Optical Sensor (2A)

- Optical Sensor Type
- Optical Sensor Characteristics

Please send corrections (or suggestions) to youngwlim@hotmail.com.

This document was produced by using OpenOffice and Octave.

Young Won Lim
9/12/09

Optical Sensor Type

Physical Effect	Photo Sensor Type	Note
Photo-conductive	CdS cell	Low Speed
	PbS cell*	
Photo-voltaic	photo-diode	High Speed
	photo-transistor	
Photo-electric	photo-tube	Large Size
	photo-multiplier	
Pyro-electric	pyro-electric detector	Infrared
	thermopile	
	bolometer	

Principles of Operation (1)

When light is absorbed by a material

Photo-conductivity Effect:

- **increases conductivity**

Photo-voltaic Effect:

- **creates a voltage (or current)**

Photo- electric Effect (Photon Emission):

- **emits electrons**

Principles of Operation (2)

Pyro-electricity:

- **generates a temporary electrical potential when certain materials are heated or cooled**
- **the opposite effect is called electro-caloric effect**

Thermo-electricity:

- **a temperature difference crates an electrical potential**
- **an electrical potential creates a temperature difference**

Photo-conductive cell (CdS cell)

Increasing incident light intensity

→ the resistance is decreased

→ the current is increased

- **Visible light**
- **High sensitivity**
- **Slow response time**

Photo-conductive cell (PbS cell)

Increasing incident light intensity

→ the resistance is decreased

→ the current is increased

Decreasing the temperature (cooling)

→ the longer waveform can be detected

→ the dark current is increased

→ the response time is slowed

- **Infrared detection**
- **High sensitivity**
- **Fast response time (200 μs)**

Photo-diode

Increasing incident light intensity

→ increasing electron-hole pairs

→ increasing photon emission

→ increasing output current

- **Measure open circuit voltage (or high load resistor)**
- **Measure closed circuit current (or low load resistor)**
- **Measure the current by applying the reverse bias**

- **linear output current**

Photo-transistor

Increasing incident light intensity

→ increasing electron-hole pairs

→ increasing output current

- **forward biased B-E**
- **reversed biased C-E**
- **transistor amplification**

- **non-linear output current**

Photo-tube

Increasing incident light intensity

→ increasing photon emission

→ increasing output current

- **Cathode + Plate**

- **small output current**
- **stable sensitivity**
- **good linearity**

Photo-multiplier

Increasing incident light intensity

→ increasing photon emission / secondary emission

→ increasing output current

- **Cathode + Many Dynodes + Plate**

- **amplified output current**
- **best sensitivity**
- **good linearity**
- **fast response time**

Pyro-electric IR Detector

Increasing incident IR intensity

→ increasing temperature

→ decreasing polarization

→ increasing the difference in charge

→ increasing output voltage

- **no dependance on wave length**
- **low sensitivity**
- **slow response time**

Thermopile IR Detector

Increasing incident IR intensity

→ increasing temperature

→ increasing Seebeck voltage

- **series connection of thermocouples**

Bolometer IR Detector

Increasing incident IR intensity

→ increasing temperature

→ decreasing resistance

→ increasing current

- **bridge circuit**

Thermopile IR Detector

Increasing incident IR intensity

→ increasing temperature

→ increasing Seebeck voltage

- **series connection of thermocouples**

Optical Sensor Characteristics

	sensitivity	response	output	size	cost
photo-conductive	High			Small	Low
photo-voltaic			Large	Small	Low
photo-electric	Very High	Fast		Large	

Optical Sensor Applications

	Applications
photo-conductive	camera exposure, photo relay, photo control
photo-voltaic	camera EE systems, bar code, card reader
photo-electric	Precision measurement

EE (electric eye)

IR Detector Characteristics

	types	sensitivity	response	wavelength
photo-conductive	PbS, PbSe	High	Fast	depend
pyro-electric	pyroelectic thermopile bolometer	Low	Slow	independent

IR Detector Applications

	Applications
photo-conductive	satellite, medical, microscope
pyro-electric	fire alarm, intrusion detection, door sensor, vending machine

Optical Detector-Emitter Pair Type

Photo-interrupter

- **detects an object when it interrupts the emitted light beam**
- ***transmitted type***
- ***reflective type***

Photo-coupler (Opto-isolator)

- **electrical isolation between two electrical systems**
- **optical connection by detector and emitter**

Optical Detector-Emitter Pair Characteristic

Emitter	Detector	response	CTR	cost	feature
LED	CdS	1 ~ 100 ms		low	dc, ac
IRED	PIN photo-diode	10 ~ 100 μs	small		good output linearity
IRED	photo-transistor	1 ~ 10 μs	relatively large	low	
LED	photo-transistor with base	1 ~ 10 μs			base resistor minimizes dark current
IRED	Darlington photo-transistor	10 ~ 100 μs	larg		large dark current

CTR (Current Transfer Ratio)

References

[1] http://en.wikipedia.org/
[2] Nam Ki Min, Sensor Electronics, Dong-il Press