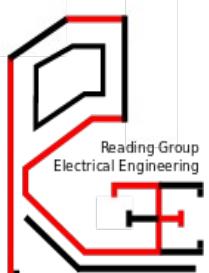


# Free Space Visible Light Communication and it's Applications



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M.Tech(Communication and Signal Processing)  
IIT BOMBAY

# | Motivation |

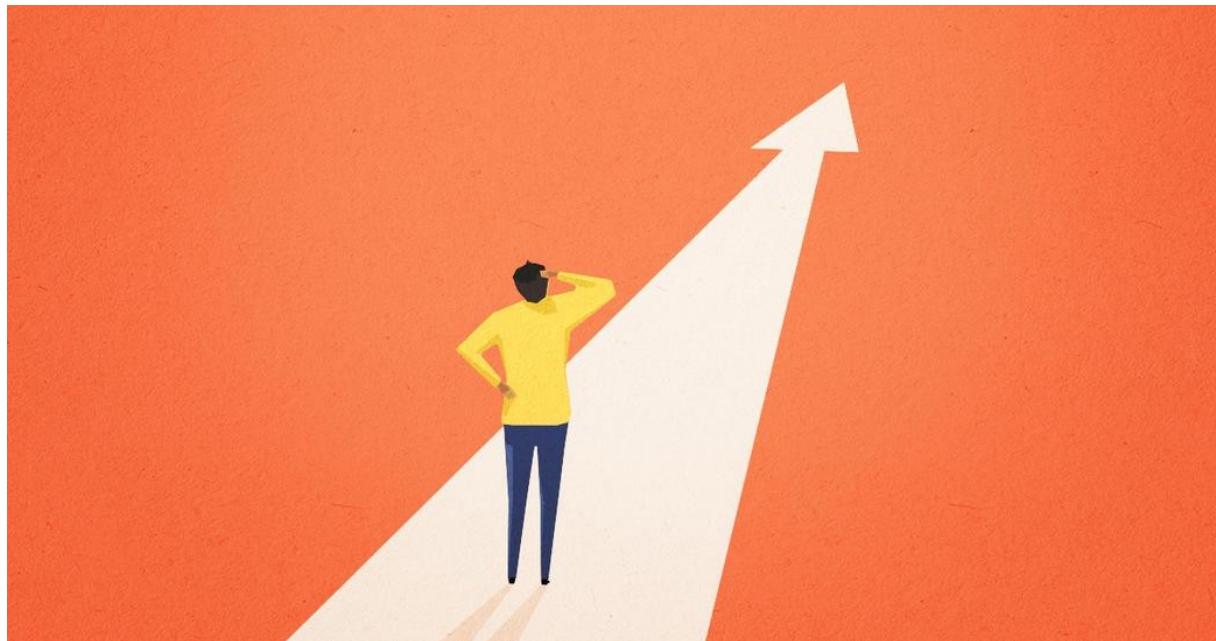
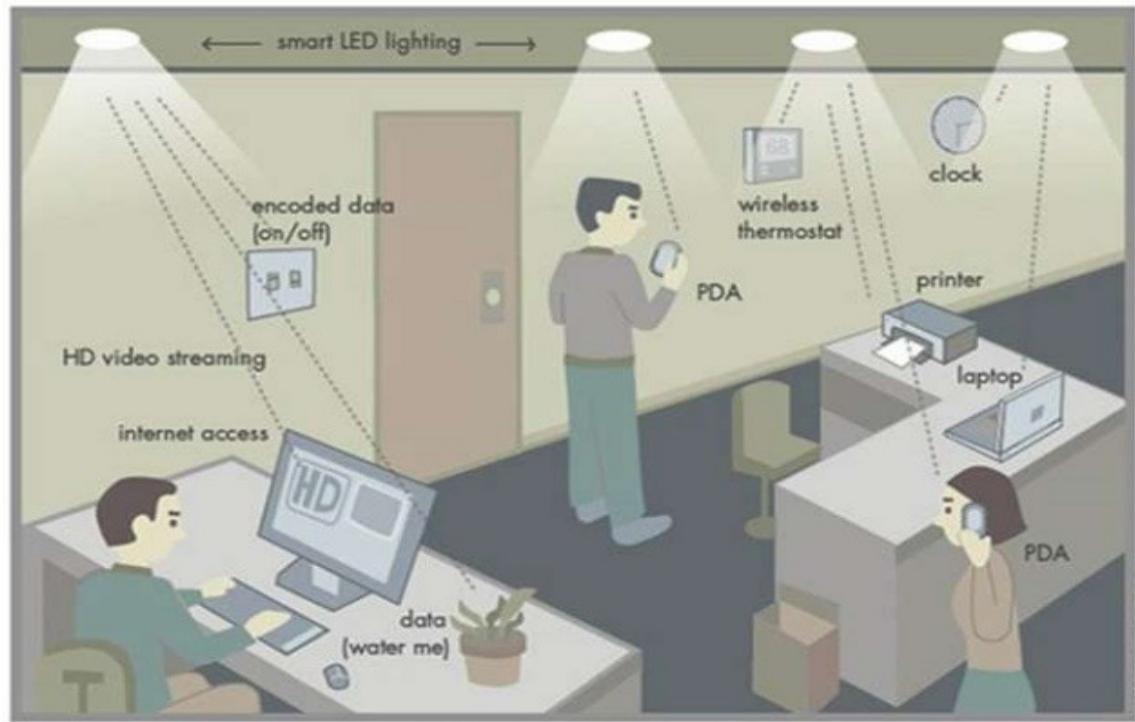


Image Ref : <https://www.ted.com/topics/motivation>

# Flow of todays presentation

- VLC Overview and Applications
- VLC for inter satellite communication : Review
- VLC Serial Link design

# Visible Light Communications : Upcoming wireless Technology



# What is LiFi

- Light Fidelity
- Information through Light?
- Internet Connectivity
- Bandwidth
- Speed



