

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

When an object (defined by a difference in luminance from its surroundings) moves, the motion can be detected by a relatively simple motion sensor designed to detect a change in luminance at one point on the retina and correlate it with a *delayed* change in luminance at a neighbouring point on the retina. Sensors that work this way have been referred to as Reichardt detectors. (Reichardt, 1961)

The basic idea behind the energy model is to build spatio-temporal filters which are oriented in space-time and therefore match the oriented space-time structure of moving spatial patterns. This is accomplished by adding together space-time separable filters. A separable filter is one in which the spatial profile remains the same shape over time but is scaled by the value of the temporal filter. For each direction two space-time filters are generated one which is symmetric (bar-like) and one which is asymmetric (edge-like). The sum of the squares of these filters is called the motion energy. The difference in the signal for the two directions is called the opponent energy. However the response of this system will also depend upon contrast and so the result must be divided though by the squared output of another filter which is tuned to static contrast. This gives a phase independent measure which increases with speed but does not reliably give the correct speed value. The model can account for a number of motion phenomenons.

(Adelson and Bergen, 1985)

Motion stimuli are classified into *first-order* stimuli, in which the moving contour is defined by luminance, and *second-order* stimuli in which the moving contour is defined by contrast, texture, flicker or some other quality that does not result in an increase in motion energy in the Fourier spectrum of the stimulus

(Chubb & Sperling, 1988; Cavanagh & Mather, 1989)

The motion aftereffect (MAE) -is a visual illusion perceived after watching a moving visual stimulus for about a minute and then looking at stationary stimulus. The stationary stimulus appears to move slightly for about 15 seconds, opposite to the direction of the original (physically moving) stimulus. The motion aftereffect is believed to be the result of motion adaptation.

(Ledgeway & Smith, 1994)

Motion opponency can be demonstrated by the motion aftereffect in which a static pattern appears to slowly move in the opposite direction to the previously viewed moving stimulus. The motion aftereffect likely results from the adaptation of ortho grade motion detectors; afterward, when viewing a static stimulus, the spontaneous activity of ret-ro grade motion detectors exceeds that of the adapted motion detectors, thereby driving the percept.

(Eagleman, 2001;Wade & Verstraten, 1998)

There was nothing in the optics literature to predict that this would happen, National Laboratories researcher Dustin Carr of his group's device, which reflects a bright light from a very small moving object.

(Sandia ,2004)

2.2 Research and Investigation

2.2.1 Definition Motion Detector

A motion detector is an electronic device that detects the physical movement in a given area and transforms motion into an electric signal. The motion detector may be electrically connected to devices such as security, lighting, audio alarms, and the like. Motion sensors are used in a wide variety of applications and as a result many different types of motion sensors are available. Motion detectors are mainly used in for security systems. For example, motion detectors are typically positioned near exterior doorways or windows of a building for monitoring the area around the building. Upon detecting motion, they generate an electrical signal that is transmitted to a preselected audible alarm or lighting device which is then activated. Therefore with applying this concept into project it seasonable to implement the real time counting system audience in football stadium.

2.2.2 Type of motion detector

Motion detectors spot the movement in areas covered by the security sensors. It transmits high frequency radio wave signals and gives a warning that someone is entering into sensor area. Actually, there are a wide variety of motion detectors available currently. To allow a better understanding of motion detectors, the following section provides a detailed description of a few different types such as Infrared Sensors, Radar Sensors, Pyroelectric Sensors and Ultrasonic Sensors.

a) Infrared Sensors

Infrared (IR) detectors are widely known in the arts of intrusion detection and in fire/smoke detection. These detectors have basically two forms: active and passive.

Active IR detectors include a radiation source and an IR sensor which is sensitive to interruptions in the radiation sensed from the source. These detectors are used as intrusion detectors by providing a path of radiation from the source to the sensor in a place where the path is likely to be interrupted by an intruder. A passive infrared motion detection system detects heat energy radiated or emitted by an object, such as a body of a person, moving across a field of view of a heat sensor, such as a pyroelectric detector, of the motion detection system. Passive infrared motion detectors generally use an optical collection system and multiple sensing elements of alternating polarity to create a detection pattern in the volume of interest. Passive IR detectors generally employ a group of radiation sensors coupled through amplifiers to a logic circuit.

The radiation sensors detect changes in ambient infrared radiation. The detection system has an electrical circuit operatively coupled to the heat sensor for producing a detection signal in response to the heat sensor detecting a change of temperature as, for example, caused by the body heat of a person entering the detection pattern. Passive infrared motion detectors and occupancy sensors employ an array of Fresnel lenses covering an entrance aperture. This lens array is illuminated by thermal infrared radiation from the object of interest.

