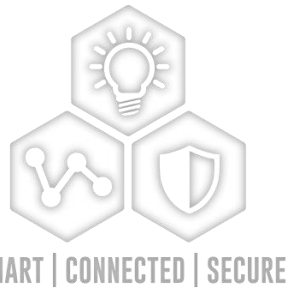
8 Bit Development Project

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



- Mohit Sathyaseelan

LiFi based communication using PIC18F57Q43.

Agenda

- What is LiFi?
- Project Overview
- Software and Hardware
- Peripherals
- Results and Observations
- Issues faced and Improvements

What is LiFi?

- Light Fidelity is an application of Visible Light Communication (VLC) which utilizes light to transmit data between devices. It is like Optical fiber where the light pulses are sent through a fiber optic cable.
- LiFi does not require a specific medium like a cable or an enclosing to send data.
- Data propagation of LiFi is similar to morse code, the Light source sends a High and a Low signal by blinking.

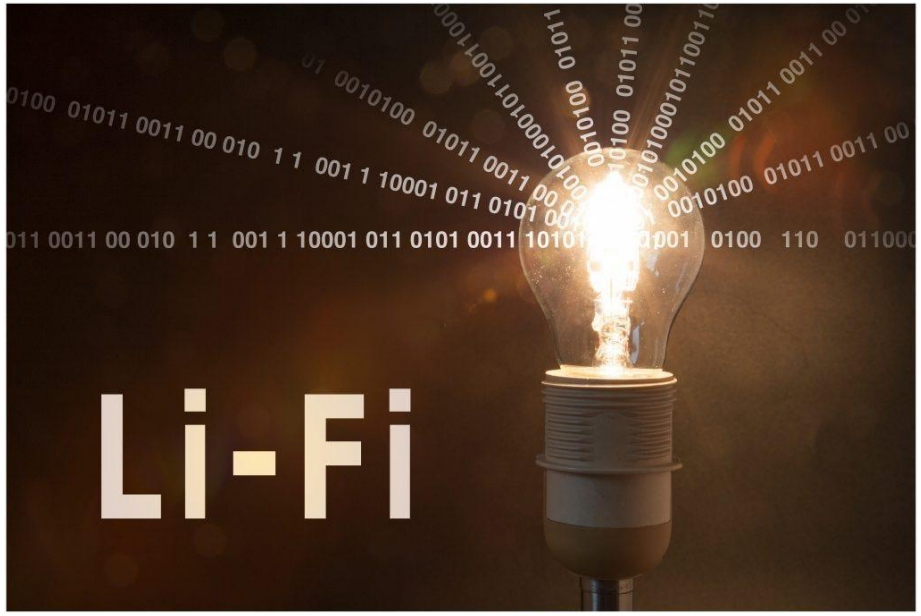
What is LiFi?

Pros

- More bandwidth
- Speed
- Interference
- Security
- Energy efficient solution

Cons

- Direct line of sight
- Range of communication
- Hardware requirement



What is LiFi?

