (b) Wind   (c) Oil   (d) None of these
       ii.   Most common material used for the construction of solar cells is?   **1**
             (a) Germanium   (b) Silicon
             (c) Aluminium   (d) Copper
       iii. The solar radiation at standard test conditions is?   **1**
             (a) 700 W/m^2 (b) 500 W/m^2 (c) 100W/m^2 (d) 1000 W/m^2
       iv.   What will be the output power in Watts of PV cell under open   **1**
             circuit condition?
             (a) Infinite   (b) Ten   (c) Zero   (d) None of these
       v.   The capacity of battery is measured in?   **1**
             (a) Ampere   (b) Ampere-hour
             (c) Volts   (d) Henry
       vi.   In PV system battery is used for   **1**
             (a) Storage   (b) Conversions
             (c) Charging   (d) Amplification
       vii. Which of following is true for Boost converter?   **1**
             (a) Steps down voltage
             (b) Steps up voltage
             (c) Increases output power level
             (d) Increases input power level
       viii. The range of duty cycle for a DC-DC converter is?   **1**
             (a) Less than zero   (b) Greater than 1
             (c) Zero to one   (d) None of these

P.T.O.

ix. At maximum power point, $\frac{dI}{dV}$ is equal to? **1**

   (a) $\frac{-I}{V}$ (b) $\frac{I}{V}$ (c) 1   (d) 0

x. A reference cell voltage scaling method is used to track maximum power point for a solar panel, the open circuit voltage is 43.6V, the voltage at maximum power point is equal to? **1**

   (a) 43.6 V   (b) 21.8 V   (c) 30.5   (d) 13.6 V

Q.2 i. What is the significance of renewable energy sources for power generation? **2**

ii. Discuss working principle of solar cell with band diagram? **3**

iii. Explain need of sustainable energy resource with increasing energy demand? **5**

OR iv. What is India's current power scenario and the major challenges for India's power sector? **5**

Q.3 i. Define efficiency and fill-factor with expression for PV cell. **4**

A PV panel at standard test condition can deliver maximum power of 240 Watts, the temperature coefficient of maximum power (α_P) is -0.47% / K. What will the maximum power that PV panel can deliver at 40°C?

ii. Draw equivalent circuit of a solar cell, sketch I-V & P-V characteristics, and indicate open circuit voltage, short circuit current, maximum power point on it? Derive current-voltage relationship for a solar cell. **6**

OR iii. What is the essential condition for series connection of PV array? Explain with neat sketch I-V characteristics of identical and non-identical series connected PV array, how problem of partial shading can be overcome in PV array? **6**

Q.4 i. Define following battery parameters: **2**
(a) Battery capacity
(b) Depth of discharge

ii. Explain Lead-acid and Nickel-Cadmium batteries with necessary chemical reactions; enlist merit and demerits of both batteries? **8**

OR iii. How batteries are classified. Discuss any three standalone PV system configurations for PV system design with block diagram? **8**

Q.5 i. Draw circuit diagram for following DC-DC converter **3**
(a) Buck converter   (b) Boost converter
(c) Buck-Boost converter

ii. Derive expression for source current ripple & input-output voltage for Boost converter. **7**

A Buck converter has input voltage as 12 volts & output voltage of 5 volts with switching frequency 25kHz, peak to peak ripple current of inductor is 0.8A, determine:
(a) Duty cycle (D)   (b) Filter inductance (L)

OR iii. Derive expression for inductor current ripple and average inductor current for Buck converter. **7**

A Boost converter is feeding a resistive load of 20 ohms from 12V source, switching frequency 250kHz, duty ratio (D)= 0.4 and inductance (L)= 100μH determine:
(a) Average source current
(b) Peak to peak source current ripple

Q.6 Attempt any two:

i. Why MPPT is essential for PV application? Explain with block diagram concept of maximum power point tracking. **5**

ii. Discuss reference cell and sampling method for tracking maximum power point. **5**

iii. Write short note on following MPPT techniques: **5**
(a) Perturb & observe   (b) Incremental & conductance

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Marking Scheme

OE00013 Photovoltaic Systems

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Q.1 i. Which one considered as renewable energy source — **1**
(b) Wind

ii. Most common material used for the construction of solar cells is? — **1**
(b) Silicon

iii. The solar radiation at standard test conditions is? — **1**
(d) $1000 \ W/m^2$

iv. What will be the output power in Watts of PV cell under open circuit condition? (c) — **1**
Zero

v. The capacity of battery is measured in? — **1**
(b) Ampere-hour

vi. In PV system battery is used for — **1**
(a) Storage

vii. Which of following is true for Boost converter? — **1**
(b) Steps up voltage

viii. The range of duty cycle for a DC-DC converter is? — **1**
(c) Zero to one

ix. At maximum power point, $\frac{dI}{dV}$ is equal to? — **1**
(a) $\frac{-I}{V}$

x. A reference cell voltage scaling method is used to track maximum power point for a solar panel, the open circuit voltage is 43.6V, the voltage at maximum power point is equal to? — **1**
(c) 30.5

Q.2 i. Significance of renewable energy source explanation — **2**

ii. Photovoltaic effect — 1 mark — **3**

Band diagram & its explanation — 2 marks

iii. Correct explanation for need of sustainable energy source — **5**

OR iv. India's power scenario — 2 marks — **5**
Major challenges for India's power sector — 3 marks

Q.3 i. Efficiency (with expression) — 1 mark — **4**
Fill-factor (with expression) — 1 mark
Numerical maximum power calculation — 2 marks

ii Equivalent circuit of a solar cell — 1 mark — **6**
I-V & P-V characteristics — 2 marks
Correct indication of open circuit voltage, short circuit current, maximum power point — 1 mark
Current-voltage relationship for a solar cell derivation — 2 marks

iii. Essential condition for series connection of PV array — 1 mark — **6**

I-V characteristics of identical and non-identical series connected PV array — 4 marks
Problem of partial shading can be overcome in PV array — 1 mark

Q.4 i. Battery capacity — 1 mark — **2**
Depth of discharge — 1 mark

ii. Lead-acid battery — **8**
Explanation & chemical reactions — 2 marks
Merits & demerits — 2 marks
Nickel-Cadmium battery
Explanation & chemical reactions — 2 marks
Merits & demerits — 2 marks

OR	iii.	Battery classification	2 marks	**8**
		Three standalone PV system configurations with block diagram		
			6 marks	

Q.5	i.	Circuit diagram of		**3**
		(a) Buck converter	1 mark	
		(b) Boost converter	1 mark	
		(c) Buck-Boost converter	1 mark	
	ii.	Derivation for Boost converter of		**7**
		source current ripple	2 marks	
		input-output voltage	2 marks	
		Numerical		
		(a) Duty cycle	1.5 marks	
		(b) Filter inductance (L)	1.5 marks	
OR	iii.	Derivation for Buck converter of		**7**
		Inductor current ripple	2 marks	
		Average inductor current	2 marks	
		Numerical		
		(a) Average source current	1.5marks	
		(b) Peak to peak source current ripple	1.5 marks	

Q.6		Attempt any two:		
	i.	MPPT is essential for PV application	2 marks	**5**
		Explanation with block diagram concept of maximum power point tracking	3 marks	
	ii.	Reference cell method	2.5 marks	**5**
		Sampling method	2.5 marks	
	iii.	(a) Perturb-observe	2.5 marks	**5**
		(b) Incremental-conductance	2.5 marks	