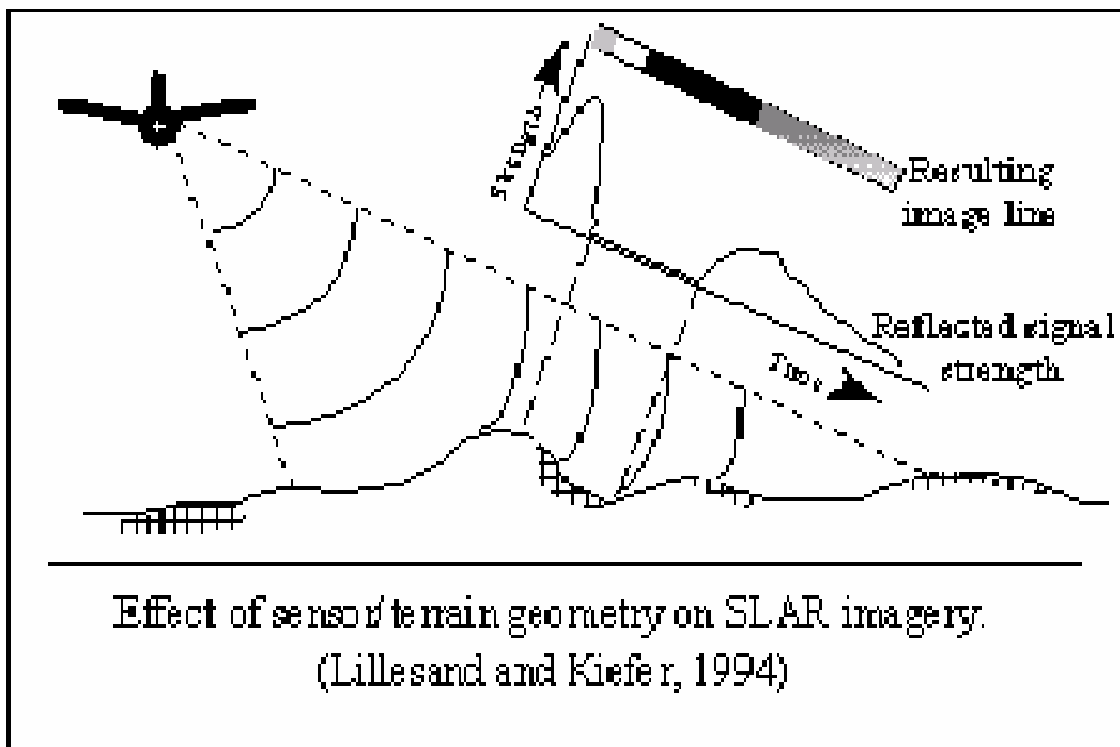
b) Radar Sensors

Radar-based motion detectors may emit a continuous-wave (CW) microwave signal and compare the emitted and echo frequencies to produce a beat frequency that is proportional to range. Such microwave sensors for detecting the presence of moving objects, and the direction of movement, are found in a variety of applications such as door openers, security systems, and toilet flushers.

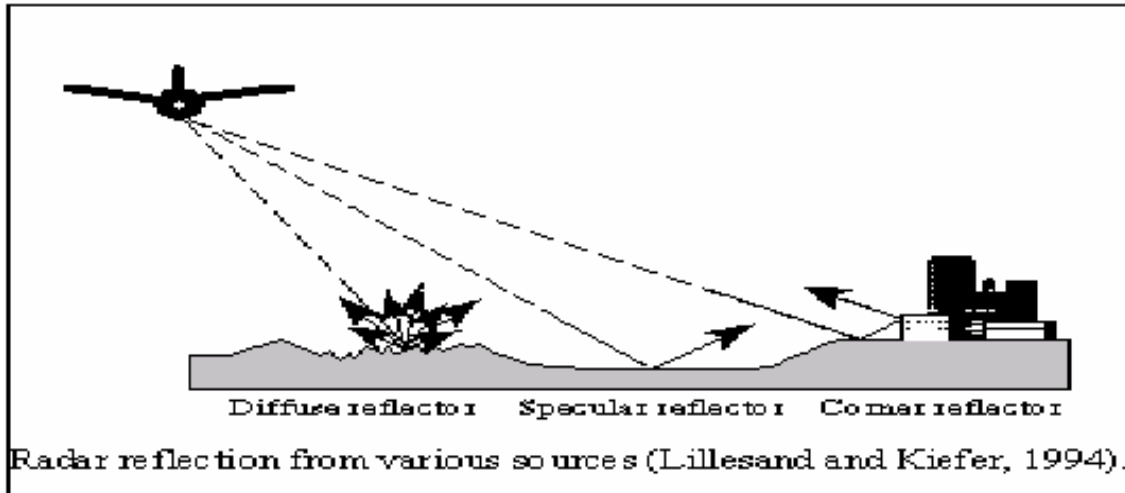
Such detectors typically comprise a high frequency RF circuit comprising an oscillator for generating a high frequency oscillating signal, an antenna or antennas for transmitting and receiving the oscillating signal, and a mixer for modulating the oscillator signal with the received signal. In order to determine the direction of motion of an object,

the oscillator signal is mixed with the receive signal to generate two output intermediate frequencies (IF), the combination of which determines the direction of movement of an object toward or away from the sensor.