Applications

Street Lamps

Server communication to prevent usage of cables

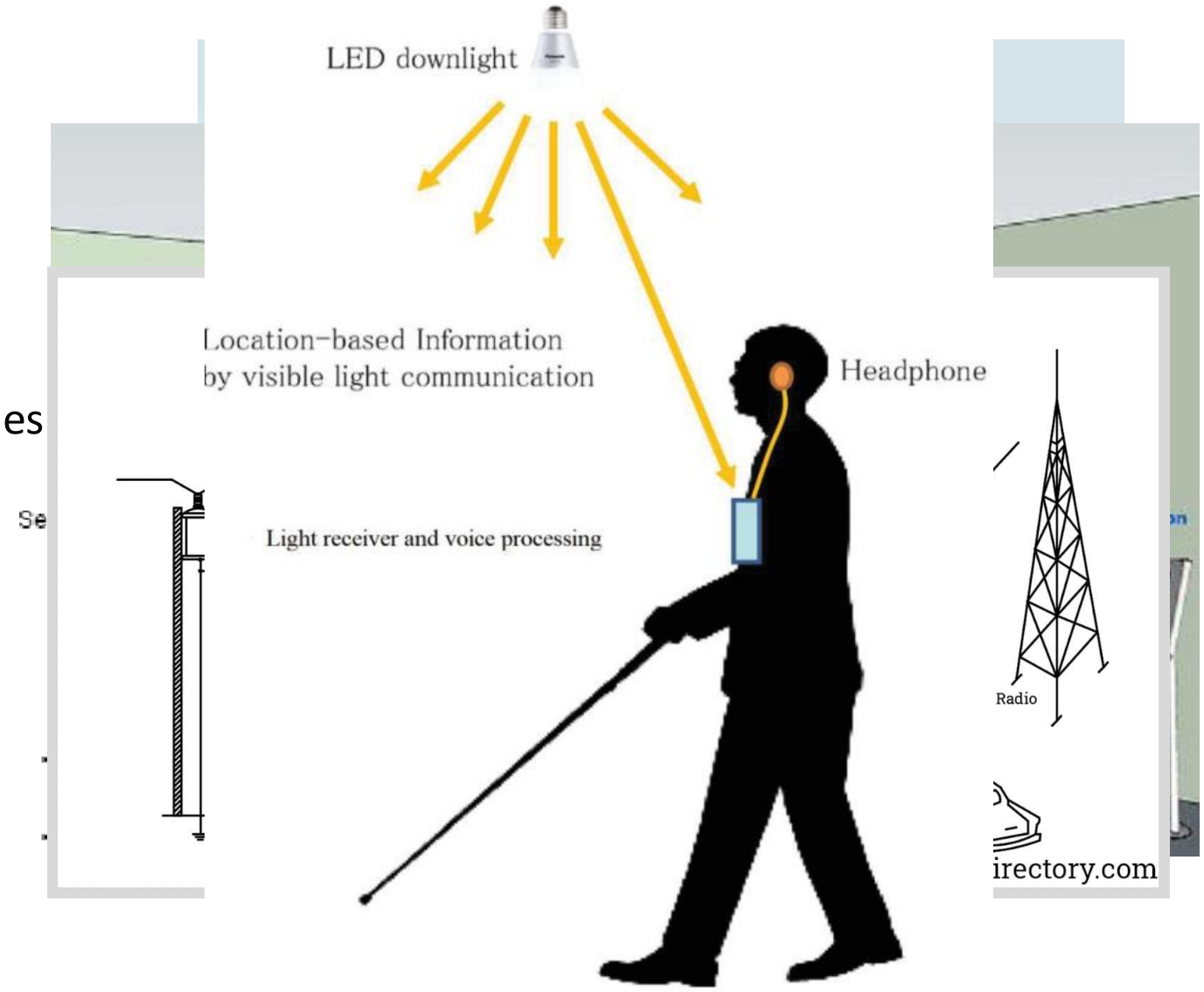
EMI sensitive environments

Underwater based technology

Smart Vehicles

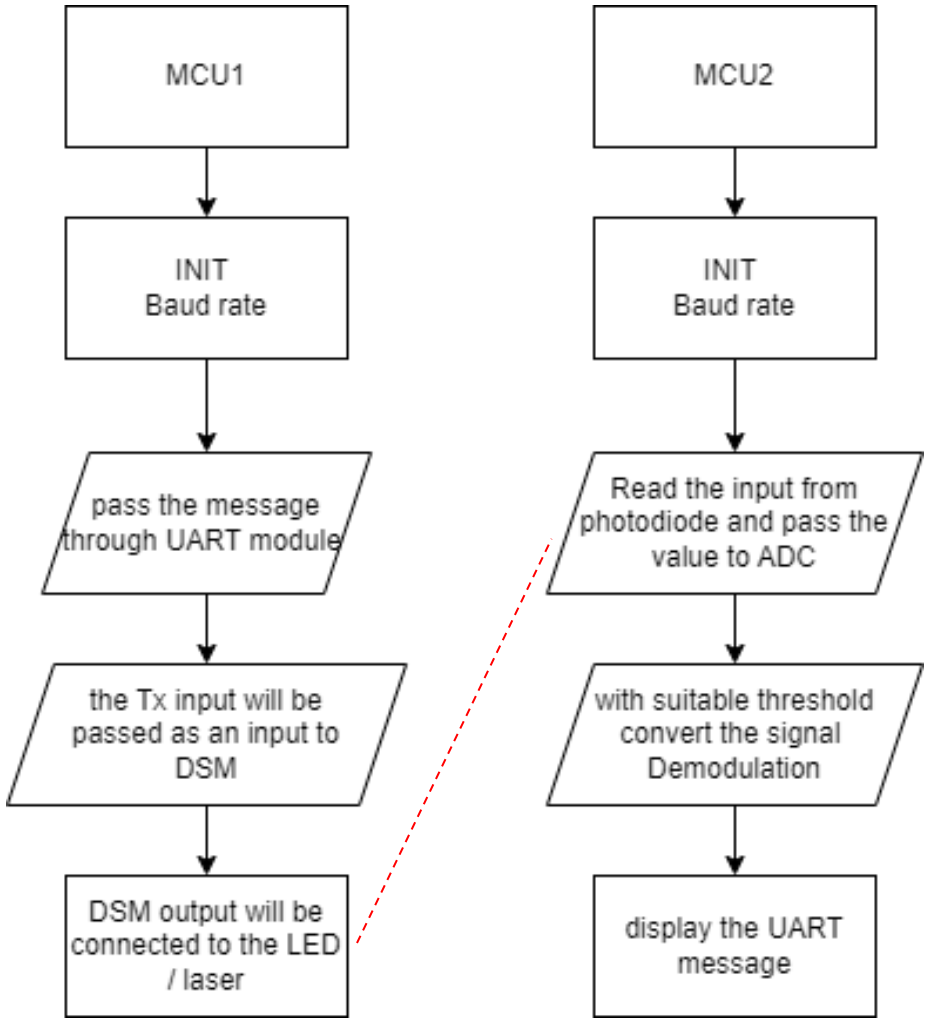
Connectivity

Indoor Navigation



Project Overview

- The two MCUs will communicate with each other using UART protocol
- Modulate the transmitter output using Digital Signal Modulator (DSM)
- The Modulated signal will be the input source for the Light source
- The photodiode will pick up this signal using Analog to Digital Converter (ADC).
- The ADC threshold output will be the input to the receiver MCU.



