EEE 333 - Optical Communication Devices

Photodiodes MCQ Question

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MCQ Questions

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1. Q What is a photodiode commonly used for in optical communication systems?

(a) To generate light

(b) To detect the arrival of light carrier and convert it to an electrical signal

(c) To regulate the flow of electrical current

(d) To amplify the signal strength

1. A (b)

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2. Q What is the principle behind the operation of a photodiode?

(a) Electromagnetic induction

(b) Photoelectric effect

(c) Magnetic field effect

(d) Electrochemical effect

2. A (b)

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3. Q What does the transparent window in a photodiode do?

(a) Amplifies the incoming light

(b) Filters out unwanted light

(c) Allows light to strike the pn junction

(d) Generates an electrical signal

3. A (c)

4. Q In what mode does a photodiode operate?

(a) Forward-bias mode

(b) Reverse-bias mode

(c) Dual-bias mode

(d) Alternating-bias mode

4. A (b)

5. Q What happens when a photodiode is reverse-biased?

(a) Current flows through the diode

(b) Potential energy between p and n regions decreases

(c) Free carriers can climb the barrier and flow

(d) No current flows through the diode

5. A (d)

6. Q How are electron-hole pairs generated in a photodiode?

(a) By applying a forward bias voltage

(b) By applying a reverse bias voltage

(c) By exposing the pn-junction to light

(d) By increasing the temperature of the photodiode

6. A (c)

7. Q How does the reverse electric current of a photodiode vary with light intensity?

(a) It decreases proportionally with the light intensity

(b) It remains constant regardless of light intensity

(c) It increases proportionally with the light intensity

(d) It is not affected by the light intensity

7. A (c)

8. Q In what mode does a photodiode operate when it is reverse biased?

(a) Forward-bias mode

(b) Photoconductive mode

(c) Dual-bias mode

(d) Alternating-bias mode

8. A (b)

9. Q What is dark current in a photodiode?

(a) A current flow when the diode is forward-biased

(b) A current flow when the diode is reverse-biased

(c) A current flow when no optical power is incident on the diode

(d) A current flow when the diode is exposed to intense light

9. A (c)

10. Q **What is the source of dark current in a photodiode?**

(a) **Thermal generation of electron-hole pairs in the depletion region**

(b) **Photoelectric effect**

(c) **Amplification of the electrical signal**

(d) **Conversion of light to voltage**

10. A (a)

11. Q **What is the cut-off wavelength in a photodiode?**

(a) **The wavelength of light at which the photodiode becomes opaque**

(b) **The wavelength of light at which the photodiode becomes saturated**

(c) **The wavelength of light at which the photodiode becomes transparent to incident light**

(d) **The wavelength of light at which the photodiode generates the maximum current**

11. A (c)

12. Q **What is the maximum wavelength required for an incoming photon to create an electron-hole pair in a photodiode?**

(a) hc/E_g

(b) hcE_g

(c) E_g/hc

(d) **electron-hole pair can be created from any photon**

12. A (a)

Quantum Efficiency

The probability of generating a photocarrier pair when a single photon incident on the detector.

$$\eta = \frac{N_c}{N_p} = \frac{I_o}{P_i}\frac{hc}{e\lambda} \tag{1}$$

Where

P_i : number of incident photons per second

$\frac{hc}{\lambda}$: photon energy

I_o : average output generated current (photocurrent)

N_c : . number of generated charges (electron-hole pairs) per second

e : (1.6×10^{-19} C) electron charge

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13. Q What is quantum efficiency in a photodiode?

(a) The probability of generating a photocarrier pair when a single photon is incident on the detector

(b) The probability of detecting a photon when it is incident on the detector

(c) The ratio of the number of photons absorbed to the number of photons incident on the detector

(d) The ratio of the number of photons incident on the detector to the number of number of photocarrier pairs generated

13. A (a)

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14. Q What factors can affect the quantum efficiency of a photodiode?

(a) The wavelength of the incident light and the thickness of the device

(b) The reflectivity of the surface and the material used to make the device

(c) The temperature of the device and the applied bias voltage

(d) The bandgap energy of the material and the doping concentration of the device

14. A (b)

Responsivity

The ratio of the output current to the input power

$$\boldsymbol{R = \frac{I_o}{P_i} = \eta e \frac{\lambda}{hc} = \eta \frac{\lambda}{1.24\mu\text{m}}}, \quad \textbf{(A/W)} \tag{2}$$

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15. Q What is responsivity in a photodiode?