Doppler shift motion detectors are active motion detectors in which a wave transmitter transmits waves into a monitoring area, and then a wave receiver receives the reflected waves and produces a reception signal. By detecting the Doppler shift in the reflected signal, the detector circuitry detects whether a moving object is present in the area. However, Doppler radar-based motion detectors are disadvantageous because of limited materials penetration, micro phonics, frequency crowding, and poor short-range operation.



(a)



(b)

Figure 2.1 (a) and (b): Radar sensor reflection

(Courtesy: <http://www.geo.hunter.cuny.edu/terrain/radariv.html>)

c) Pyroelectric Sensors

The pyroelectric sensor is made of a crystalline material that generates a surface electric charge when exposed to heat in the form of infrared radiation. When the amount of radiation striking the crystal changes, the amount of charge also changes and can then be measured with a sensitive FET device built into the sensor. The sensor elements are sensitive to radiation over a wide range so a filter window is added to the TO5 package to limit incoming radiation to the 8 to 14mm range which is most sensitive to human body radiation.

This arrangement cancels signals caused by vibration, temperature changes and sunlight. A body passing in front of the sensor will activate first one and then the other element whereas other sources will affect both elements simultaneously and be cancelled. The radiation source must pass across the sensor in a horizontal direction when sensor pins 1 and 2 are on a horizontal plane so that the elements are sequentially exposed to the IR source. A focusing device is usually used in front of the sensor.

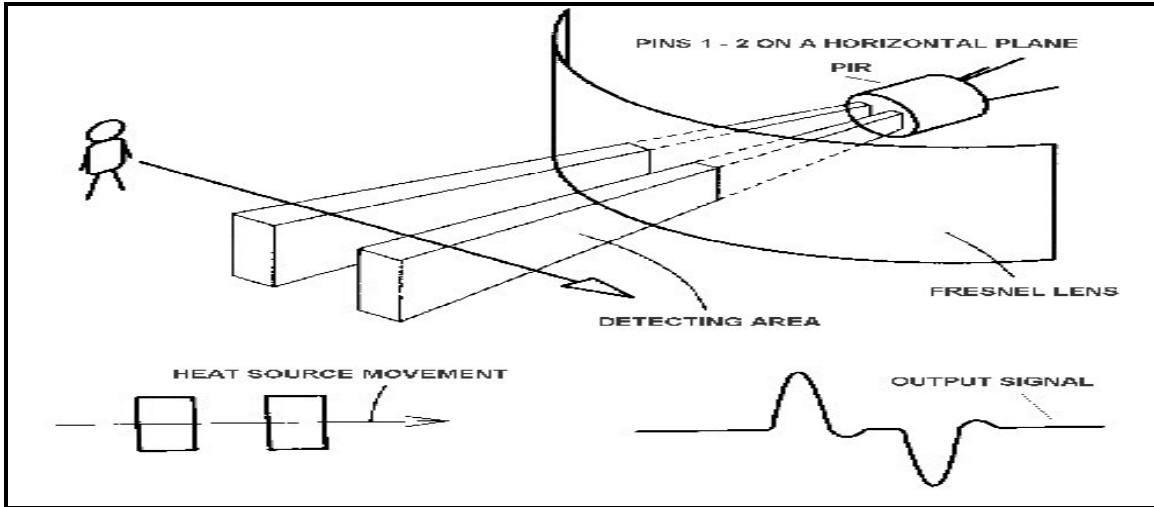


Figure 2.2: Pyroelectric sensor system when someone through detecting area.

(Courtesy: <http://www.glolab.com/pirparts/infrared.html>)

d) Ultrasonic Sensors

Ultrasonic motion detectors project and receive ultrasonic sound energy in a region of interest. Object motion within the region of interest and in the range of the ultrasonic motion sensor is detected and an alarm signal representative thereof is produced. The effective range of ultrasonic motion detectors differs from design range whenever the actual ambient atmospheric sound propagation conditions vary from the design or nominal atmospheric conditions.

Ultrasonic motion detectors are commonly used for automatic door openers and security alarms. They are inexpensive and can operate with narrow beam widths. However, installation options are limited because ultrasonic beams are easily blocked by thin materials, including paper. False triggering is easily caused by reflections from blowing curtains, pets, and flying insects. Some motion detectors operate on the principle of relative movement between a conductor and a magnetic field resulting in a current

being induced in the conductor. Such induction-type sensors generally include a magnetic circuit with a permanent magnet, the magnetic circuit comprising a stator, a rotor and an electrical coil devised around the stator.