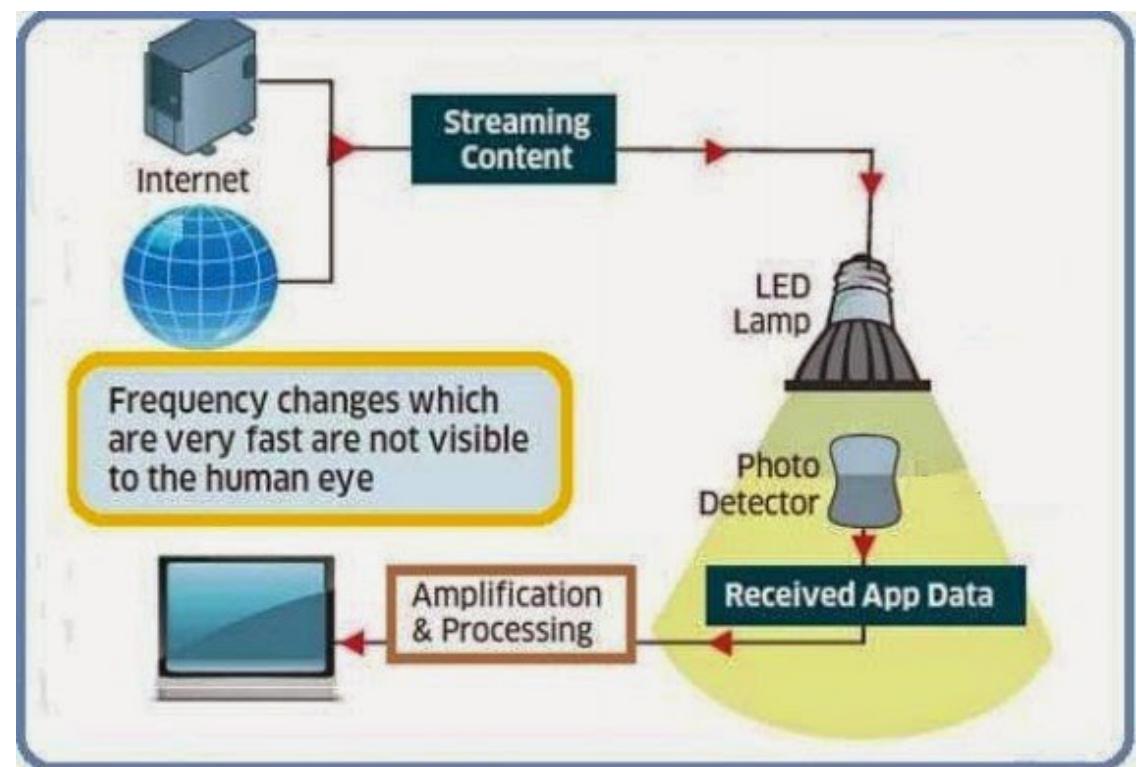
Reference for image :

<https://www.google.co.in/search?>

q=li+fi+technology&dcr=0&source=lnms&tbo=isch&sa=X&ved=0ahUKEwifncL4gcbWAhWBjpQKHaW7DBwQ\_AUICigB&biw=1714&bih=859#imgrc=0xP1DBIQ\_iTbKM:

# How it Works

- Light Emitter Diode
- Photodiode or detector
- Intensity Modulation
- Signal Processing



# Advantages over Wifi

- Unlicensed wide Bandwidth
- High Security
- More speed
- Dual purpose i.e illumination + communication
- Environmental Friendly



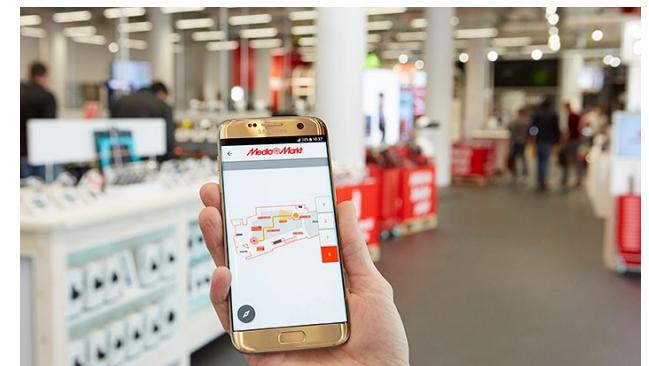
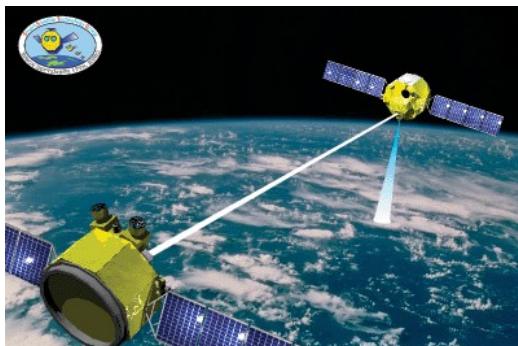
# Disadvantages

- Line of sight LOS is required
- Coverage limitation
- Issues like dispersion and other losses
- Interference with other light sources
- New Infrastructure Requirement



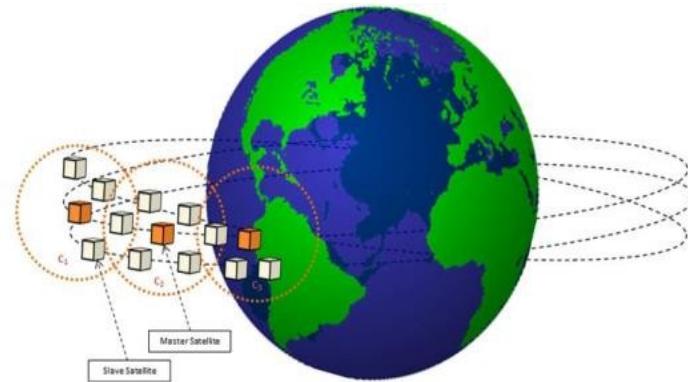
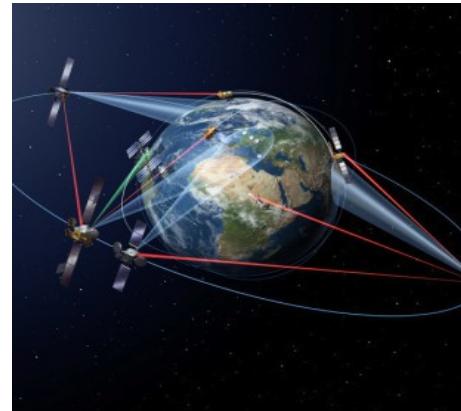
# Applications of VLC and LiFi

- Inter and Intra satellite Communication
- Data communication in spacecraft/flights
- Data communication in Hospitals
- Indoor navigation/localization
- Data connectivity in indoor environment



# Intersatellite Wireless Optical links

- Space based VLC System
- Nano satellites sensor network
- Communication with LASER
- Data relay
- Mobile communication network
- Advantage of visible light links over RF
- Eg. ShindaiSat