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Software and Hardware

Software used:

- MPLAB X IDE: https://www.microchip.com/en-us/tools-resources/develop/mplab-x-ide
- MPLAB XC8 Compiler: https://www.microchip.com/en-us/tools-resources/develop/mplab-xc-compilers
- MPLAB Code Configurator (MCC): https://www.microchip.com/en-us/tools-resources/configure/mplab-code-configurator

Hardware used:

- Two MCUs with DSM and ADC peripheral
- Laser
- Photodiode
- Resistors
- Jumper cables

Software and Hardware

Hardware

PIC18F57Q43:

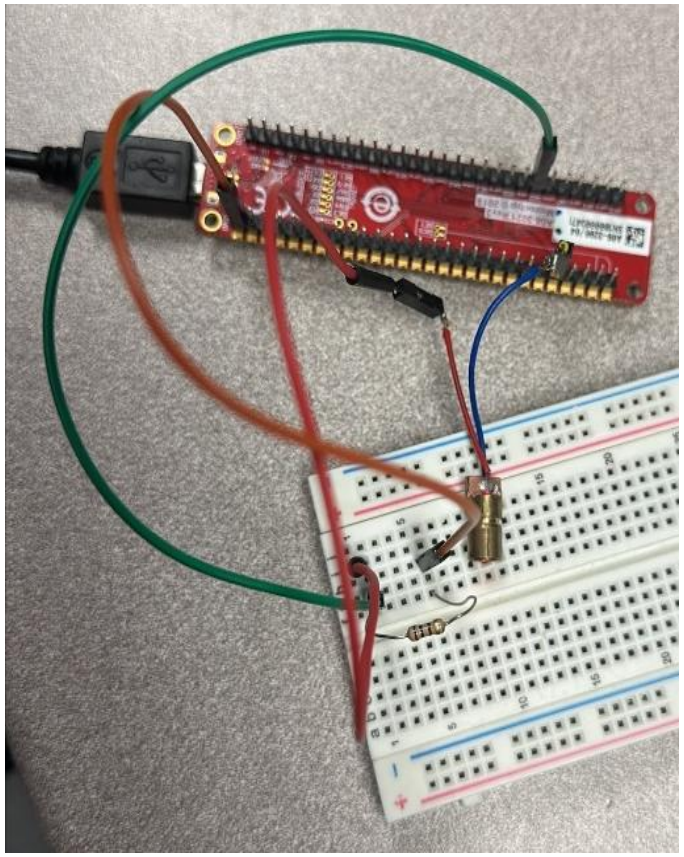
- For the Li-Fi project i have selected the PIC18F57Q43 as, it has a ADC, DSM and UART peripheral. The datasheet and schematic design of the eval board is readily available and is a great resource for the project.

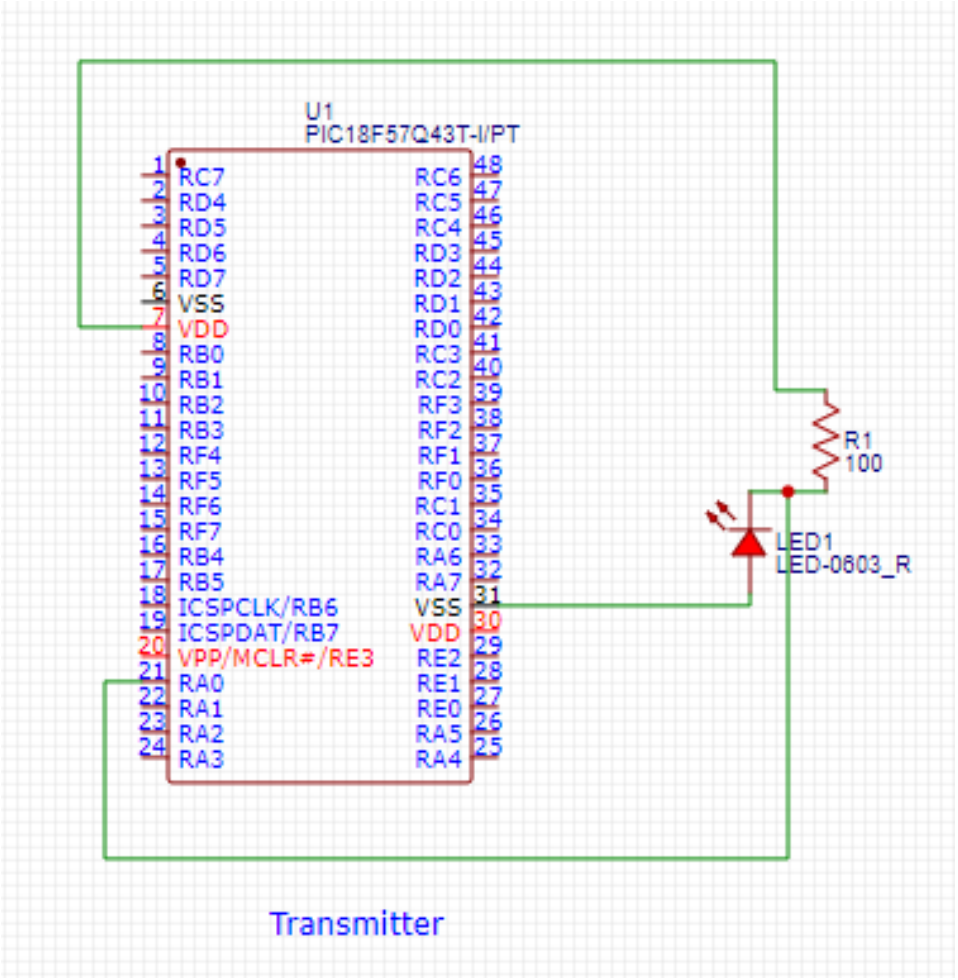
Laser and Photodiode:

- Choosing the Laser and Photodiode is a crucial part of the project as the responsiveness of the device impacts the whole project. A major factor to note down is that the wavelength of the laser should be in the spectral bandwidth of the Photodiode. (If in case you want to use IR laser, check Photodiode data sheet)