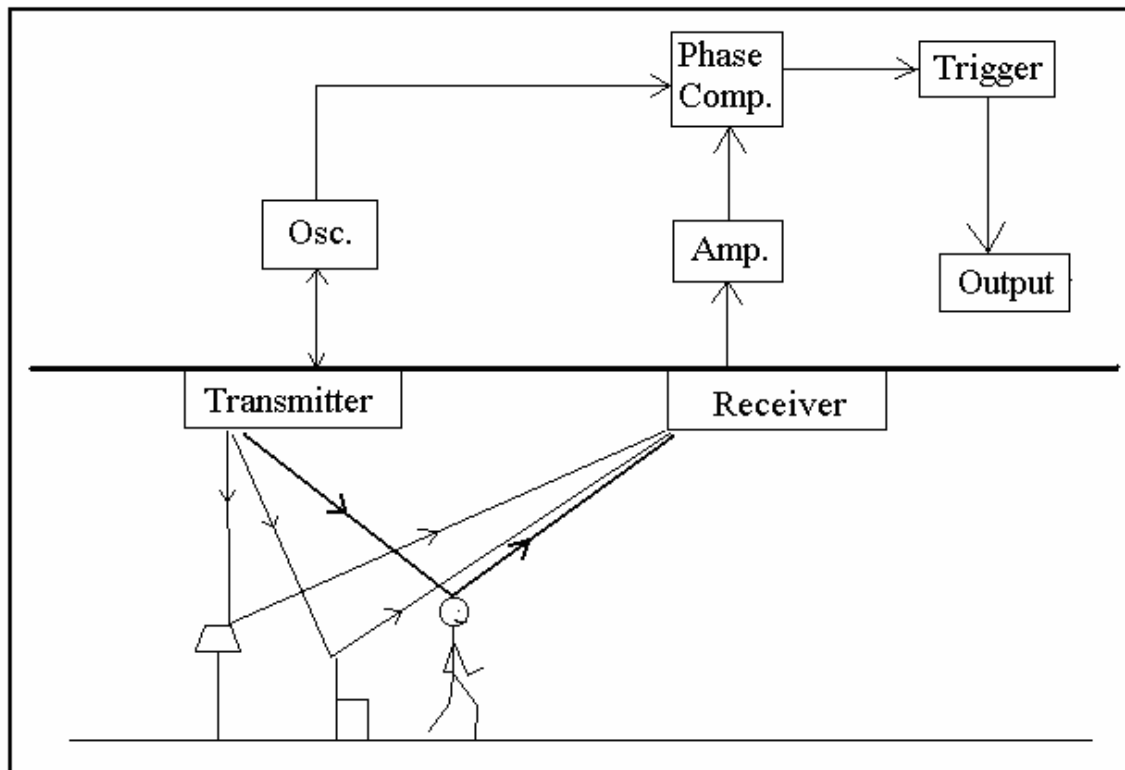


Figure 2.3: Motion Detector Ultrasonic

Figure 2.3 shows the operation of an ultrasonic motion detector. There are two transducers: one emits an ultrasonic wave and the other picks up reflections from the different objects in the area. The reflected waves arrive at the receiver in constant phase if none of the objects in the area are moving. If something moves, the received signal is shifted in phase. A phase comparator detects the shifted phase and sends a triggering pulse to the alarm.

2.2.3 Basic flow process of infrared motion detector

The various type of motion detector had explained in section above and infrared was chosen for this project. This based on the capability of sensor to operate, facile to get the spare part component and fast to build with considering the duration of project is in short term. This section will elaborate more detail about infrared motion detector.

Infrared sensor also well known as an electro-optic detector absorbs electromagnetic radiation and outputs an electrical signal that is usually proportional to the irradiance (intensity of the incident electromagnetic radiation). Depending on the type of detector and the way in which it is operated, the output signal can be either a voltage or a current.

2.2.3.1 Electromagnetic Radiance

The electromagnetic spectrum is rather arbitrarily divided into regions. The spectral region to which the human eye is sensitive is referred to as visible. It extends from wavelengths of about 400 *nm* to about 700 *nm*. Wavelengths shorter than visible are successively referred to as ultraviolet, x-rays and gamma rays. The infrared region is considered to extend from 700 *nm* to 1000 *mm*. Wavelengths longer than 1 *mm* are referred to as radio waves. There are no consistent definitions of the various infrared spectral bands, but the region from 700 *nm* to 1 *mm* is usually called the Near Infrared (NIR). The infrared region is further subdivided into Short Wave Infrared (SWIR) (1-3 *mm*), Mid-Wave Infrared (MWIR) (3-6 *mm*) and Long Wave Infrared (LWIR) (>6 *mm*). However, the MWIR region is often considered to be 3-5 μm and LWIR 8 μm and longer. The reason is that the atmosphere absorbs strongly in the 5-8 μm band, and these wavelengths are seldom used. Concept summary of electromagnetic radiance:

- Near IR (NIR): from 0.7 to 1.0 micrometers (from the approximate end of the response of the human eye to that of silicon)
- Short-wave infrared (SWIR): 1.0 to 3 micrometers (from the cut off of silicon to that of the MWIR atmospheric window. InGaAs covers to about 1.8 micrometers; the less sensitive lead salts cover this region)
- Mid-wave infrared (MWIR): 3 to 5 micrometers (defined by the atmospheric window and covered by InSb and HgCdTe and partially PbSe)
- Long-wave infrared (LWIR): 8 to 12, or 7 to 14 micrometers: the atmospheric window (Covered by HgCdTe and microbolometers)
- Very-long wave infrared (VLWIR): 12 to about 30 micrometers, covered by doped silicon

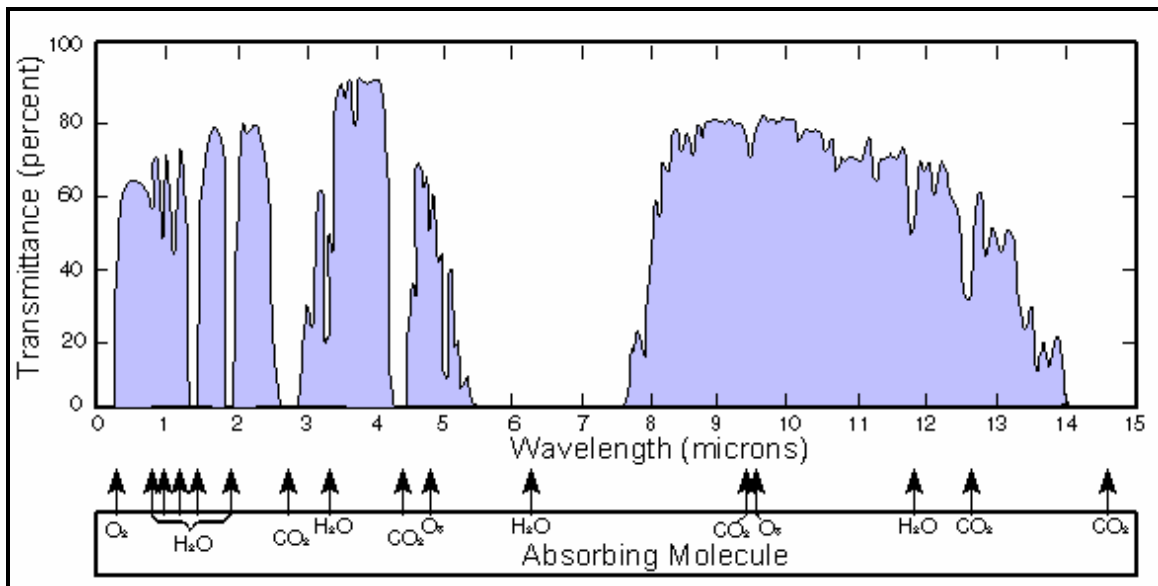


Figure 2.4: Plot of atmospheric transmittance in part of the infrared region.

(Courtesy: <http://en.wikipedia.org/wiki/Infrared>)

2.2.3.2 Reflected Radiation

The radiation emanating from a surface includes not only that emitted by the surface but also that reflected by the surface. The objects surrounding the surface in question also emit radiation in spectral distributions appropriate to their respective temperatures. This radiation, or at least some portion of it, is incident on our surface of interest where it is partially absorbed and partially reflected. To an observer the reflected radiation is indistinguishable from the emitted radiation.

2.2.3.3 Infrared Emitter and Infrared Phototransistor

Motion detector system comprises two main parts:

- a) Infrared Emitter
- b) Infrared Phototransistor

An infrared emitter is an LED made from gallium arsenide, which emits near-infrared energy at about 880nm. The infrared phototransistor acts as a transistor with the base voltage determined by the amount of light hitting the transistor. Hence it acts as a variable current source. Greater amount of IR light cause greater currents to flow through the collector-emitter leads. As shown in the diagram below, the phototransistor is wired in a similar configuration to the voltage divider. The variable current traveling through the resistor causes a voltage drop in the pull-up resistor. This voltage is measured as the output of the device.

