University of Technology

Department of Laser & Opto-electronic Engineering

Final Examination 2011-2012

Subject: Infrared Technology | *Class: 3^{rd} year*
Division: Opto-electronic Eng. | *Time: 3 hours*
Examiner: Dr. Alaa Hussein Ali | *Date: 27/5/ 2012*

Answer five questions only

Q.1/A Explain the reticle that generates pulse width and phase modulation. **(10 MARKS)**

Q.1/B There are four types of the source of noise most encountered in a system for visible and infrared detection, State that **(10 MARKS)**

Q.2/A What is the difference between the Xenon arc Lamp and the Tungsten Lamp. **(10 MARKS)**

Q.2/B Draw and explain a basic circuit for a thermal detector that employs a temperature-based change in resistance **(10 MARKS)**

Q.3/A a Varity of photodiodes structures is available, What are these? **(10 MARKS)**

Q.3/B There are two criteria for an antireflection coating for optical materials used in air. State that. **(10 MARKS)**

Q.4 With the development of better photoconductive detectors it has become increasingly important to match the spectral band pass of the system to one of the atmospheric transmission windows. The principle means of accomplishing this to use optical filters. Explain that in details. **(20 MARKS)**

Q.5/A Write a comparison between the rotating reticle fixed optics, stationary reticle nutating optics and rotating reticle nutating optics (advantages, disadvantages, and types of modulation. **(10 MARKS)**

Q.5/B State the rotating eyeball method. **(10 MARKS)**

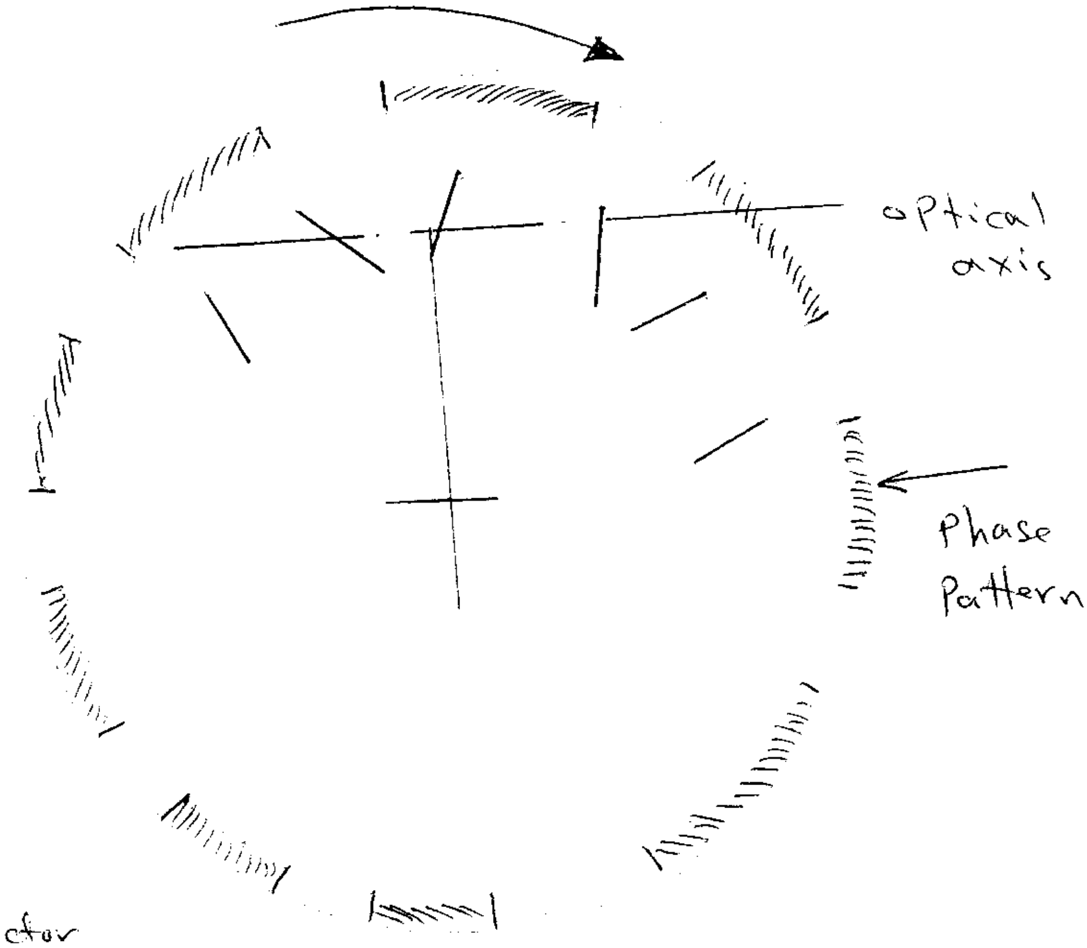
Q.6/A Some noise present in the o/p of a photodetector because of the random arrival rate of photons from the sources, which called the photon noise. Explain that **(10 MARKS)**

