Use Case

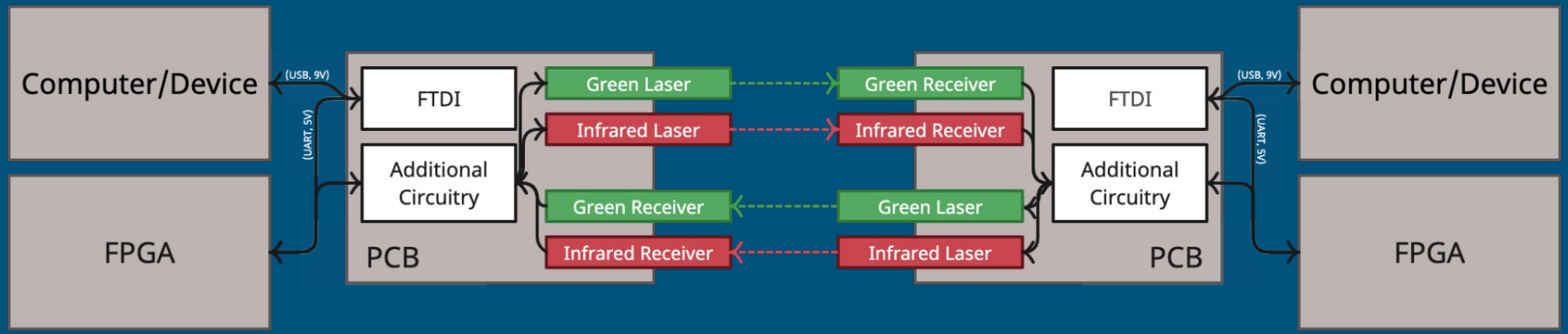
- Espionage
  - Alternative to dead drops
- Secure, discrete information transfer
  - Difficult to intercept
  - No RF signals
  - No physical connection
  - No traces

Description	Requirement
Data Transmission Range	1 m
Allowable Angular Error	0.5 to 2 degrees
Ambient Light	Constant indoor ambient light
Max Optical Power	5 mW (Class IIIa)
Error Detection	Detect 2 bits, Correct 1 bit
Minimum Data Transmission Speed	4 Mbps (50 pdf pages per second)
Power	USB Power Delivery compatible

Design Requirements

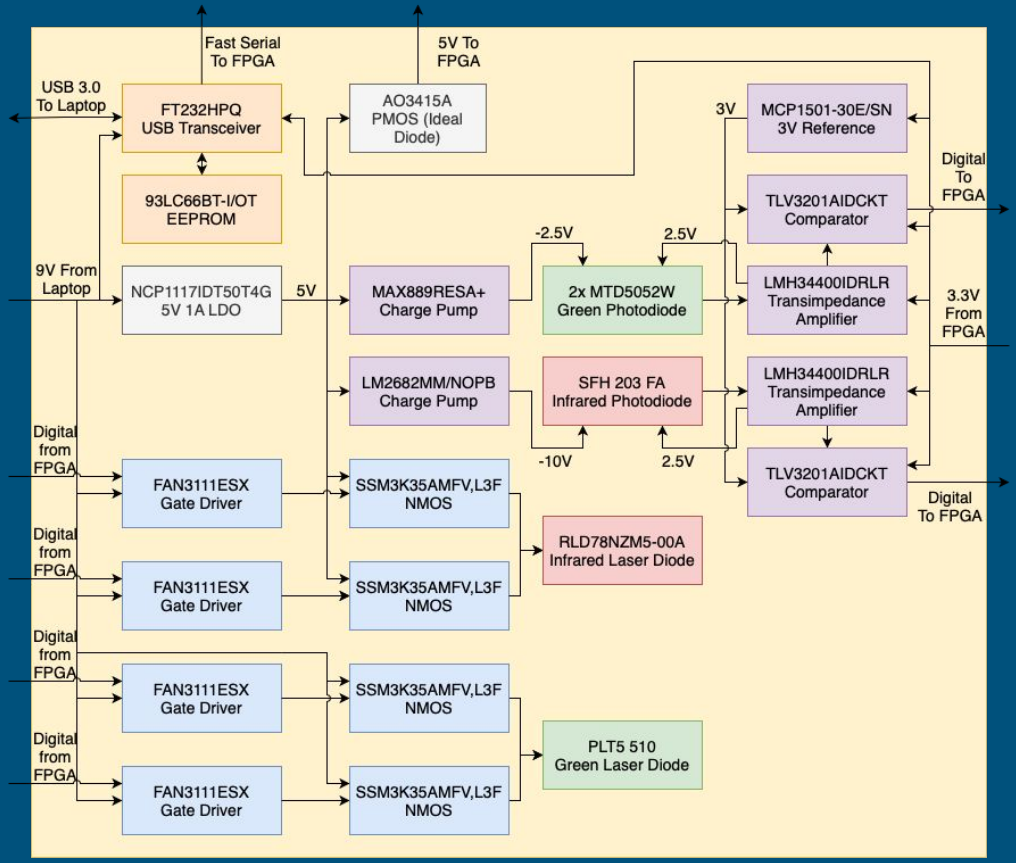
Description	Requirement
Minimum hardware bitrate	5.67 Mbps = 4 Mbps x 1.417
Max combined rise/fall time of optical signal chain	70.5 ns = (1 / (5.67 Mbps / 2)) x 0.2
Minimum input voltage	7 V
Minimum Photocurrent	5 µA
Max allowed bitrate between FPGA and PCB	25 Mbps
Laser radius @ 1m	0.87 cm - 3.5 cm