Software and Hardware

- **Transmitter Setup:**





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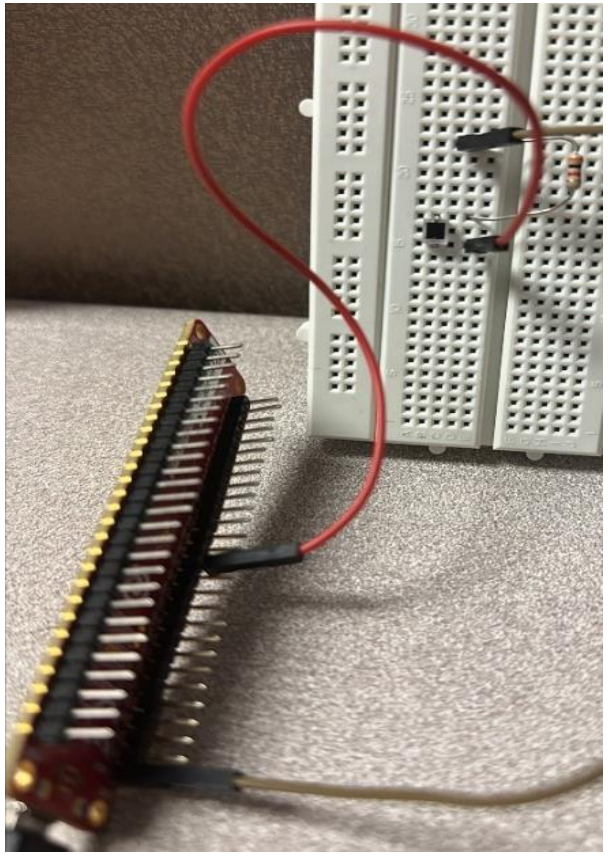
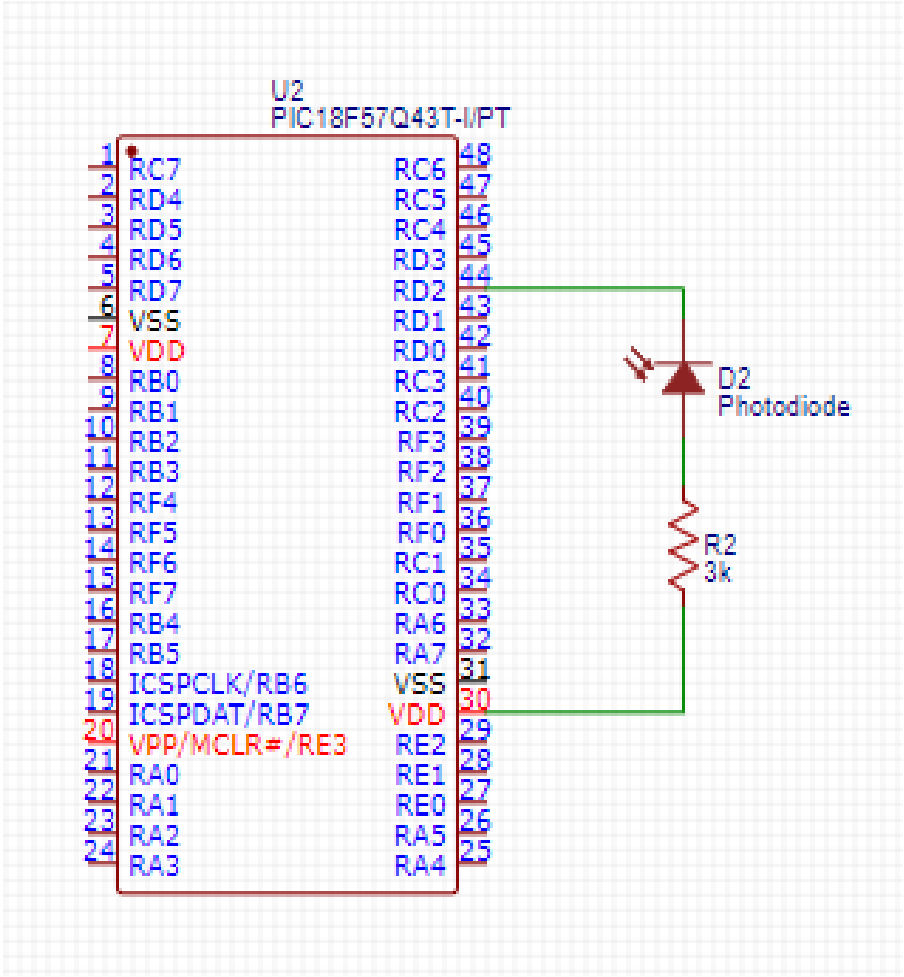
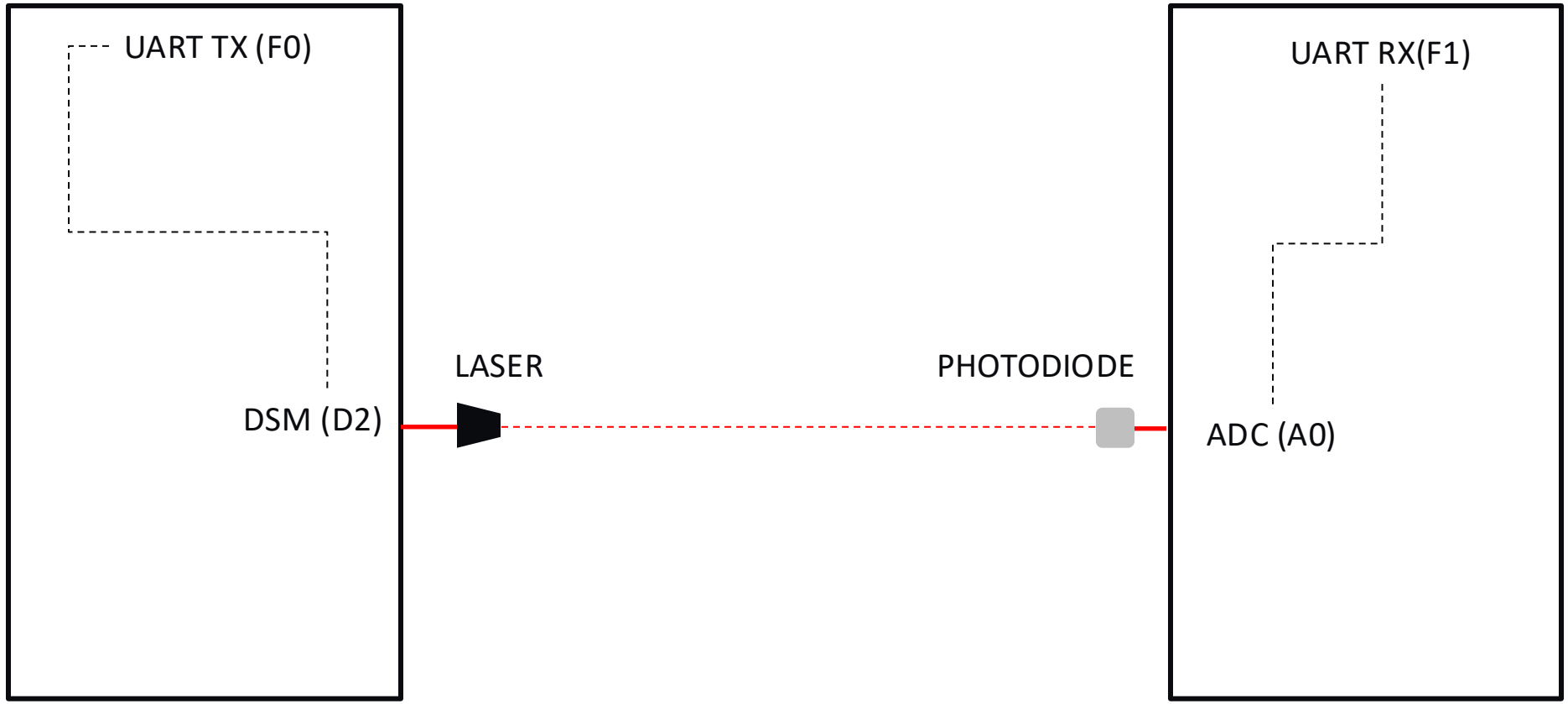
Software and Hardware