# Timeline

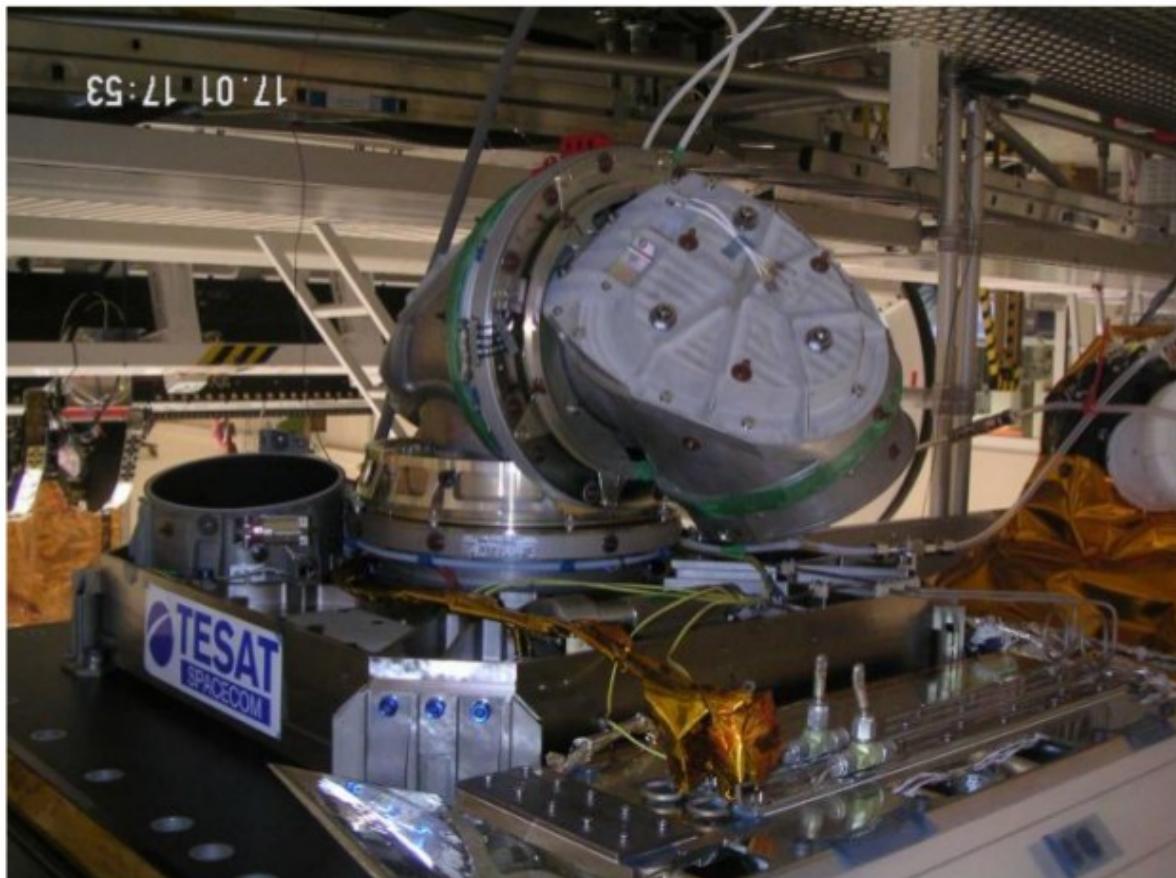
LEO to GEO links

LEO to LEO links



SPOT4 to ARTEMIS  
SILEX  
NFIRE to terraSAR

# LCT(LASER communication terminals )



# LCT performance

Link	LEO – LEO Full duplex communication
Data Rate	5.625 Gbps
Link Distance	1,000 – 5,100 km
Bit Error Rate	$< 10^{-9}$
Optical Transmit Power	0.7 W
Telescope Diameter	125 mm
Mass	35 kg
Power Consumption	120 W
Volume	0.5 x 0.5 x 0.6 m <sup>3</sup>

Link	LEO – GEO Full duplex communication
Data Rate	1.8 Gbps
Link Distance	> 45,000 km
Bit Error Rate	$10^{-8}$
Optical Transmit Power	2.2 W
Telescope Diameter	135 mm
Mass	50 kg
Power Consumption	160 W
Volume	0.6 x 0.6 x 0.7 m <sup>3</sup>