Solution Approach



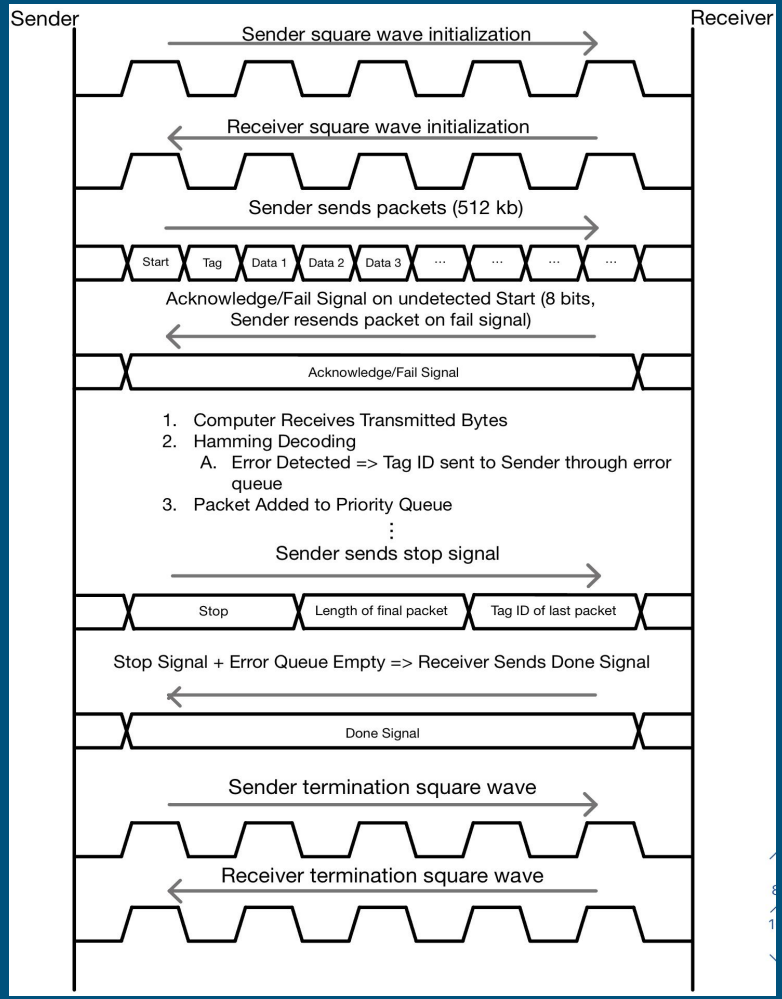
PCB Design

- 12 Mbps max
  - 6 Mbps per laser
- Backup plans included via pullup/down, 0Ω resistors, and DNPs
- Ambient light filtering