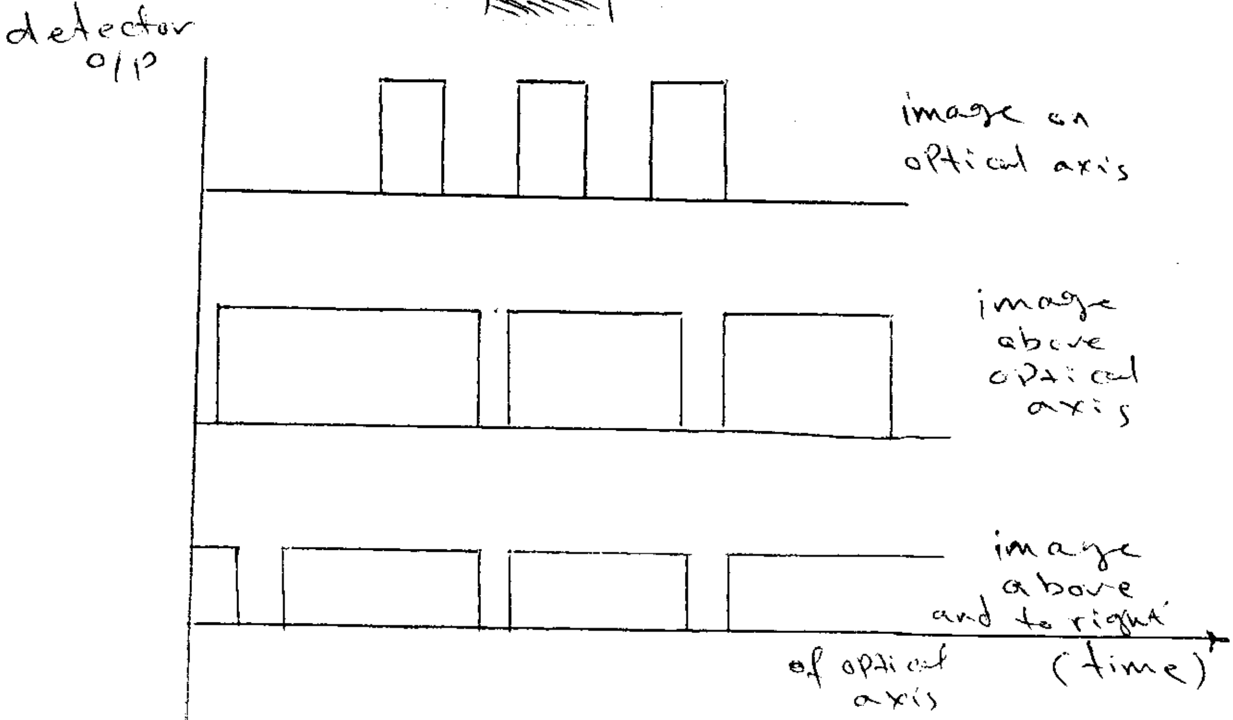
Q.6/B The performance of optical detector is commonly described by a number of different characteristics. State that in details **(10 MARKS)**

الدور الاول
حلول الاسئلة النموذجية (تقنية الرصد تحت الحمراء) لسنة ٢٠١١ - ٢٠١٢

Q.1/A

The Pattern consists of triangular - shaped elements with the bases of the triangles alternately toward or away from the center of the reticle. an image on the optical axis is chopped into a series of pulses. If the image move vertically from the optical axis, the pulse width varies in proportion to the distance from the axis. If the image moves horizontally it causes a change in the phase of the pulses. the modulation generated by this reticle is proportional to the cartesain rather than to the polar coordinates of the target position, the equally spaced slots around the periphery of the reticle are used to generate a phase refrence.


optical
axis
Phase
Pattern


detector
o/p
image on
optical axis
image
above
optical
axis
image
above
and to right
of optical
axis
(time)