# EDRS system

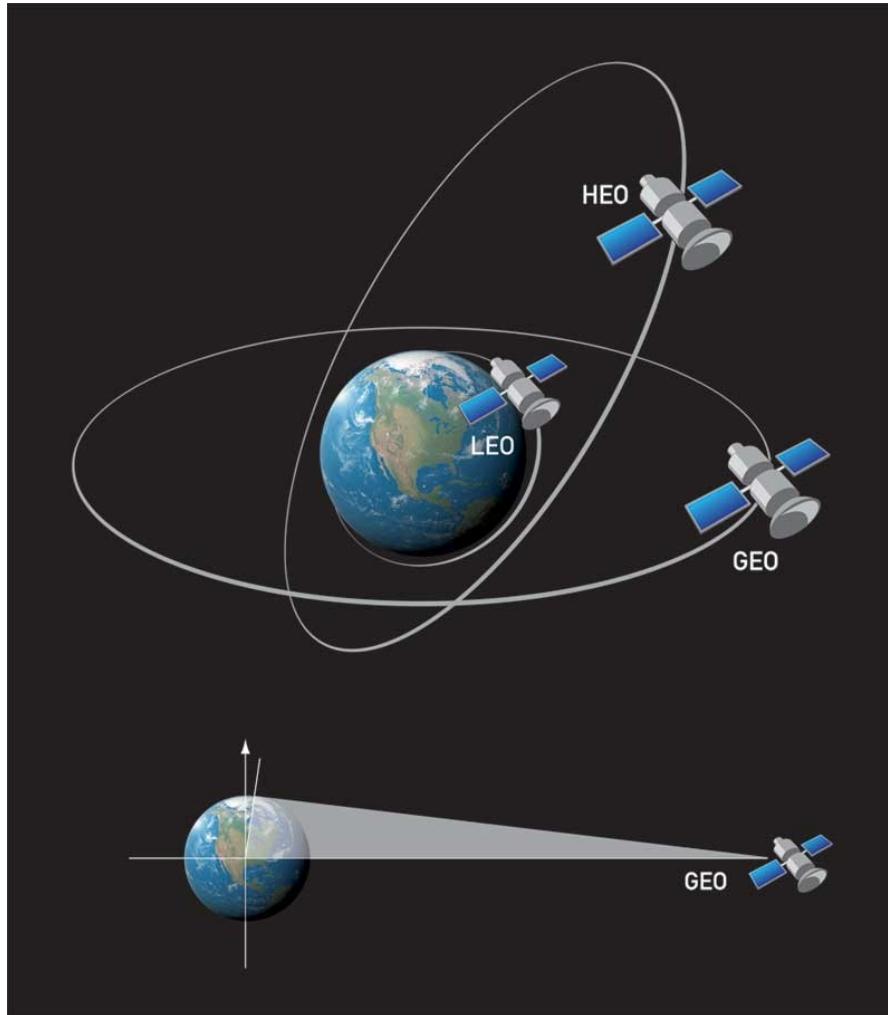


Image Ref : <https://www.researchgate.net/figure>

# How it works

The lower satellite responds and the two terminals establish a connection



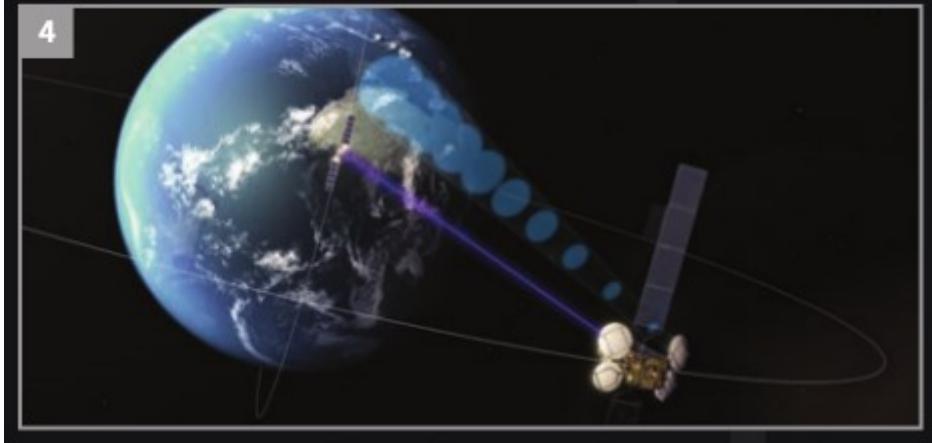
An EDRS laser terminal locates the lower orbiting satellite



User data is exchanged at 1800 Mbit/s



The EDRS high-speed feeder link relays the data to Earth

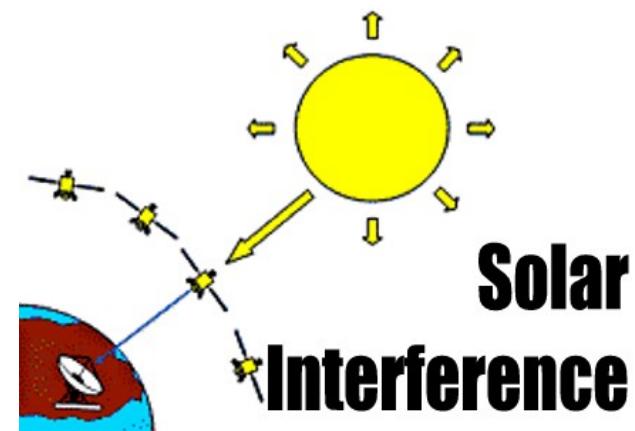
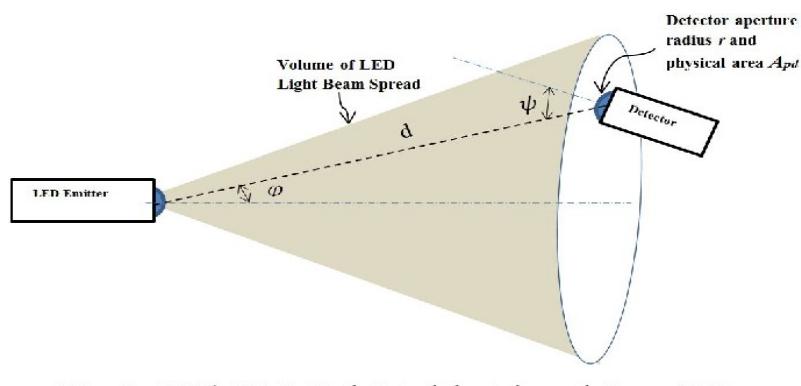