(a) The ratio of the output voltage to the input power

(b) The ratio of the output current to the input power

(c) The ratio of the output power to the input current

(d) The ratio of the output current to the input voltage

15. A (b)

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16. Q What factors does responsivity depend on in a photodiode?

(a) Operating voltage and temperature

(b) Operating current and wavelength

(c) Operating wavelength and quantum efficiency

(d) Operating voltage and quantum efficiency

16. A (c)

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17. Q Why does the responsivity .... as the wavelength increases and comes closer to the material cut-off wavelength and it as the wavelength decreases the responsivity .... because the number of the incident photon is reduced

(a) decreases, decreases

(b) decreases, increases

(c) increases, decreases

(d) increases, increases

17. A (a)

18. Q What is rise time in a photodiode?

(a) The time for the detector output current to change from 0% to 100% of its final value

(b) The time for the detector output current to change from 10% to 90% of its final value

(c) The time for the detector output current to change from 20% to 80% of its final value

(d) The time for the detector output current to change from 30% to 70% of its final value

18. A (b)

19. Q What limits the switching speed rate at which the current can vary in response to light?

(a) The wavelength of the incident light

(b) The size of the photodiode

(c) The quantum efficiency of the photodiode

(d) The rise time of the photodiode

19. A (d)

20. Q What are the two mechanisms that restrict the rise time (or switching speed) in a photodiode?

(a) Quantum efficiency and junction capacitance

(b) Transit time and quantum efficiency

(c) Transit time and junction capacitance

(d) None of the above

20. A (c)

1 Transit Time

It is the time taken by the photogenerated carriers to traverse the depletion layer, given by:

$$t_{tr} = \frac{w}{v_d} \tag{3}$$

Where

v_d **: carrier drift velocity**

w **: depletion layer width**

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21. Q **What is transit time in a photodiode?**

(a) **The time taken by the photodiode to respond to light**

(b) **The time taken by the photogenerated carriers to traverse the depletion layer**

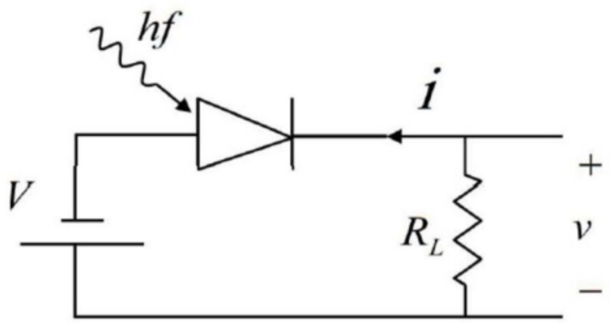
(c) **The time taken by the photodiode to reach steady-state operation**

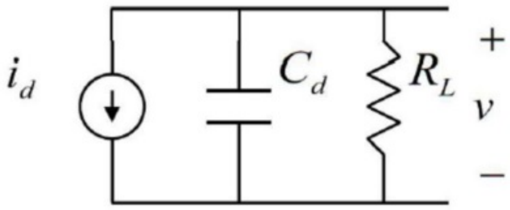
(d) **The time taken by the photogenerated carriers to recombine**

21. A (b)

Receiver Circuit - Resistor Termination

An equivalent circuit for photodiode terminated by a load resistance R_L is shown in the figure.





The frequency response function:

$$\boldsymbol{H(f) = \frac{I_L(f)}{I_d(f)} = \frac{1}{1 + j2\pi f R_L C_d}} \tag{4}$$

The 3 dB bandwidth:

$$\boldsymbol{f_{3\text{ dB}} = \frac{1}{2\pi R_L C_d}} \tag{5}$$

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22. Q **What is the frequency response function for a photodiode terminated by a load resistance R_L and a junction capacitance C_d?**

