8. Photodetectors: General Concepts

8.1. Introduction

A detector can be defined as a device that converts one type of signal into another as illustrated in Fig. 8.1. Various forms of input signal can be entered into the detector, which then generates the measurable output signal, such as an electrical current or voltage. There exist many different types of detectors depending on the objects or physical properties that they sense. The input signal can be mechanical vibrations, electromagnetic radiation, small particles, and other physical phenomena. Smoke detectors can sense the soot particulates caused by fire and seismometers sense the mechanical vibrations caused by the earth. The human body has various types of detectors: the eyes can sense electromagnetic radiation in the visible range, the ears detect sound from pressure variations through a medium such as atmospheric air or water, the tongue senses various types of chemicals, and the skin can detect temperature and pressure. Our natural sensory skills have been augmented through the development of advanced instruments such as the microscope and the thermometer, that were made possible thanks to the development of technology. Furthermore technology has made it possible for humans to detect things that could not be naturally sensed by the human body. For example, we can observe the infrared (IR) light emitted from...
warm objects and the ultraviolet (UV) light from hot objects with the help of photodetectors which will be the focus of the this and the next Chapters.

![Fig. 8.1. Concept of a detector. The input signal usually has the form of electromagnetic radiation and the output signal is often an electrical signal. The detector is a device which converts one type of signal into another which can then be processed.](image)

Human eyes respond only to visible light, from violet to red. However, the light spectrum is much broader and includes radiation beyond violet (e.g. ultraviolet, gamma rays) and red (e.g. infrared, microwaves). If the temperature of the object is larger than 6,000 K, it will emit predominantly in the ultraviolet. However, colder objects ( <2,000 K) emit predominantly in the infrared. Most of the objects on earth emit IR light, and by choosing the correct materials and growth and fabrication techniques, photodetectors can be designed to sense light in this wavelength range. Using infrared photodetectors, we can obtain information on the objects emitting this radiation to determine their geometry, temperature, surface quality, and chemical content. We can also get information on the atmosphere through which the IR light is propagated.

Due to the fact that some wavelengths of infrared light are transmitted with little loss within the Earth’s atmosphere, the IR spectrum offers some attractive advantages for photodetection purposes. Because of this and other advantages, IR photodetectors have been in active development over the last several decades and found numerous applications, such as night vision, missile guidance, and range finders. As the cost of these IR photodetectors has decreased, they have become more available for civilian and industrial applications where they are used in hazardous gas sensing, security systems, thermal imaging for medical purposes, hot spot monitoring and optical communications. Specialized infrared imagers have recently been used to detect malignant cancers and have acted as collision and ranging sensors in automobiles. Due to their prominence in commercial and military applications, in this and the next Chapters we will focus on photodetectors designed for the infrared regime.

Regardless of sensing wavelength, photodetectors are usually integrated into a system that generates a signal which can be easily recognized and interpreted by humans. A few elements of such a system are shown in a block diagram form in Fig. 8.2. The system may be designed to detect the target, to track it as it moves, or to measure its temperature. If the radiation from the target passes through any portion of the earth’s atmosphere, it will be attenuated because the atmosphere is not perfectly transparent. The