Data are received by a European ground station

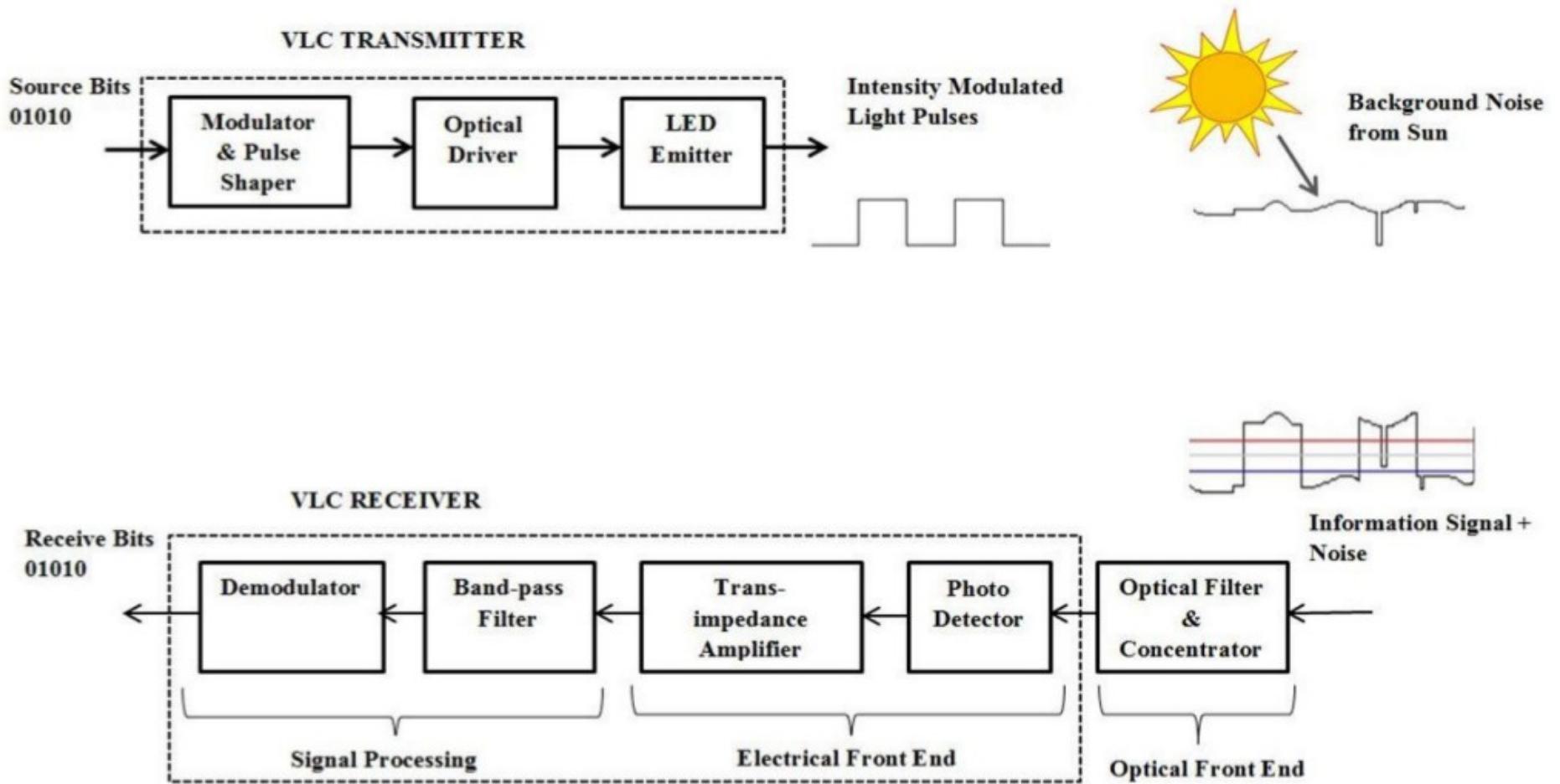


# Design challenges

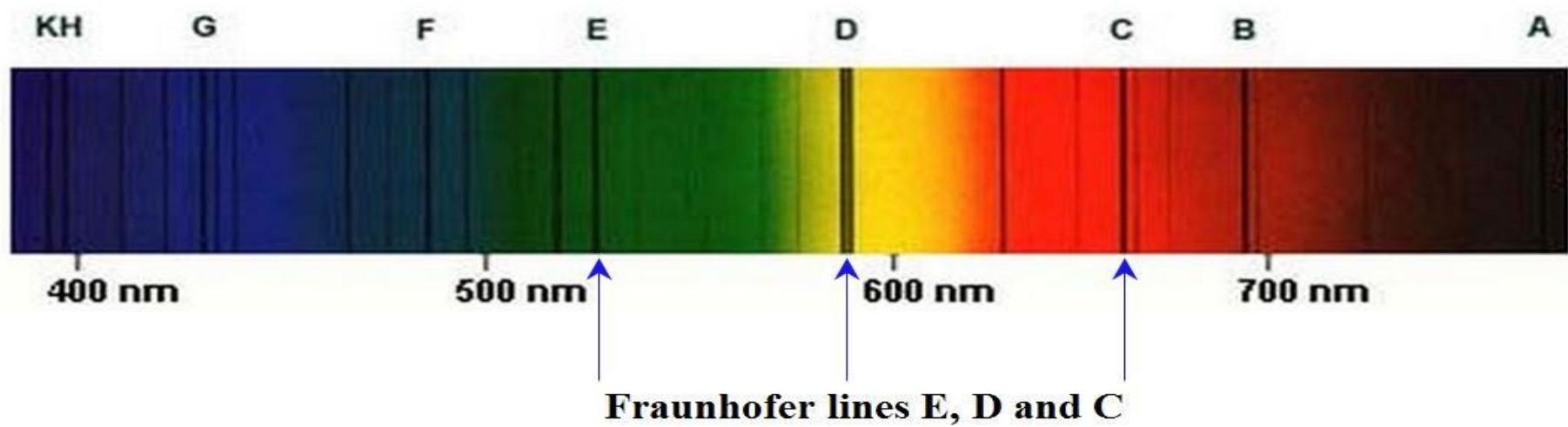
- LED and photodiode specifications
- Interference from solar background
- Degradation of SNR at Receiver
- Choice of modulation and bandwidth
- Directivity and dispersion
- PAT (Pointing accuracy and tracking)