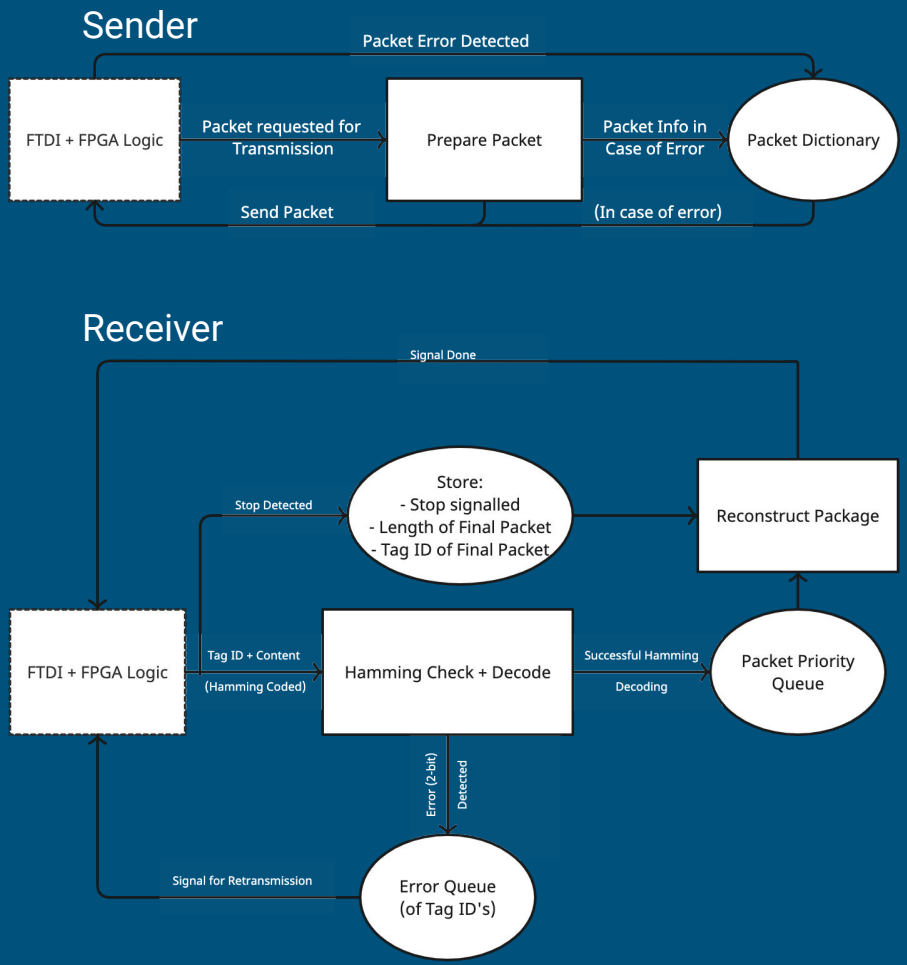
Comms Protocol

- Send data in packages
- 1 package 512 bits (64 bytes)
  - Start Sequence
  - Package ID
  - 60 bytes data
  - Hamming encoding
- UART-based over 2 lasers
- 32-bit timeout