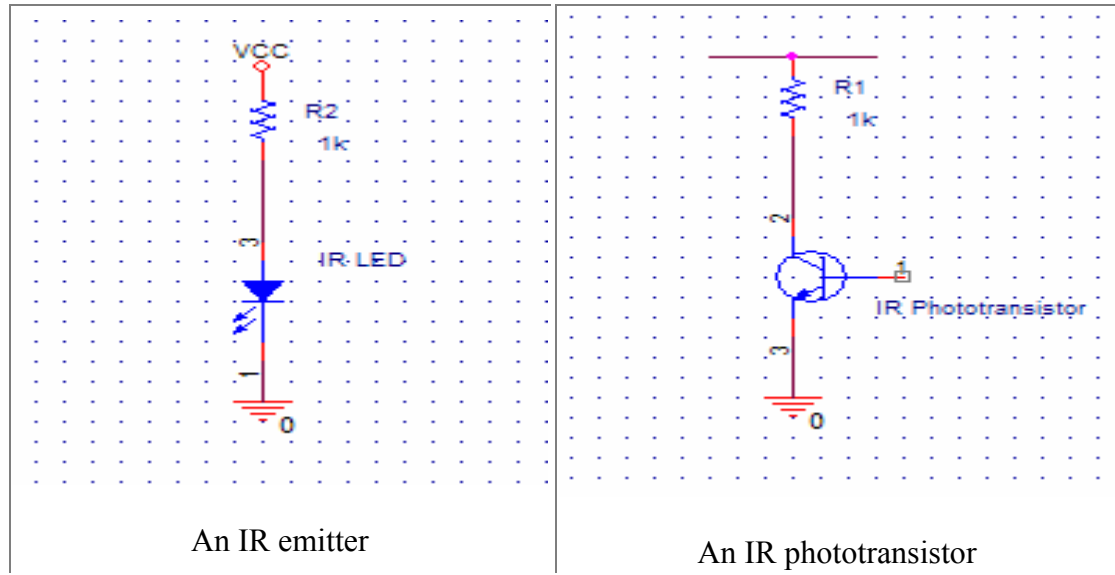


Figure 2.5: Basic an IR emitter and an IR phototransistor circuit.

One of the applications of the IR emitter and IR phototransistor is a photo-reflector. The photo-reflector is a small rectangular device that contains a phototransistor (sensitive to infrared light) and an infrared emitter. The amount of light reflected from the emitter into the phototransistor yields a measurement of a surface's reflectance.

2.2.3.4 Basic infrared photo-detector circuit

Figure 2.6 shows the LED will turn on when the infrared beam is broken or bothered. The R1 resistor is determines the sensitivity of the phototransistor Q1.

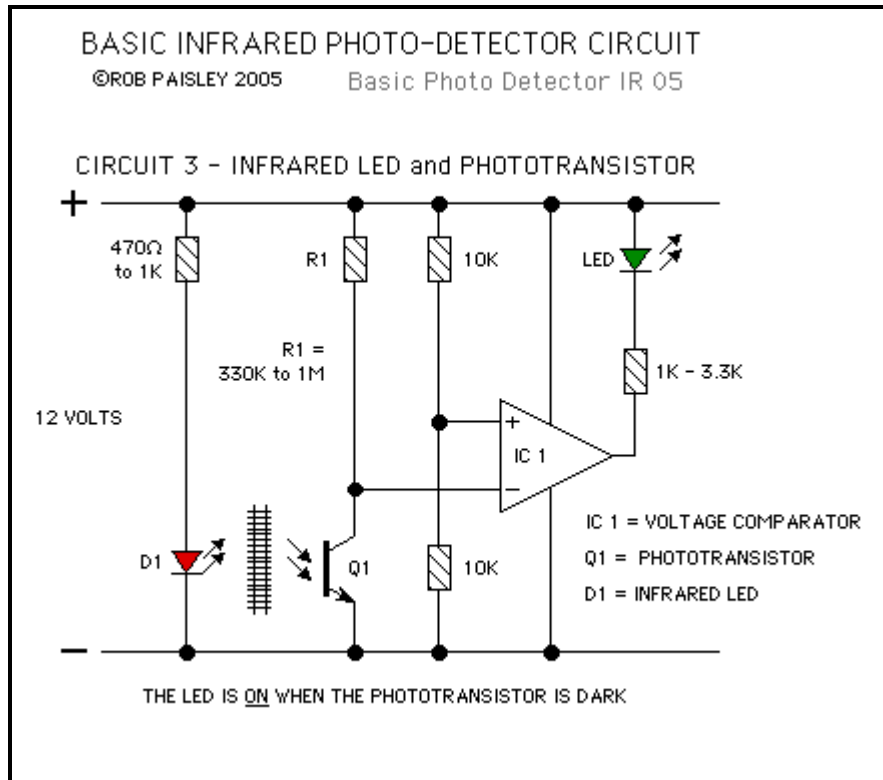


Figure 2.6: Basic Infrared Detector Schematic

(Courtesy: <http://home.cogeco.ca/~rpaisley4/ATDetIR.html>)

Circuit Operation - When a train breaks through the infrared beam the phototransistor will conduct less current. This will cause voltage at the MINUS input of the comparator will rise above the reference voltage at the PLUS which determined by R3 and R4. The output of the comparator to turn ON state and the LED will be light up.

2.2.3.5 Emitter and Detector Alignment

In order to enhance continuity operation of sensor the feature that must emphasize is alignment of the emitter and detector, especially if the gap is large. The easy way to execute is by with a piece of string stretched between and in line with LED and phototransistor. A length of dowel or stiff wire could be used to set the alignment. Laser pointer shone through one of the mounting holes also can be use for longer

distance. Figure 2.7 shows two methods of aligning the emitter and detector mountings. In order to get best results, the height of the "beam" should be at coupler height and at an angle across the tracks.