(a) $H(f) = 1$

(b) $H(f) = j2\pi f R_L C_d$

(c) $H(f) = \dfrac{1}{1 - j2\pi f R_L C_d}$

(d) $H(f) = \dfrac{1}{1 + j2\pi f R_L C_d}$

22. A **(d)**

23. Q **How does reducing the width of a photodiode affect the 3dB bandwidth?**

(a) It increases

(b) It decreases

(c) It remains constant

(d) It depends on the type of material used

23. A (b)

24. Q **How does reducing the width of a photodiode affect the junction capacitance C_d?**

(a) It increases

(b) It decreases

(c) It remains constant

(d) It depends on the type of material used

24. A (a)

25. Q **What is the purpose of using a transimpedance amplifier (TIA) in a receiver circuit for a photodiode?**

(a) To decrease the junction capacitance of the photodiode

(b) To increase the bandwidth of the photodiode

(c) To eliminate nonlinearity due to diode voltage

(d) To increase the responsivity of the photodiode

25. A (c)

26. Q What is the function of transimpedance amplifier (TIA) in a photodiode receiver circuit?

(a) To convert diode current to a proportional output voltage

(b) To decrease the transit time of the photogenerated carriers

(c) To increase the junction capacitance of the photodiode

(d) To reduce the responsivity of the photodiode

26. A (a)

27. Q What is the main difference between a PIN photodiode and a regular p-n photodiode?

(a) A PIN photodiode has a wider intrinsic layer between the p and n regions.

(b) A PIN photodiode has no intrinsic layer between the p and n regions.

(c) A PIN photodiode has a p region only.

(d) A PIN photodiode has an n region only.

27. A (a)

28. Q What is the advantage of using a PIN photodiode over a regular p-n photodiode?

(a) PIN photodiode can generate more electron-hole pairs due to incoming photons.

(b) PIN photodiode is smaller in size.

(c) PIN photodiode has a higher responsivity at longer wavelengths.

(d) PIN photodiode has a lower dark current.

28. A (a)

29. Q **What is the main difference between the operation of PIN diodes and avalanche photodiodes (APD)?**

(a) In PIN diodes, one electron-hole pair is generated for each photon entering the device, while in APD, the generated electrons can stimulate other electron-hole pairs creating an avalanche effect.

(b) In PIN diodes, the generated electrons can stimulate other electron-hole pairs creating an avalanche effect, while in APD, one electron-hole pair is generated for each photon entering the device.

(c) Both PIN diodes and APDs generate one electron-hole pair for each photon entering the device, but the depletion region is wider in APDs.

(d) Both PIN diodes and APDs generate one electron-hole pair for each photon entering the device, but APDs have a narrower depletion region.

29. A (a)

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30. Q **What is the avalanche effect in an avalanche photodiode (APD)?**

(a) The generation of one electron-hole pair for each photon entering the device.

(b) The amplification of the generated electrons due to the wider depletion region in APDs.

(c) The stimulation of other electron-hole pairs by the high-energy electrons generated in the device, leading to an avalanche of electrons.

(d) The reduction of the capacitance of the depletion region in APDs, which improves the frequency response of the device.

30. A (c)

31. Q What is the operation principle of an avalanche photodiode (APD)?

(a) It generates one electron-hole pair for each photon entering the device

(b) It builds a low electric field inside the device to collect the generated carriers

(c) It accelerates the generated conduction electrons to stimulate more electrons by impact i

(d) It uses an intrinsic semiconductor layer between the p and n regions

31. A (c)

32. Q What happens in an avalanche photodiode (APD) when the generated conduction electrons gain high energy and travel at high velocities?

(a) They recombine with the holes in the valence band

(b) They stimulate the generation of one electron-hole pair

(c) It stimulate more electrons from the valence band into the conduction and create an aval

(d) They create a depletion region between the p and n regions

32. A (c)

33. Q What is the main issue with using APDs in optical communications?

(a) APDs are expensive to produce

(b) APDs are not sensitive enough to detect light signals

(c) APDs have a very short lifespan

(d) APDs suffer from a gain-bandwidth trade-off and noisy avalanche process

33. A (d)

34. Q **What is the gain-bandwidth trade-off in APDs? a. b. c. d.**

(a) The higher the multiplication factor, the lower the noise

(b) The higher the multiplication factor, the higher the responsivity

(c) The higher the multiplication factor, the shorter the avalanche continue time

(d) The higher the multiplication factor, the longer the avalanche continue time

34. A (d)

35. Q **Which statement is true about the avalanche noise in APDs?**

(a) It is always present, even when there is no light

(b) It appears only when light is applied

(c) It is greater on ZEROs than on ONEs in binary communication

(d) It does not affect the signal-to-noise ratio

35. A (b)

36. Q **Why is it necessary to control the reverse-bias applied voltage in APDs?**

(a) To reduce the avalanche noise

(b) To increase the multiplication factor

(c) To increase the responsivity

(d) To prevent full avalanche breakdown

36. A (d)

37. Q **What is required to obtain high responsivity in APDs at high reverse voltage?**

(a) **Low reverse voltage**

(b) **High operating frequency**

(c) **Low operating temperature**

(d) **additional powers supply**

37. A **(d)**