Ideal Answers for 1st attempt 2nd semester

Final Examination

Physics of Optics

Q1:A

$$R = \frac{\eta e \lambda}{hc} = \frac{0.8 \times 1.602 \times 10^{-19} \times 0.9 \times 10^{-6}}{6.626 \times 10^{-34} \times 2.998 \times 10^{8}}$$

$$= 0.581 \text{ A W}^{-1}$$

Also, from Eq. (8.4), the photocurrent:

$$I_p = P_o R$$
$$= 0.5 \times 10^{-6} \times 0.581$$
$$= 0.291 \ \mu\text{A}$$

Finally, using Eq. (8. 30):

$$M = \frac{I}{I_p} = \frac{11 \times 10^{-6}}{0.291 \times 10^{-6}}$$
$$= 37.8$$

The multiplication factor of the photodiode is approximately 38.

Q2:A:

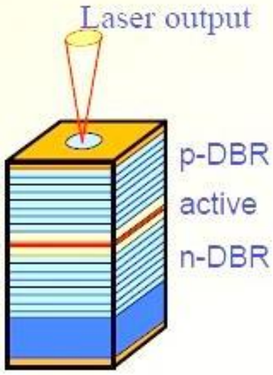
Periodicity of the long-period Used for flattening the response grating is typically several hundred of an EDFA times greater than that of the Bragg grating Band reject filters .The bandwidth of the long-period grating is relatively large. Used for fiber-optic sensing. Optical Sensors

The physical length (typically a few centimetres) of the long-period grating is much longer than that of the FBG.

Long-period grating is extremely sensitive to bends in the fibre; long-period grating may experience a significant non uniform strain field along a grating length of a few centimetres .

B:

- Distributed Bragg reflector mirrors
  - Alternating layers of semiconductor material
  - 40 to 60 layers, each λ / 4 thick
  - Beam matches optical acceptance needs of fibers more closely
- Key properties
  - Wavelength range: 780 to 980 nm (gigabit ethernet)
  - Spectral width: <1nm
  - Total output power: >-10 dBm
  - Coherence length:10 cm to10 m
  - Numerical aperture: 0.2 to 0.3



Q3:A:

$$V = \frac{2\pi}{\lambda} a(NA) = \frac{2\pi \times 25 \times 10^{-6} \times 0.2}{1 \times 10^{-6}}$$

$$= 31.4$$

The mode volume may be obtained from Eq. (2.95) where for a parabolic profile:

$$M_g \simeq \frac{V^2}{4} = \frac{986}{4} = 247$$

Hence the fiber supports approximately 247 guided modes.

B: A light-emitting diode (LED) is a semiconductor device that emits incoherent light , through spontaneous emission , when a current is passed through it .

Typically LEDs for the 850-nm region are fabricated using GaAs and

AlGaAs . LEDs for the 1300-nm and 1550-nm regions are fabricated using InGaAsP and InP. The use of LEDs in single mode systems is severely limited because they emit unfocused incoherent light . Even LEDs developed for single mode systems are unable to launch

sufficient optical power into single mode fibers for many applications.

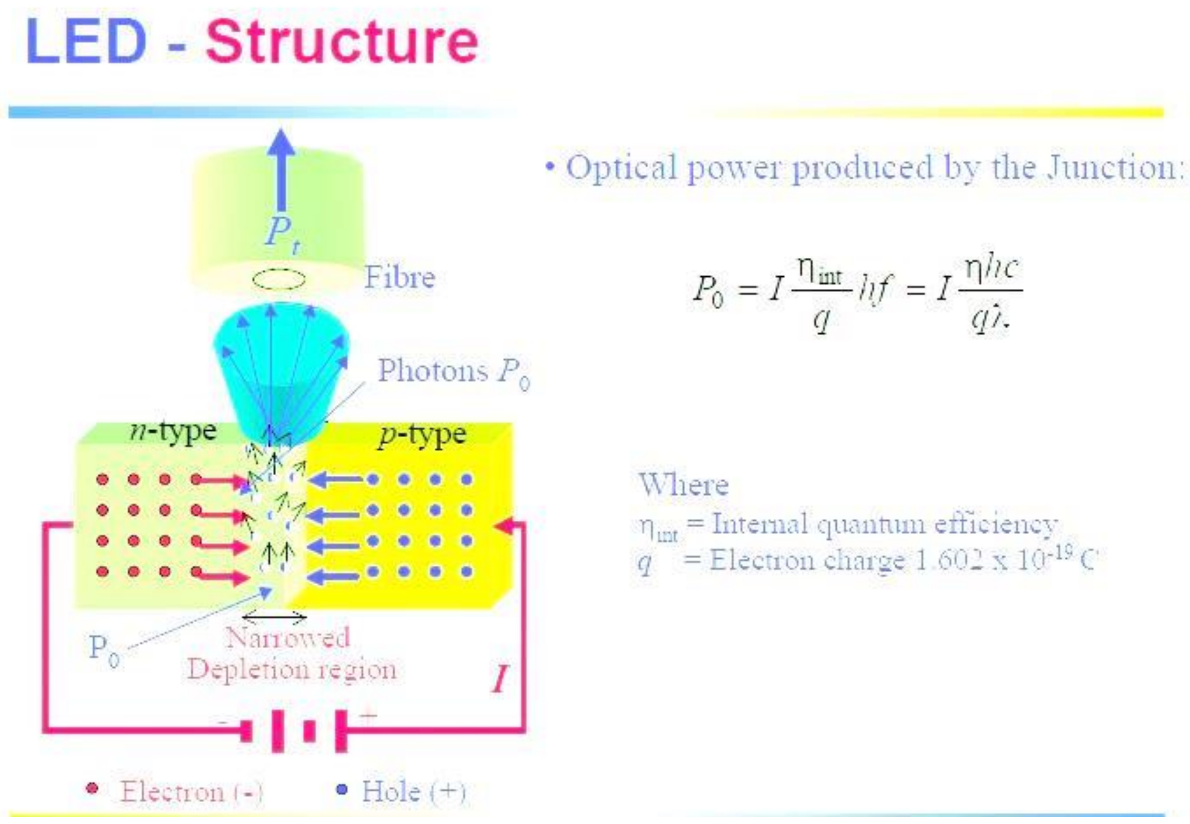
LEDs are the preferred optical source for multimode systems because they