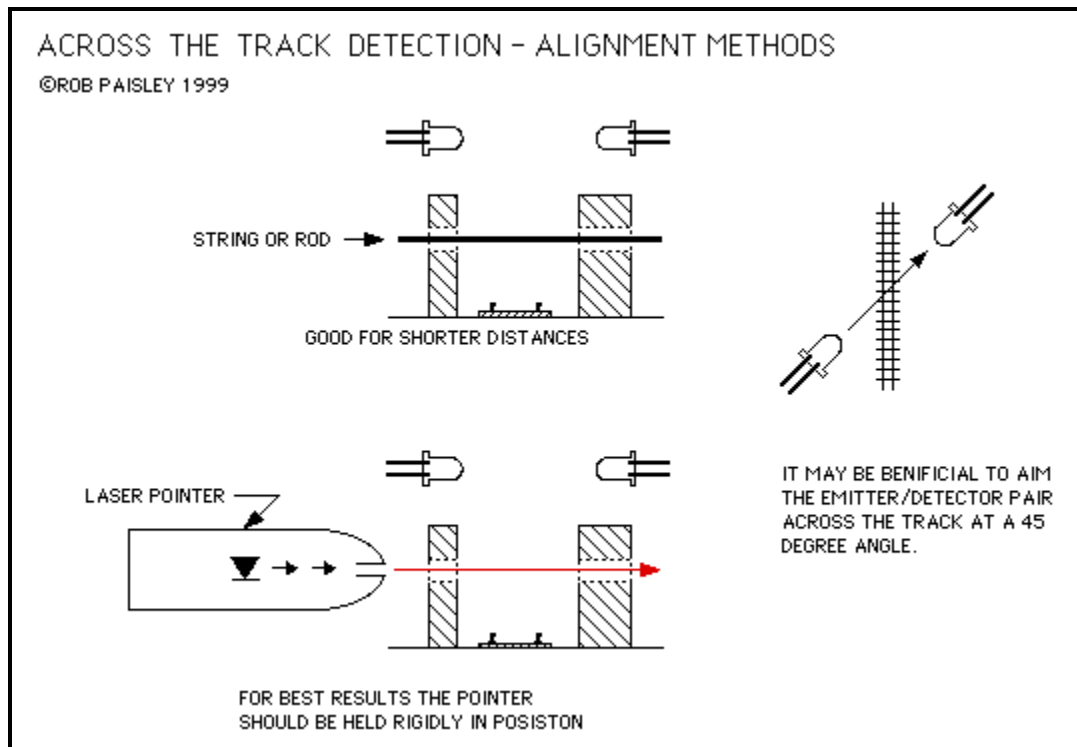


Figure 2.7: Emitter/Detector Alignment Methods

(Courtesy: <http://home.cogeco.ca/~rpaisley4/ATDetIR.html>)

The emitter could also be mounted above the track with the phototransistor placed between the rails in locations such as hidden yards. By placing the emitter and detector at an angle would again be helpful.

2.2.3.6 Phototransistor Shielding

Shielding requirement when there will be another phototransistor nearby which can affect the beam. This intention also influence by the certain of infrared phototransistors are sensitive to visible light and therefore will need to be shielded in someway to prevent the device from being swamped by the rooms lighting. Therefore, to implement this necessity with hiding the phototransistor inside a line side structure or placing it inside a short piece of opaque tubing as shown in Figure 2.8. The back of the phototransistor can be painted black to prevent room light from entering if it is in the open.