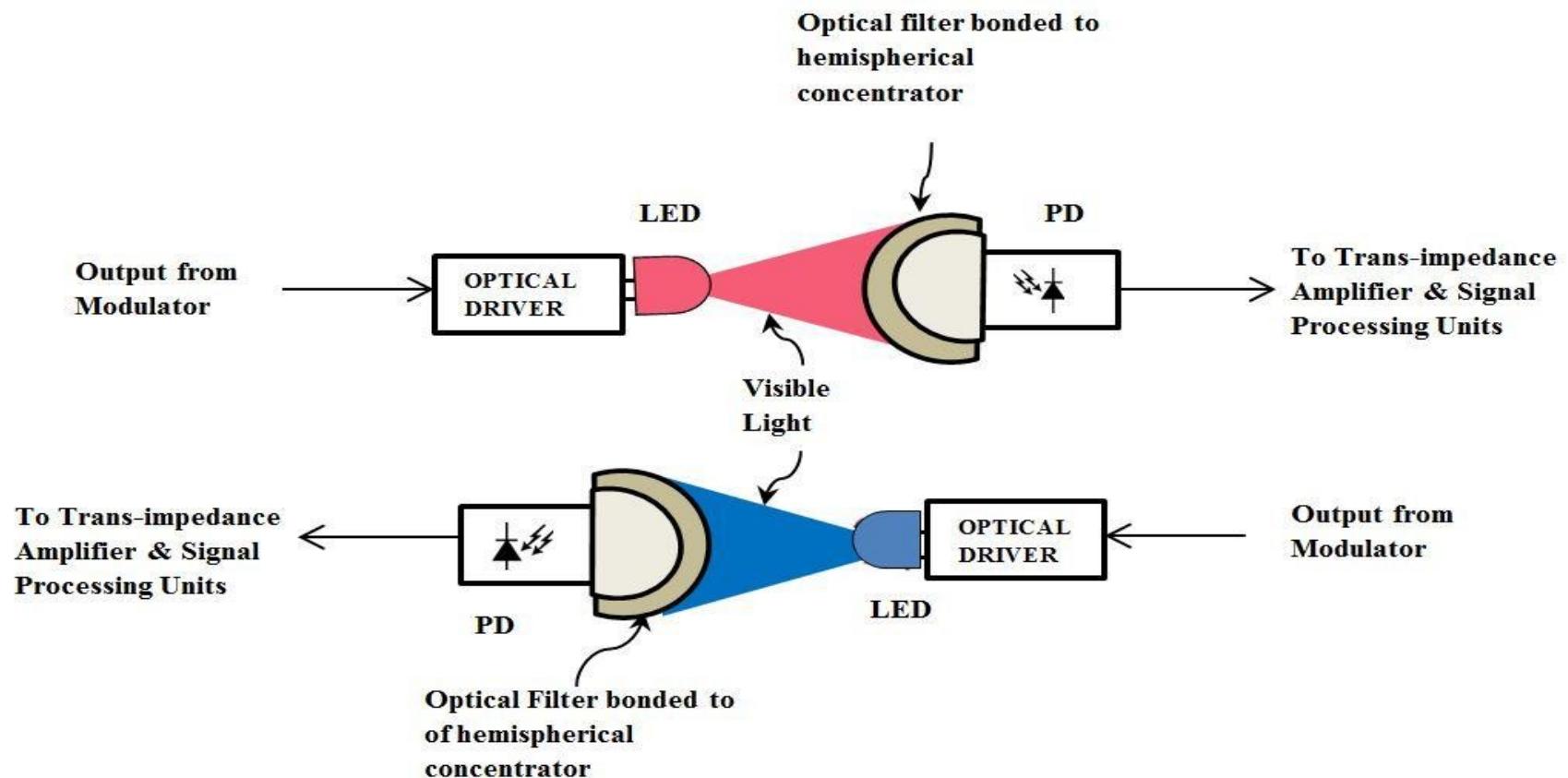
# Block diagram : IsOWC link



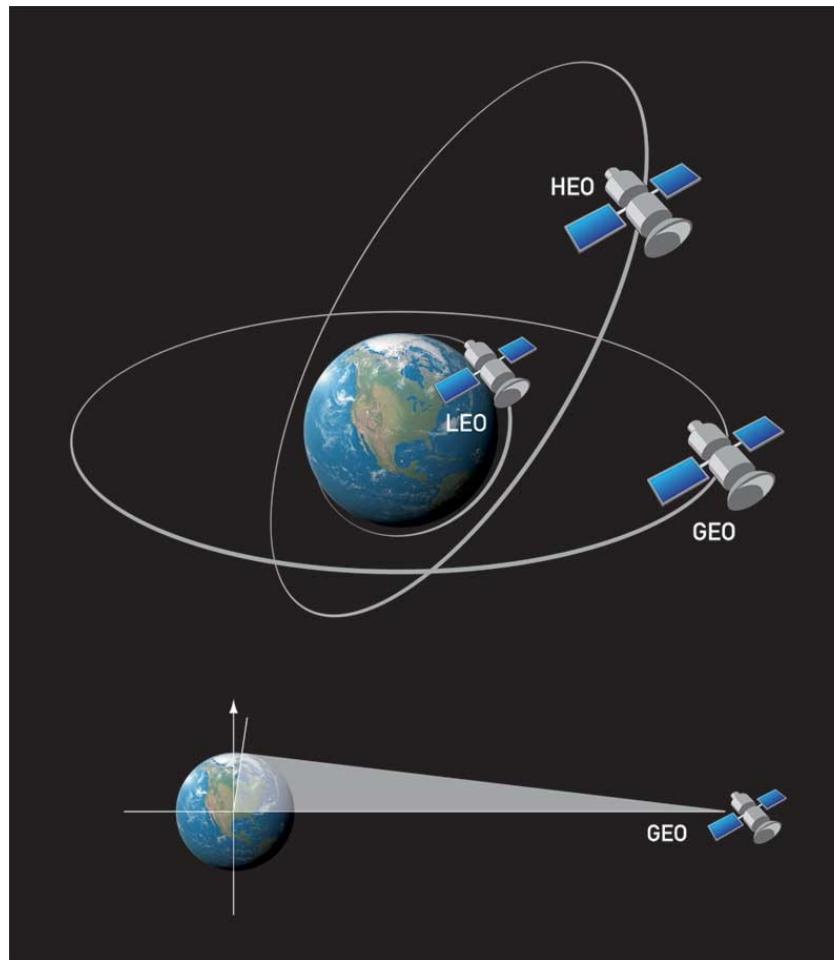
## ▪ Fraunhofer lines and spectrum choice