Q.1/B

a) Johnson noise: The equation indicates methods to reduce the magnitude of the Johnson noise one may cool the system, especially the load resistor, one should reduce the value of the load resistance, although this is done at the price of reducing the ~~availabl~~ available signal, one should keep the bandwidth of the amplification small.

b) Shot noise: its derived from fluctuations in the stream of electrons in a vacuum tube. These variations create noise because of the random fluctuations in the arrival of electrons at the anode. it originally was likend to the noise of a hail of shot striking a target.

c) 1/f noise: The noise power is inversely proportiona to f, The modulation frequency. This dependent of the noise power leads to the name for this type of noise. To reduce 1/f noise, a photodetector should be operated at a reasonably high frequency often taken as 1000 HZ. This is a high enough value to reduce the contribution of 1/f noise to a small amount.

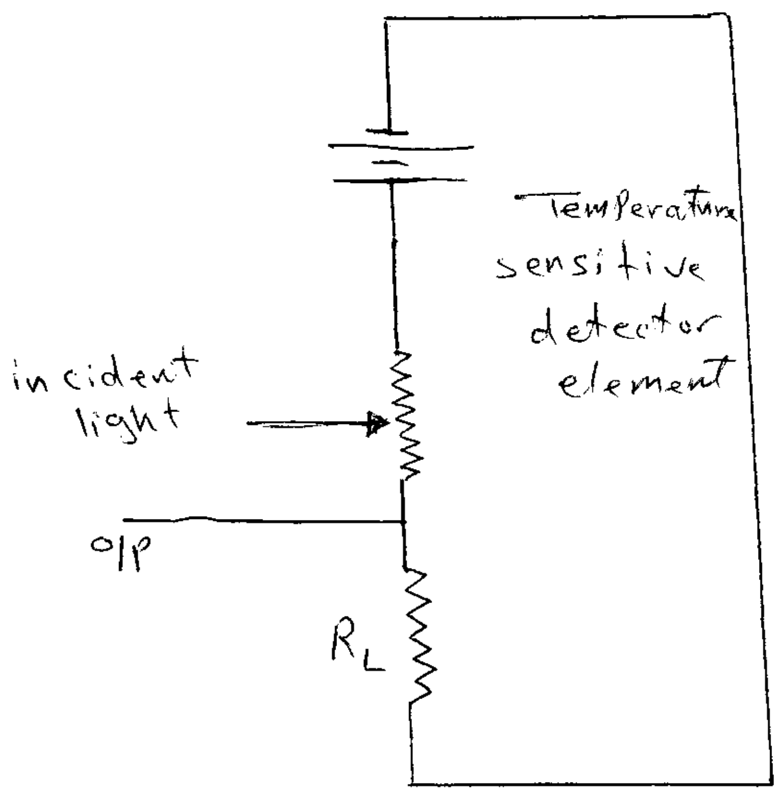
d) Photon noise: its associated with the fluctuatio in the arrival rate of Photons in the desired signal is not something that can be reduced. The contribution of fluctuations in the arrial of Photons from the background, a contributio that is called background noise, can be reduced the background noise increase with the temperature of the background. In some case it may be Possib to reduce the field of view of the detector so as to view only the source of interest.

Tungsten Lamp are used as Sources, but only for the near infrared Since their glass envelope do not transmit radiant energy beyond 4 μm. filament temperature as high as 3300°K can be obtained, the average emissivity of a tungsten filament at 2800°K is about 0.23 from 2 to 3 μm.

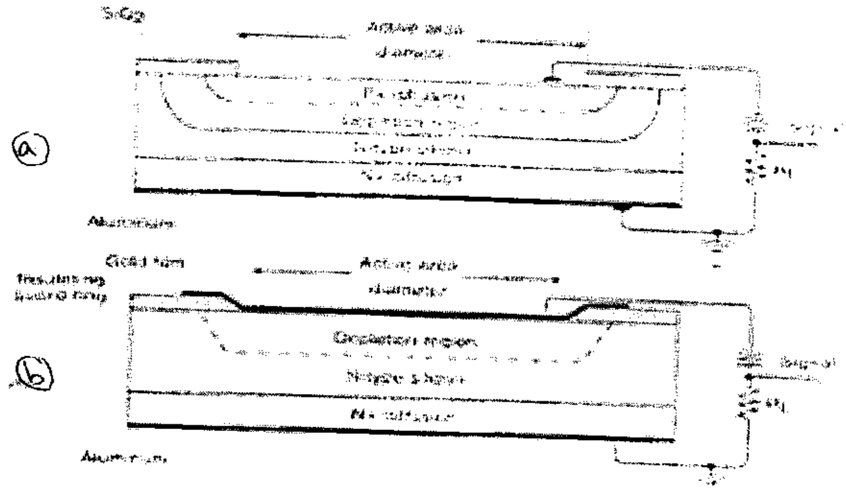
The Xenon-arc Lamp has been used in near infrared Communication system, its particular advantage is the ease with which o/p can be modulated by varying the current supplied to the Lamp.