- **Receiver Setup:**





Peripherals Overview



Peripherals

UART

We will be setting UART baud rate to 9600 bauds for both transmitter and receiver. The theoretical speed of sending 9600 bauds is 1200 bytes/s where a bit duration is 104.167 microseconds. Although the actual or practical speed is 960 bytes/s where the byte duration is 1.042 ms.

The actual speed of transmission is crucial as we need the DSM to modulate this signal and the ADC has to read this message.

Peripherals

DSM

As we want to modulate the UART signal from the transmitter, we will be using the DSM peripheral which is provided in the MCU board we selected.

The DSM has various Modulation techniques that it can implement. (FSK, PSK and OOK). After going through few research papers, I've decided to go with OOK modulation as the Disadvantage of this technique can be corrected by redesigning the Open Drain Circuit.

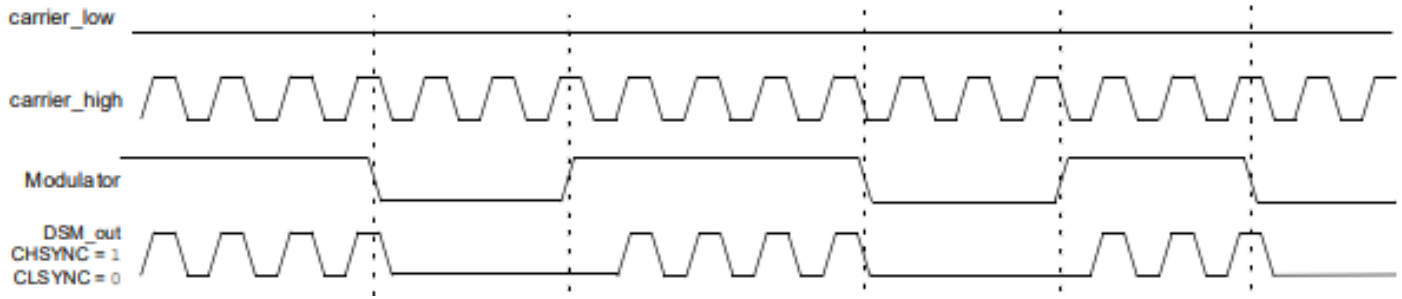
The DSM will take in three inputs, they are Modulator Source, High Carrier and Low carrier source. The modulator source will be the UART signal

Modulation	working	Advantage	Disadvantage
On-Off keying	Dimming based modulation scheme which transmits data	System performance implementation complexity	Increasing or decreasing the brightness
Pulse Width Modulation	Square ware width of the pulses are adjusted based	PWM changing the intensity level of pulses	Data rate is low
Variable pulse position modulation	Width of the signal pulses changed according to specified brightness level	Better spectral efficiency as compared to PPM	Lack power efficiency
Optical spatial modulation	Transmission modulation technique in which input bits sequence is mapped	Power and bandwidth efficient	Correlation because it depends upon transmitter and receiver units

Peripherals

DSM

The low and High carrier can be set according to the modulation we require. From the datasheet for the device, to get a OOK modulation we can verify what the carrier high and low signal should be.