# Optical Concentrator

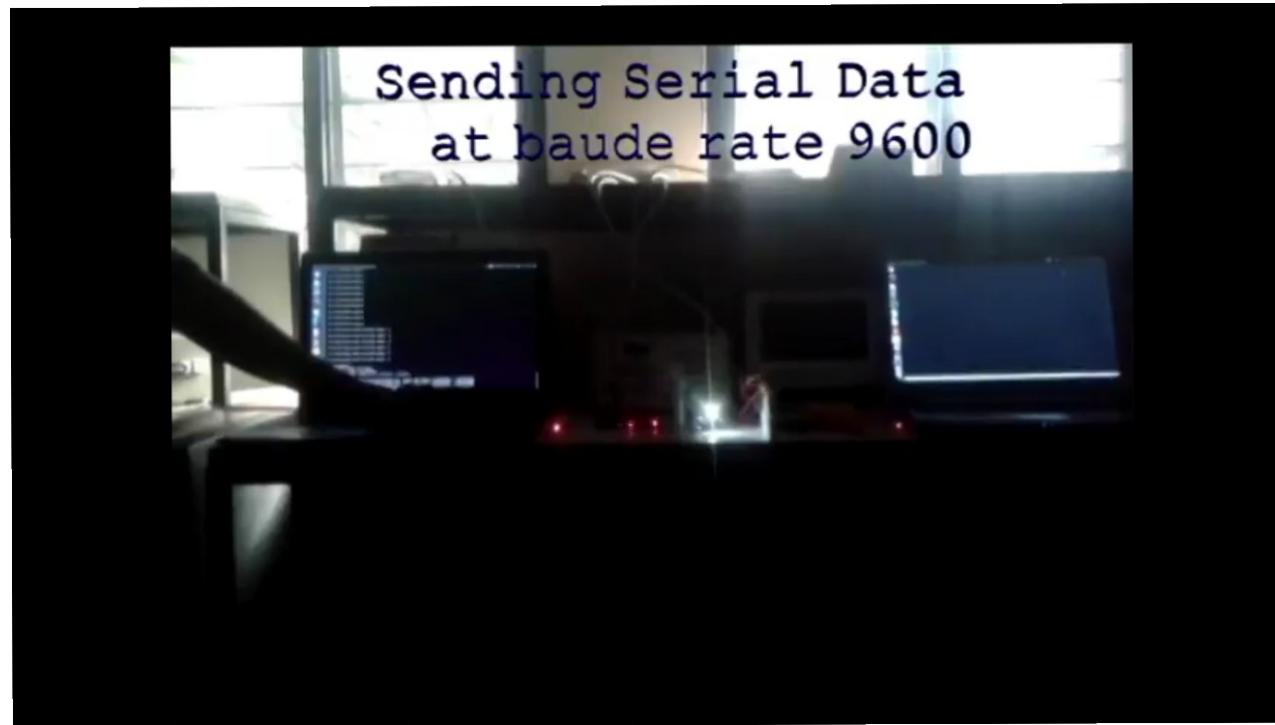


# Doppler shifts

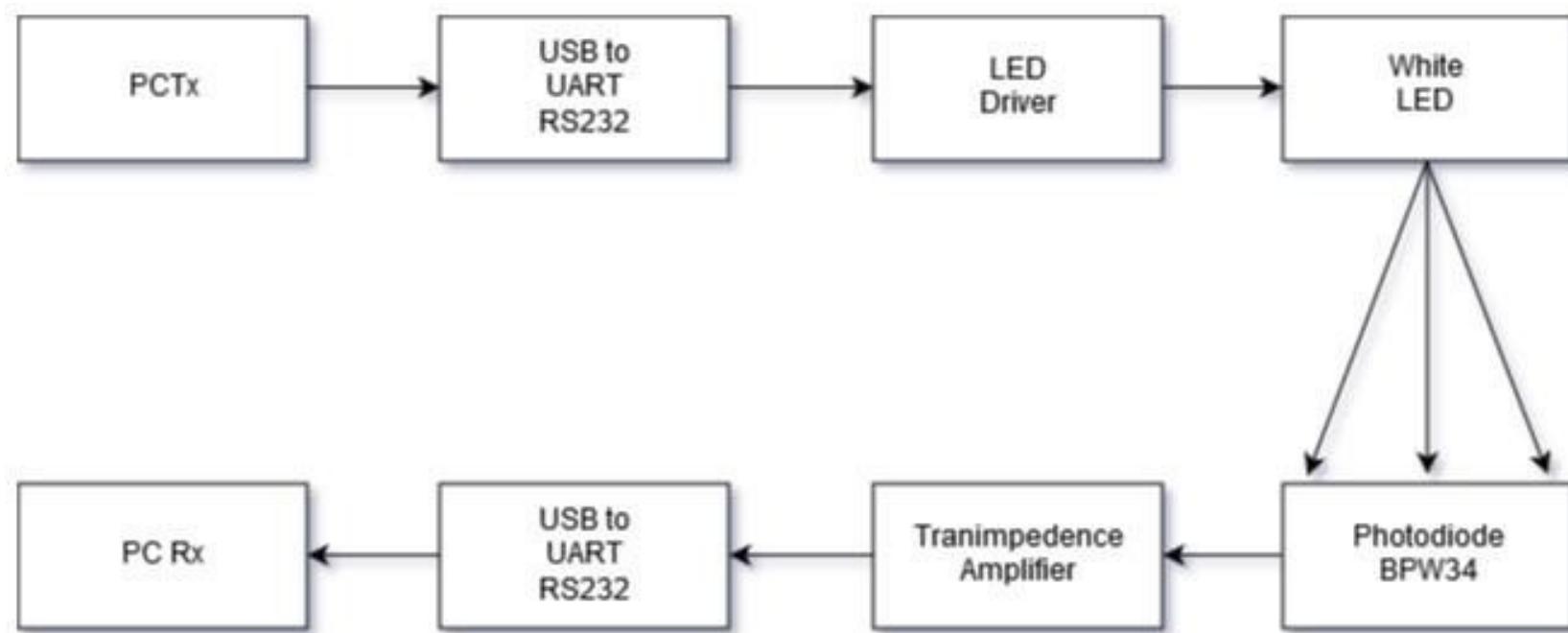


# Serial Wireless Optical Link between 2 computers

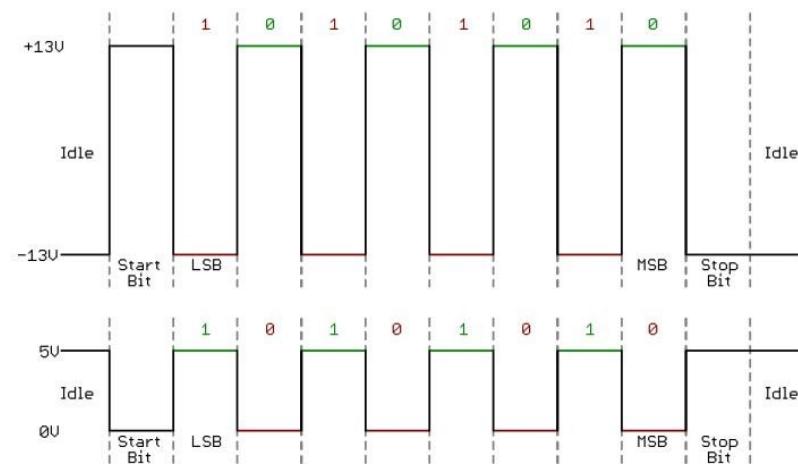
- ON OFF keying
- NRZ format
- Intensity Modulation