Q.2/B

In this very simple circuit, the signal aries from the charge in voltage drop across the Load, the Load resistor, when the resistance of the detector element is charged by heating by the incident radiant energy. if the Load resistance is much smaller than the resistance of the detector element the perecentage change of the signal will be maximized.



Q.3/A



Photodiode structure: ⓐ Planar diffused photodiode
ⓑ Schottky photodiode.

A number of different semiconductor materials is in common use as optical detectors. They include silicon in the visible and near ultraviolet and near infrared, germanium and indium gallium arsenide in the near infrared, and indium antimonide, indium arsenide, mercury cadmium telluride, and germanium doped with elements, like copper and gold in the longer-wavelength infrared.

Q.3/B

① it's index of refraction must be equal to the square root of the index of the optical materials to be coated.

② it's optical thickness must be equal to one-fourth of the wavelength at which minimum reflection is to occur.

Q.4

With the development of better Photoconductive detection (detectors) it has become increasingly important to match the spectral bandpass of the system to one of the atmospheric transmission windows. The Prinicipal means of accomplishing this is to use optical filters.

Two types are available. The absorption filter depends for its effectiveness or the absorbing characteristics of various dyes, plastics, and optical materials. The reflection or interference wavelengths. The relatively new interference filter can be made to have almost any desired spectral transmittance c/cs. Thus it desirable to have a more quantitative descriptive terminology for specifying filters.

ⓐ A bandpass filter: transmits a band of wavelengths. sharply bounded by extended regions of low transmittance.

ⓑ spectral bandwidth. describes the wavelength interval transmitted by the filter in terms of the center wavelenght and the half-width.

ⓒ half-width: is the wavelength interval (in micron) over which the transmittance exceeds one-half. the Peak transmittance of the filter.

ⓓ Peak transmittance: is The maximum transmittance within the spectral bandwidth of the filter.

ⓔ A long-wavelength Pass filter: transmits all wavelength Longer than a specified cut-off wavelength