One of the carrier high or low carrier signal can be set to the Internal oscillator signal, and the other signal should be low.

NOTE:
Since OOK has a disadvantage of increasing/decreasing the brightness, we will connect the DSM output to an Output Drain Pin. (create an Output Drain Circuit). This will let us choose the brightness of the laser.

The open-drain feature allows the generation of outputs higher than the supply voltage (VDD) on any desired digital output pin.

Peripherals

ADC

The ADC and clock settings on the receiver side is crucial and impacts the system performance.

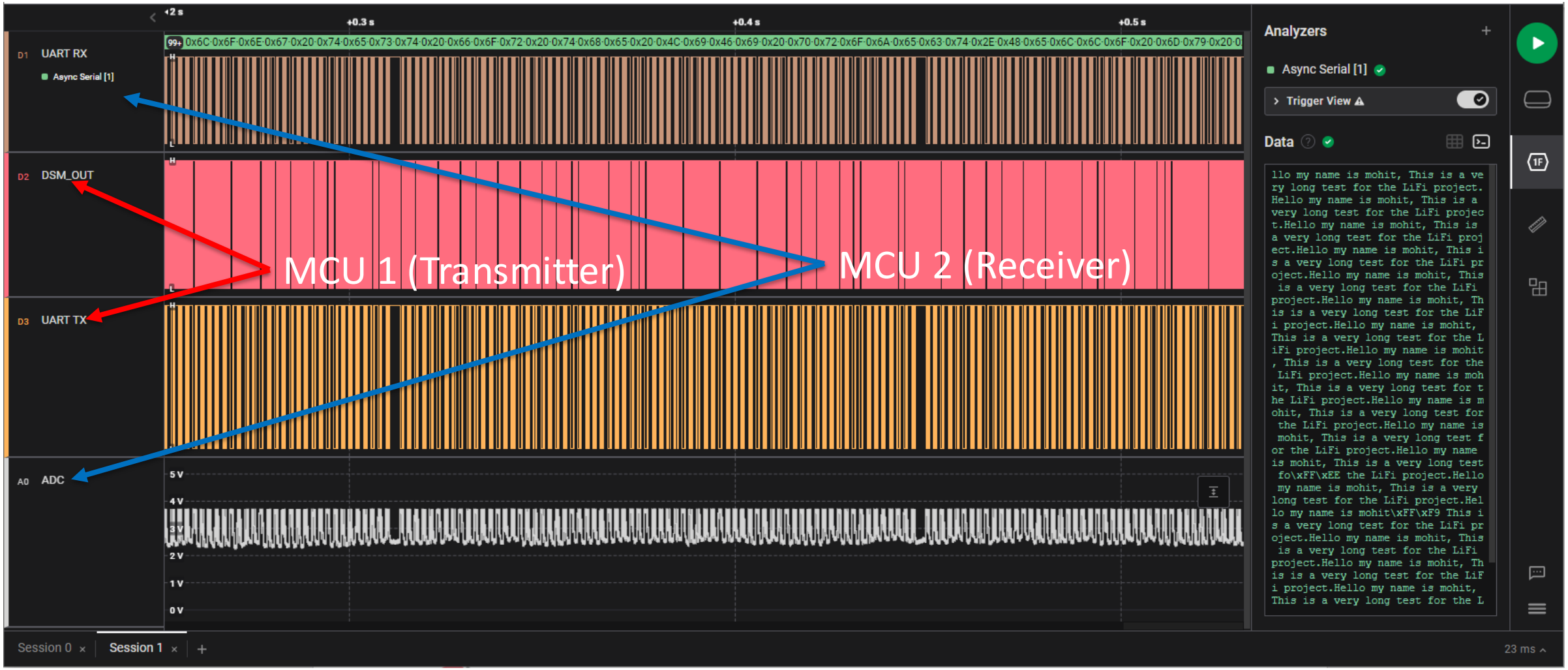
We will also use Shannon's theorem to set the threshold, i.e setting the sample rate of the ADC to atleast twice the rate of signal we receive.

Although from the test, I've noticed the more signals we sample the better the result is. This need not say that setting a highest sample rate will give the best result. (Over sampling is not the solution)

The reason is due to the DSM, we notice when the signal is high; the frequency it blinks the light is high. We don't want the ADC to sample this.

Hence the ADC sample rate should be between these to limits.