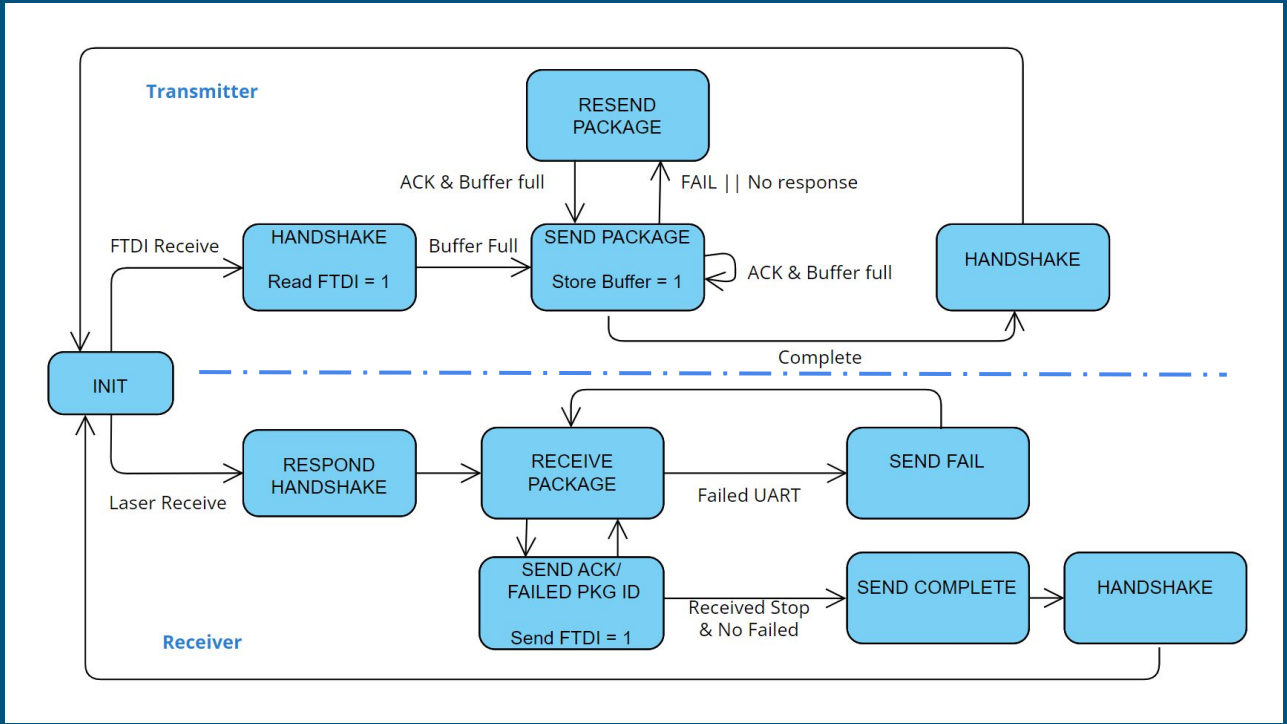


Software

- USB VCP implementation
- Clarifications:
  - Packet Dictionary: Tag ID key, index in package to read from as data
  - Packet Priority Queue: Stores packets, Tag ID as priority for reconstruction
  - Error Queue: Queue of Tag ID's where error was detected for retransmission



FPGA Logic


Transmitter
RESEND PACKAGE
ACK & Buffer full
FAIL || No response
FTDI Receive
HANDSHAKE
Read FTDI = 1
Buffer Full
SEND PACKAGE
Store Buffer = 1
ACK & Buffer full
HANDSHAKE
Complete
INIT
RESPOND HANDSHAKE
Laser Receive
RECEIVE PACKAGE
Failed UART
SEND FAIL
SEND ACK/ FAILED PKG ID
Send FTDI = 1
Received Stop & No Failed
SEND COMPLETE
HANDSHAKE
Receiver

Implementation Plan

	Hardware	Software
COTS	• Laptop • DE0-CV FPGA • Lens	• FT_PROG (configuration) • FTDI Driver (VCP) • USB protocol handling (FTDI chip)
Custom	• Laser Transmitter Circuit • Laser Receiver Circuit • Power Circuit • USB Interface • Lens Housing	• Communication protocol • FPGA code • CPU software • Error detection and correction • File reconstruction • Handshaking

Budget

Item	Link	Quantity	Price	Total Price	Spent	Remaining	Planned Purchases	Planned Remaining
Green Test Laser	https://www.mou	1	15.67	15.67	118.97	481.03	431.71	49.32
IR Test Laser	https://www.mou	1	20.28	20.28				
IR Test Photodiode	https://www.mou	1	1.54	1.54				
Out of Stock Blue Photodiode	https://www.mou	1	26.42	26.42				
Shipping Test Parts		1	9.99	9.99				
MSP-EXP430F5529LP	https://www.mou	1	17.28	17.28				
Shipping MSP Launchpad		1	9.99	9.99				
Laser Lens x3	https://www.ama	2	8.9	17.8				
Proposed to Buy:								
PCB BOM	https://docs.goo	4	92.93	371.72				
3D Printing	https://www.amaz	1	19.99	19.99				
5x PCB	https://jlcpcb.cor	1	40	40				

Test, Verification, Validation

Laser Test: transmit 5.67 MHz square wave between 2 devices at 1m, measure that FPGA receives lines with oscilloscope to verify signal cleanliness

USB Test: echo data at 5.67 Mbaud between FPGA and laptop, verify no errors

Full Speed/Latency Test: transmit a file to/from the same laptop, time transmission

Full Range Test: test with 2 laptops at 1m, time receiving laptop to verify speed

Error Correction Test: inject messages with 1 and 2 bit errors. Verify errors are corrected and detected, respectively

Power Test: measure current draw from a 9V power supply. Verify it is < 3A

Project Management

Tasks	Week 3 (2/20)	Week 4 (2/27)	Week 5 (3/6)	Week 6 (3/13)	Week 7 (3/20)	Week 8 (3/27)	Week 9 (4/3)	Week 10 (4/10)	Week 11 (4/17)	4/24
Hardware										
PCB schematic design & simulation	KJ									
Test laser lens		Anju								
PCB layout		KJ								
PCB & parts ordering		KJ								
3D Print Laser Housing				KJ						
Assemble & test PCB				KJ						
Firmware/FPGA										
Develop detailed FPGA design	Anju									
FPGA Implementation		Anju								
Test & refine				Roger/Anju						
FPGA compilation onto PCB			Spring		Anju/KJ					
Software			Break							
Setup USB environment from computer	Roger									
Implementation - Computer to FTDI		Roger								
Develop UI				Roger						
Design a test suite					Roger					
Systems										
SW/HW integration						All				
Testing & Validation										
Speed/latency test							All			
Range test							All			
Error correction test							All			
Power consumption test							All			
Slack								All	All	
Deadlines	Design Review	Report Due (3/3)					Interim Demo (4/3)			Final Presentation

Integration

Conclusion

- Securely and discretely transmit data via lasers
- Use FPGA and custom PCB to convert between USB and dual laser communication protocol