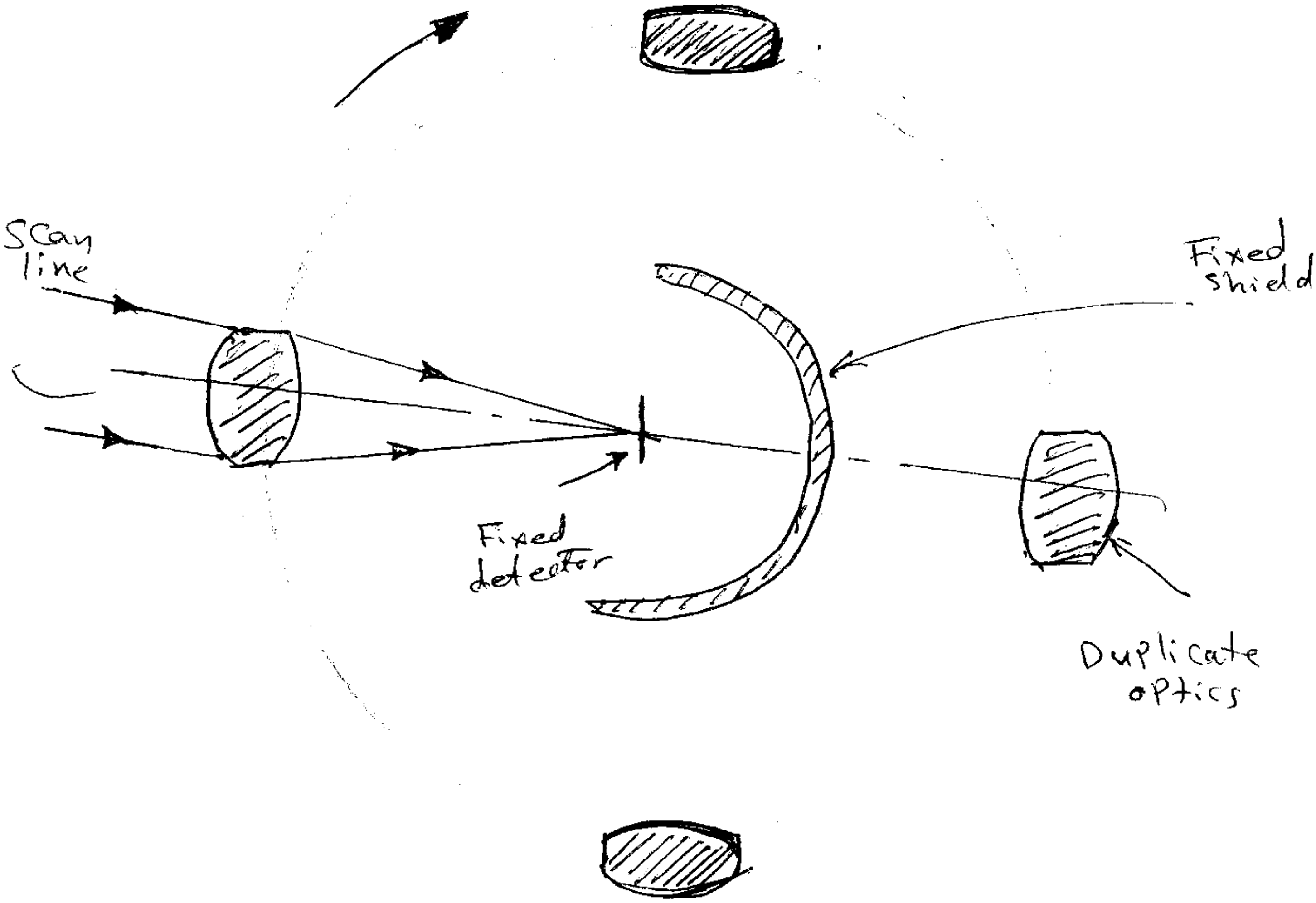
ⓕ A short-wavelength Pass filter: transmits all wavelengths shorter than a specified cut-off wavelength.