Results and Observation



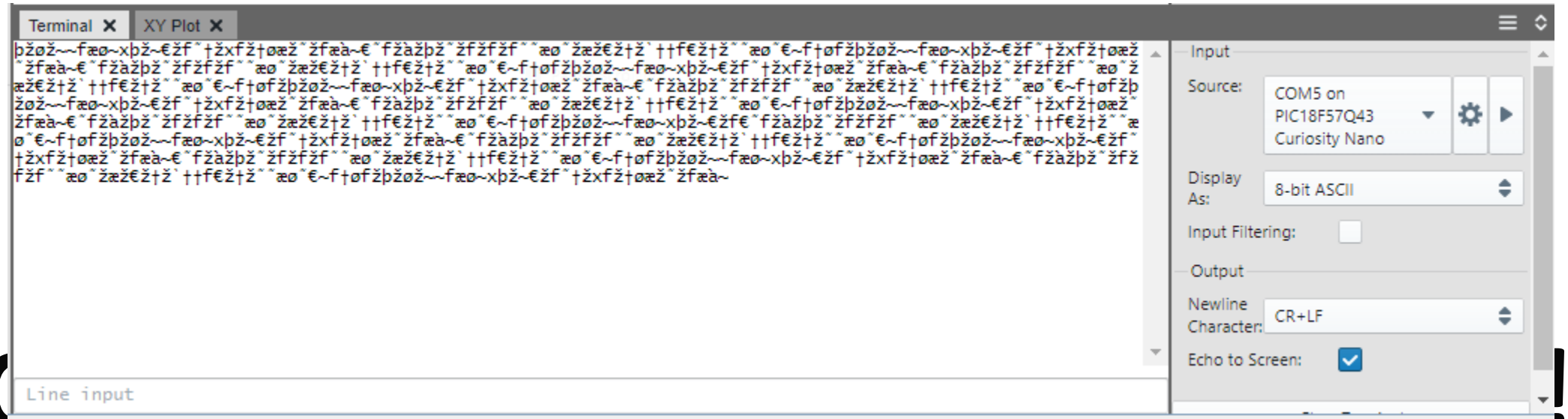
Results and Observation

- 20230501_182009000_iOS.MOV

Results and Observation

- The test for the image was conducted in my cube.
- The transmitter and receiver was placed away by 30 inches away from each other.
- Angle of transmitter had to be carefully placed as slight deviation changes the system performance.
- The Open Drain circuit improved the range of communication. (better the ADC read's the signal the further the communication)
- If the UART displays the data and ADC samples the signal, the system performance is poor. Area of improvement is vast.
- DMA to print the UART messages, doesn't affect the system performance.