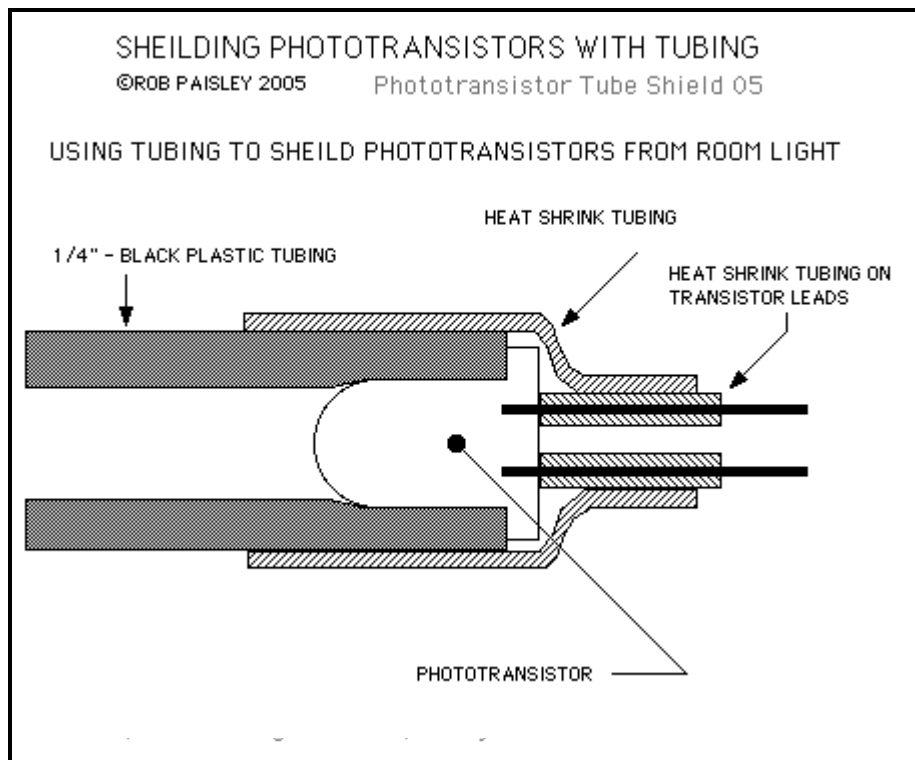


Figure 2.8: Detector Shielding Method

(Courtesy: <http://home.cogeco.ca/~rpaisley4/ATDetIR.html>)

The tube can be wood or plastic as long can prevent light via it. The longer the length of tubing, the narrower the entrance angle to the phototransistor.

2.2.3.7 Longer Range Infrared Detector

Figure 2.9 shows a method of increasing the distance of infrared across track detectors by using additional LEDs to supply a higher infrared light level. This arrangement will enhance the capability phototransistor to receive longer distance from transmitter. Circuit operation is near same as basic detector.

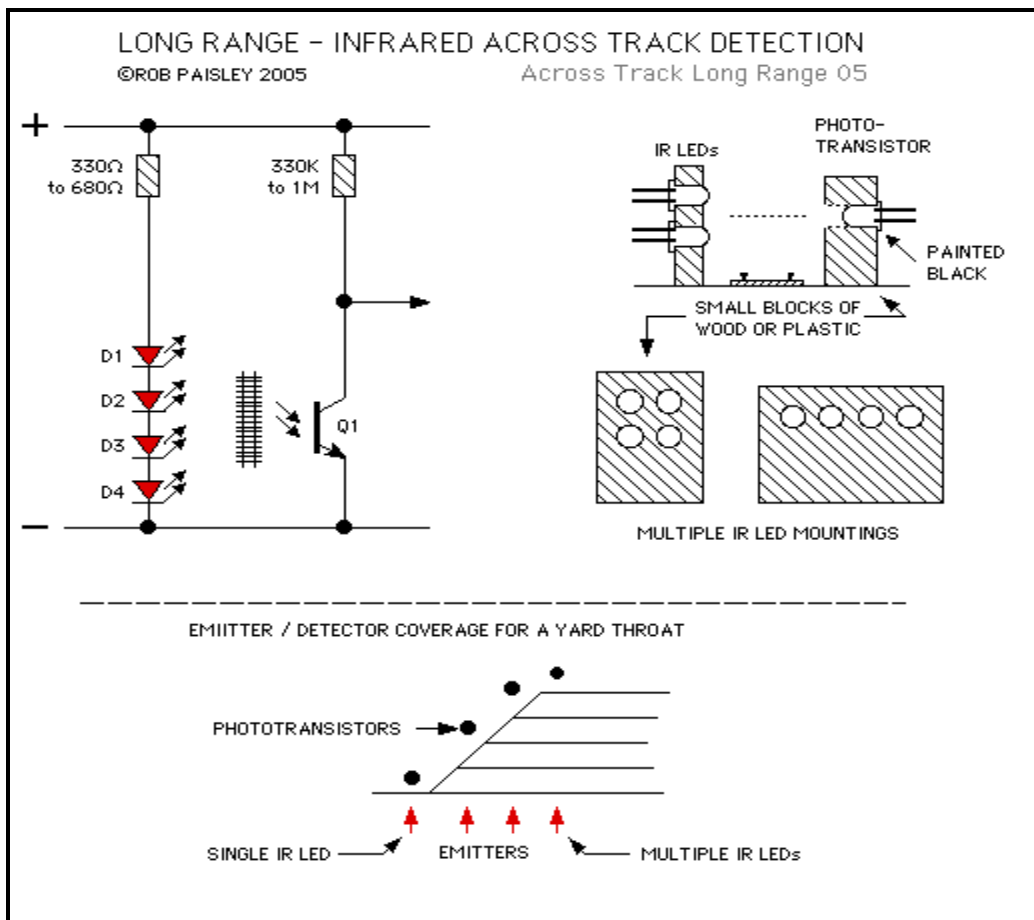


Figure 2.9: Longer Range Infrared Detector

(Courtesy: <http://home.cogeco.ca/~rpaisley4/ATDetIR.html>)