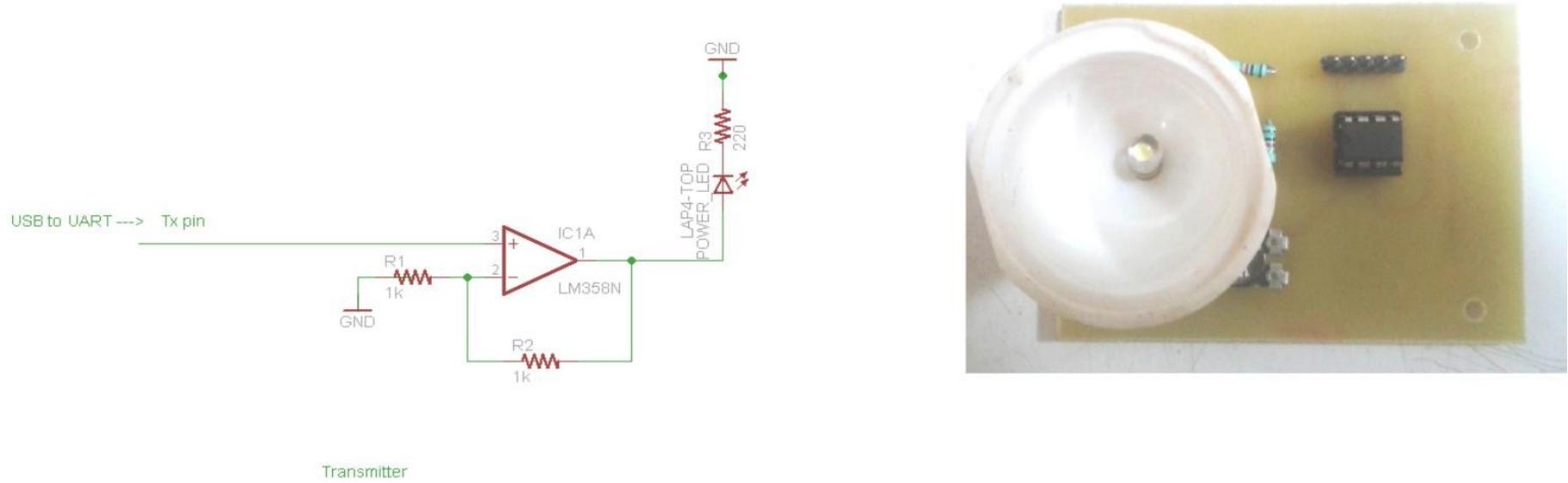
# System Block Diagram



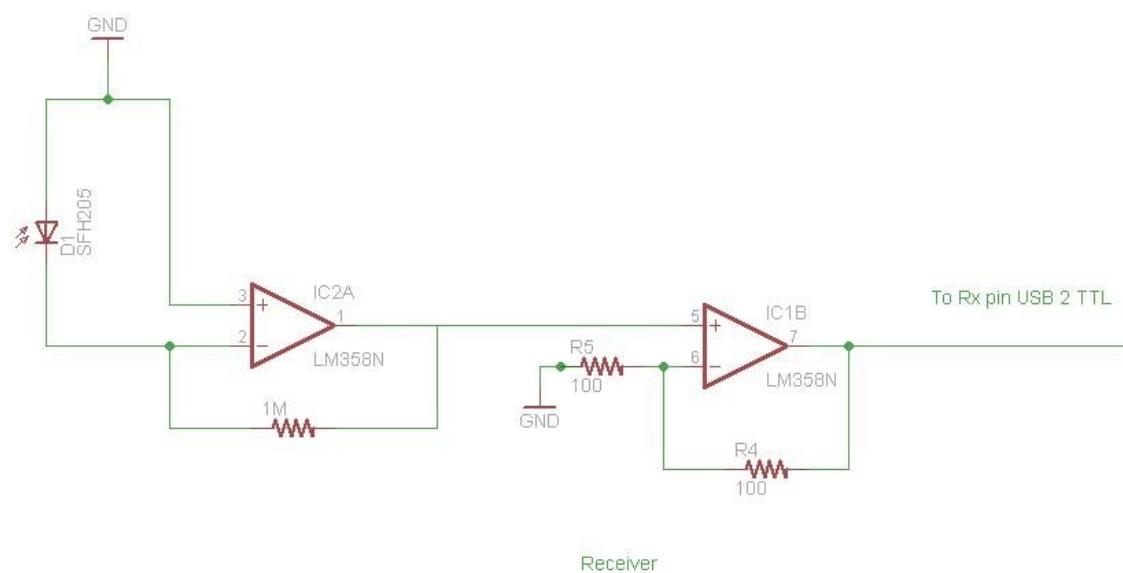
# USB to UART MAX232 Conversion



# Transmitter Design

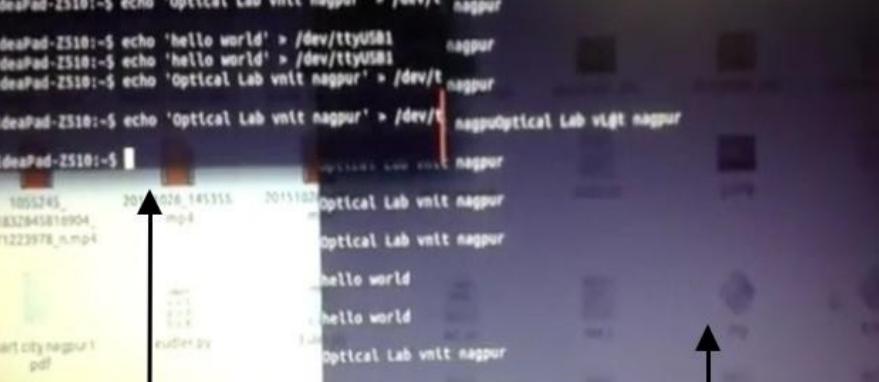


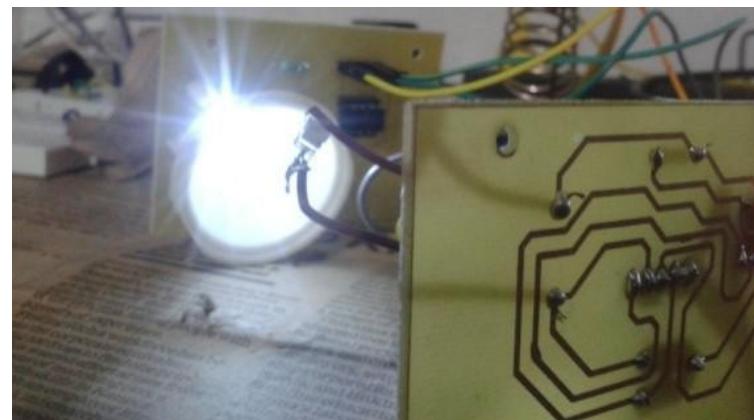
# Receiver Design



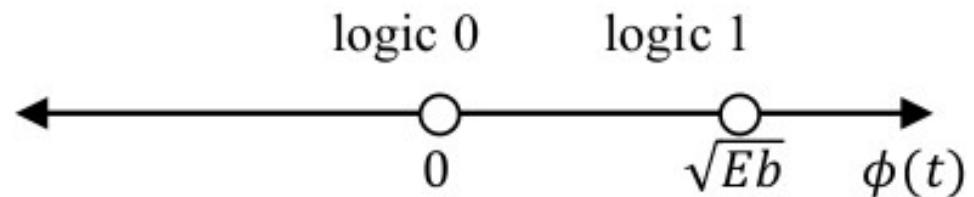
## Testing and Results

```
Lenovo-IdeaPad-Z510:~$ echo 'Optical Lab vnit nagpur' > /dev/ttynagpur
Lenovo-IdeaPad-Z510:~$ echo 'Optical Lab vnit nagpur' > /dev/ttynagpur
Lenovo-IdeaPad-Z510:~$ echo 'Optical Lab vnit nagpur' > /dev/ttynagpur
Lenovo-IdeaPad-Z510:~$ echo 'hello world' > /dev/ttyUSB1nagpur
Lenovo-IdeaPad-Z510:~$ echo 'hello world' > /dev/ttyUSB1nagpur
Lenovo-IdeaPad-Z510:~$ echo 'Optical Lab vnit nagpur' > /dev/ttynagpur
Lenovo-IdeaPad-Z510:~$ echo 'Optical Lab vnit nagpur' > /dev/ttynagpur
Lenovo-IdeaPad-Z510:~$ echo 'Optical Lab vnit nagpur' > /dev/ttynagpur
Lenovo-IdeaPad-Z510:~$
```





# Constellation Diagram



*Logic 1 :  $s_1(t) = +5V$  for  $0 \leq t \leq T_b$*

*Logic 0 :  $s_2(t) = 0$  for  $0 \leq t \leq T_b$*

# Basis Function

$$Eb = \int_0^{Tb} s1(t)^2 \cdot dt$$

$$Eb = \int_0^{Tb} 5^2 \cdot dt$$

$$Eb = \int_0^{0.1041} 25 \cdot dt$$

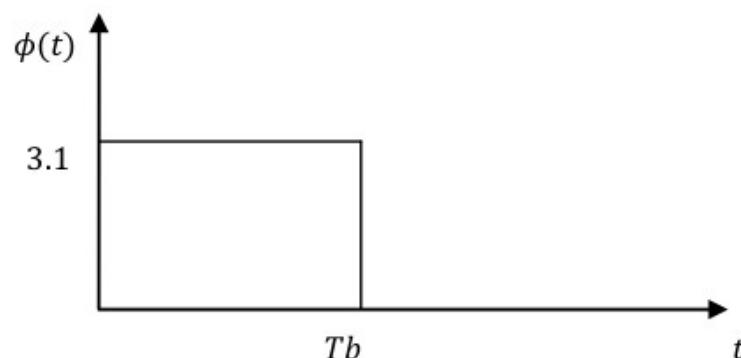
$$Eb = 2.6025$$

Now Basis function for our system will be,

$$\phi = \frac{s1(t)}{\sqrt{Eb}} \quad \text{for } 0 \leq t \leq Tb$$

$$\phi = \frac{5}{\sqrt{2.6025}} \quad \text{for } 0 \leq t \leq Tb$$

$$\phi = 3.1 \quad \text{for } 0 \leq t \leq Tb$$



Thank You