can launch sufficient power at a lower cost than semiconductor LDs.

Current flowing through a semiconductor optical source causes it to produce light. LEDs generally produce light through spontaneous emission when a current is passed through them. Spontaneous emission is the random generation of photons within the active layer of the LED. The emitted photons move in random directions. Only a certain percentage of the photons exit the semiconductor and are coupled into the fiber. Many of the photons are absorbed by the LED materials and the energy dissipated as heat. The basic LED types used for fiber optic communication systems are :

Surface - emitting LED (SLED) .

- Edge - emitting LED (ELED)



- Electric field is concentrated in a thin intrinsic (I) layer .
- • No internal gain
- • Low bias voltage
- [10-50 V @ λ = 850 nm, 5-15 V @ λ = 1300 –1550 nm].
- • Highly linear .
- • Low dark current .
- • Most widely used .

- Avalanche Photo-Detector (APD)
- Like p-i-n photodiodes, but have an additional layer in which an average of secondary electron-hole pairs are generated through impact ionization for each primary pair .

• Internal gain (increased sensitivity) .

where , G = APD gain .

• Best for high speed and highly sensitive receivers .

• Strong temperature dependence .

• High bias voltage[250 V @ λ = 850 nm, 20-30 V @λ= 1300 – 1550 nm] .

• Costly .

Q4:

$$q = \frac{2nL}{\lambda} = \frac{2 \times 1.78 \times 0.04}{0.55 \times 10^{-6}} = 2.6 \times 10^5$$

Using Eq. (6.14) the frequency separation of the modes is:

$$\delta f = \frac{2.998 \times 10^8}{2 \times 1.78 \times 0.04} = 2.1 \text{ GHz}$$

Q5:A:

$$\phi_c = \sin^{-1}\frac{n_2}{n_1} = \sin^{-1}\frac{1.47}{1.50}$$
$$= 78.5°$$

(b) From Eq. (2.8) the NA is:

$$NA = (n_1^2 - n_2^2)^{\frac{1}{2}} = (1.50^2 - 1.47^2)^{\frac{1}{2}}$$
$$= (2.25 - 2.16)^{\frac{1}{2}}$$
$$= 0.30$$

(c) Considering Eq. (2.8) the acceptance angle in air θ_a is given by:

$$\theta_a = \sin^{-1} NA = \sin^{-1} 0.30$$
$$= 17.4°$$

B:

Photodetector –The most commonly used photodetectors in optical communications are:

- Positive – Intrinsic - Negative (PIN) .
- Avalanche Photo-Detector (APD) .

PIN

- Intrinsic layer is introduced
    - Increase the space charge region .
    - Minimize the diffusion current .
    - Electric field is concentrated in a thin intrinsic (I) layer .
    - • No internal gain
    - • Low bias voltage
    - [10-50 V @ λ = 850 nm, 5-15 V @ λ = 1300 –1550 nm].

- ▪ • Highly linear .
- ▪ • Low dark current .
- ▪ • Most widely used .

- Avalanche Photo-Detector (APD)
- Like p-i-n photodiodes, but have an additional layer in which an average of secondary electron-hole pairs are generated through impact ionization for each primary pair .

  • Internal gain (increased sensitivity) .

  where , G = APD gain .

  • Best for high speed and highly sensitive receivers .

  • Strong temperature dependence .

  • High bias voltage[250 V @ λ = 850 nm, 20-30 V @λ= 1300 – 1550 nm] .

  • Costly .