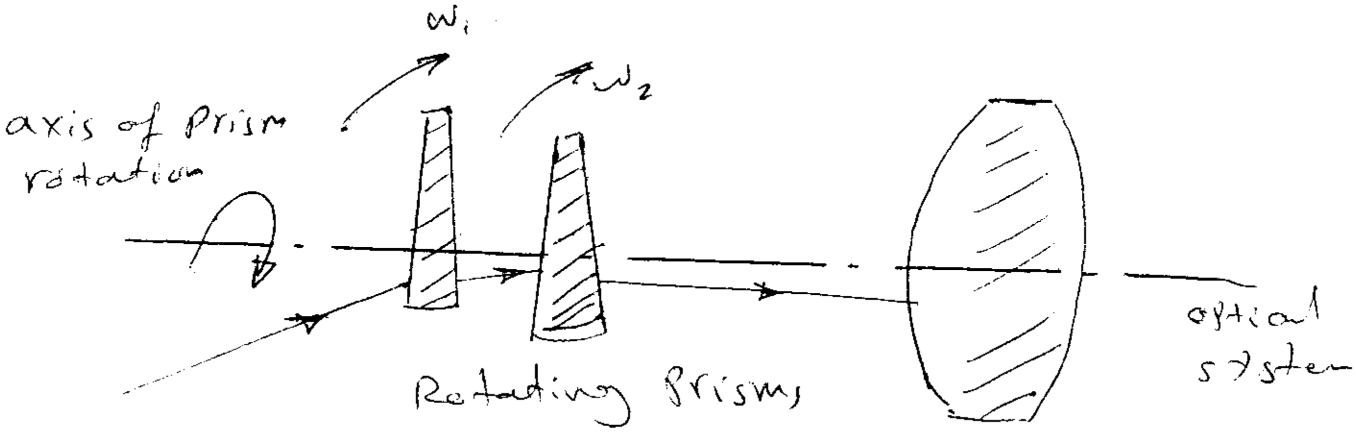
Q.5 1H

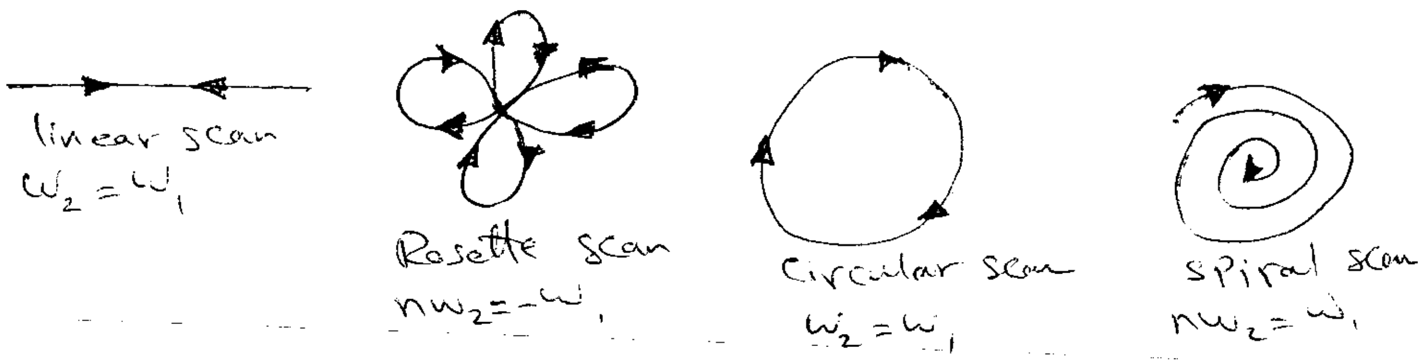
Type	Type of modulation	Advantages	disadvantages
Rotating reticle fixed optics	AM	Simple mechanical construction Adequate discrimination against Low-radiance backgrounds	Loss of carrier in absence of Pointing error Relatively Poor discrimination against high-radiance background.
	FM	Same as for AM	Same as for AM wide electrical band width.
stationary reticle nutating optics	AM	Excellent discrimination against high-radiance backgrounds No loss of carrier with zero Pointing error Relatively simple mechanical construction	Moderatly wide electrical bandwidth Shift in apparent position of target for a large image size
	FM or FM/AM	Same as for AM	Reversal of FM signal when image crosses center of reticle Abrupt shift in apparent position of target for a large image size wide electrical band width
Rotating reticle nutating optics	FM	good discrimination against high-radiance backgrounds No loss of carrier with zero Pointing error	Highly complex mechanical construction wide electrical bandwidth.

Q.5/B

Four lenses rotates about a single fixed detector a shield placed around the detector ensures that it "sees" only one set of optics at a time and limits the azimuthal coverage to 80 deg. If each optical axis lies in the plane of the papers, each lens scan in turn the same scan line. To provide elevation coverage a pair of thin prisms placed in front of the optics. If the prisms rotate in opposite directions and if their angular velocities as are equal, a linear scan results, if these velocities are not equal, a rosette scan is obtained, Similarly if they rotate in the same direction and if their angular velocities are equal, acicular scan results, if their velocities are unequal, a spiral scan is obtained.


Scan line
Fixed shield
Fixed detector
Duplicate optics


ω_1
ω_2
axis of Prism rotation
Rotating Prisms
optical system


linear scan
$\omega_2 = \omega_1$
Rosette scan
$n\omega_2 = -\omega_1$
Circular scan
$\omega_2 = \omega_1$
spiral scan
$n\omega_2 = \omega_1$

(V)

Q.6/A

The Photon noise associated with the fluctuations in the arrival rate of Photons in the desired signal is not something that can be reduced. The contribution of fluctions in the arrival of Photons from the background a contribution that is called background noise, can be reduced. The background noise increases with the field of view of the detector and with the temperature of the background. In some cases it may be Possible to reduce the field of view of the detector so as to view only the source of interest.

Q.6/B

① responsivity : This is defined as the detector o/P per unit of i/P Power.

② NEP (Noise equivalent Power) : This is defined as the radiant Power that Produces a signal Voltage (Current) equal to the noise Voltage (Current) of the detector.

$$NEP = I A V_N / V_s (\Delta f)^{1/2}$$

I = Irradiance incident on the detector of area A

V_N : is the root mean square noise voltage within the measurment bandwidth (Δf)

V_S : is the root mean square signal voltage.

③ Detectivity (D^*)

$D^* = A^{1/2}/NEP$

$D^*(\lambda, \Delta f, f)$

④ quantum efficiency : which is the ratio of countable events produced by photons incident on the detector to the number of photons.

$Q = 100 \times R_d \times h\nu = 100 * R_d \times \left(\frac{1.2395}{\lambda} \right)$

R_d : responsivity of the detector at wavelength λ

⑤ speed of the detector response to changes in light intensity.

⑥ response time

⑦ linearity