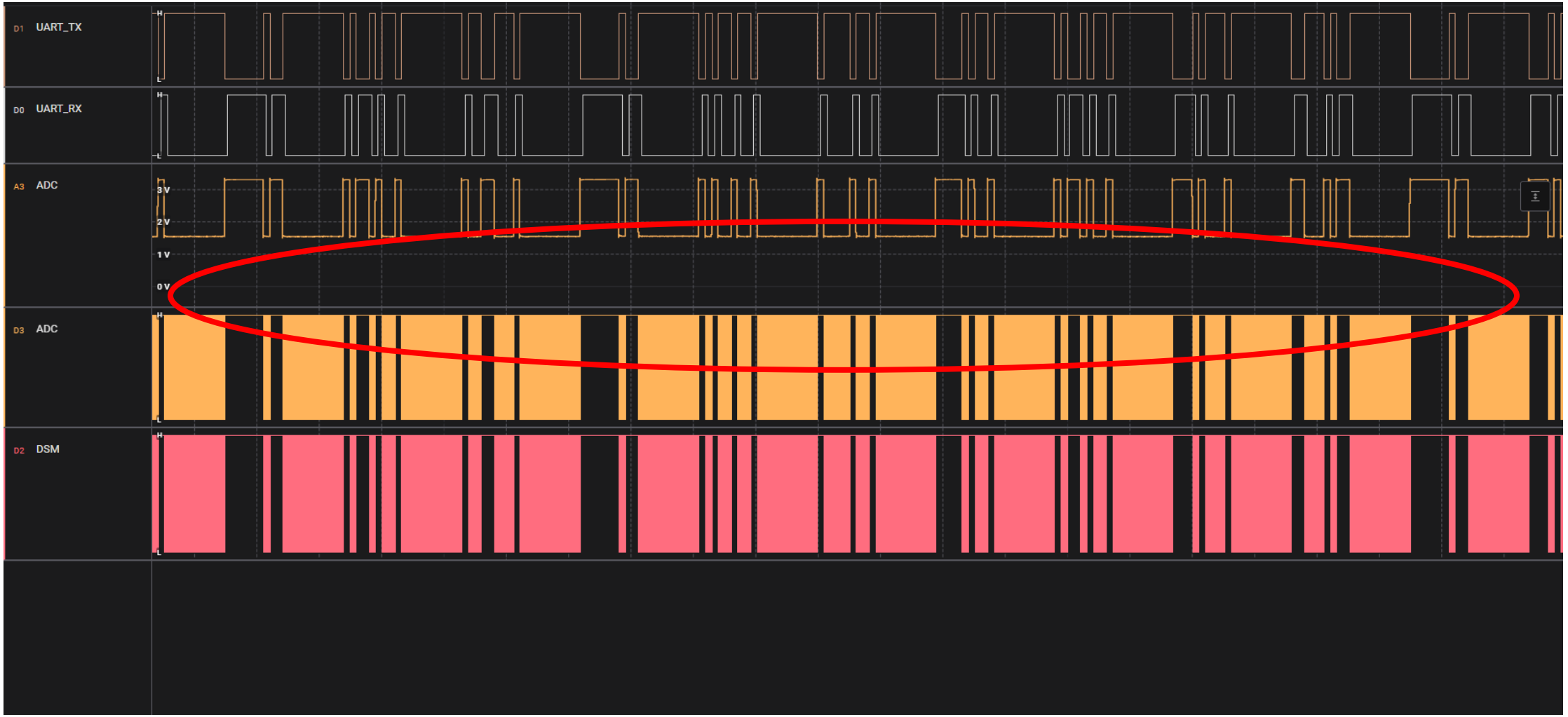
Issues faced and Improvements



Output | Configuration Bits

Address	Name	Value	Field	Option	Category	Setting
300000	CONFIG1	FF	-	-	-	-
		7	FEXTOSC	ECH	External Oscillator Selection	EC (external clock) above 8 MHz
		7	RSTOSC	EXTOSC	Reset Oscillator Selection	EXTOSC operating per FEXTOSC bits (device manufacturing default)
300001	CONFIG2	FF	-	-	-	-
		1	CLKOUTEN	OFF	Clock out Enable bit	CLKOUT function is disabled
		1	PR1WAY	ON	PRLOCKED One-Way Set Enable bit	PRLOCKED bit can be cleared and set only once
		1	CSWEN	ON	Clock Switch Enable bit	Writing to NOSC and NDIV is allowed
		1	FCMEN	ON	Fail-Safe Clock Monitor Enable bit	Fail-Safe Clock Monitor enabled
300002	CONFIG3	FF	-	-	-	-
		1	MCLRE	EXTMCLR	MCLR Enable bit	If LVP = 0, MCLR pin is MCLR; If LVP = 1, RE3 pin function is MCLR
		3	PWRTS	PWRT_OFF	Power-up timer selection bits	PWRT is disabled
		1	MVECEN	ON	Multi-vector enable bit	Multi-vector enabled, Vector table used for interrupts
		1	IVT1WAY	ON	IVTLOCK bit One-way set enable bit	IVTLOCKED bit can be cleared and set only once
		1	LPBOREN	OFF	Low Power BOR Enable bit	Low-Power BOR disabled
		3	BOREN	SBORDIS	Brown-out Reset Enable bits	Brown-out Reset enabled , SBOREN bit is ignored

Issues faced and Improvements



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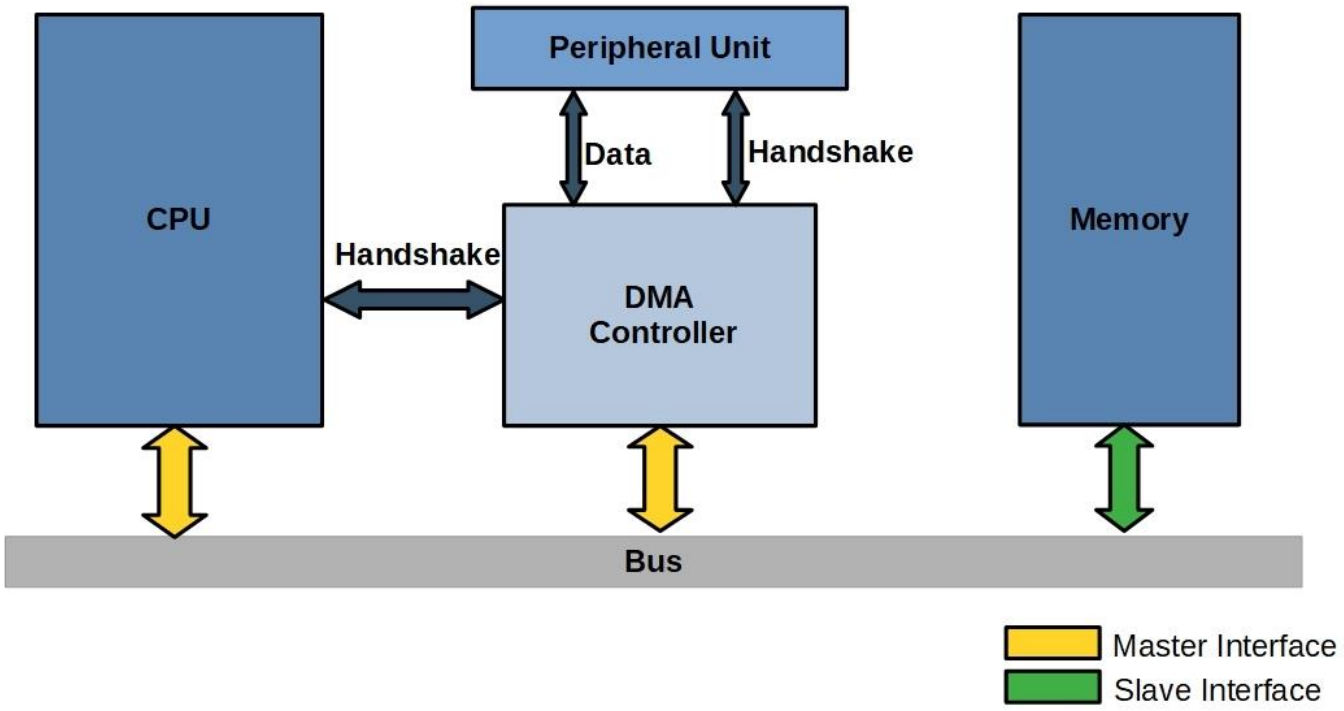
Issues faced and Improvements

DMA



DMA 8 Bit UART Project

- LINK

DMA using MCC

- DMA needs to display 1 byte of data
- UxRX register is a trigger used by DMA
- Custom software trigger or Timer trigger for every 1 Byte

References :

- Li-Fi: Internet at the Speed of Light | The Future of Networking
- ADCC Threshold Comparison Example - Developer Help
- High sensitivity universal lifi receiver for enhance data communication | IEEE Conference Publication | IEEE Xplore
- (PDF) Modulation Techniques for Li-Fi
- Design of a Li-Fi Transceiver
- Design schematic for the project
- PIC18F27/47/57Q43 28/40/44/48-Pin, Low-Power, High-Performance Microcontroller with XLP Technology
- bpw34.pdf
- WOWOONE Laser Diode, 30pcs Mini Red Laser Diode Laser, 5V 650nm 5mW, Red Dot Laser Head, with Leads Head Outer Diameter 6mm: Amazon.com: Industrial & Scientific

THANK YOU