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23 Jan 17

MEMORANDUM FOR RECORD

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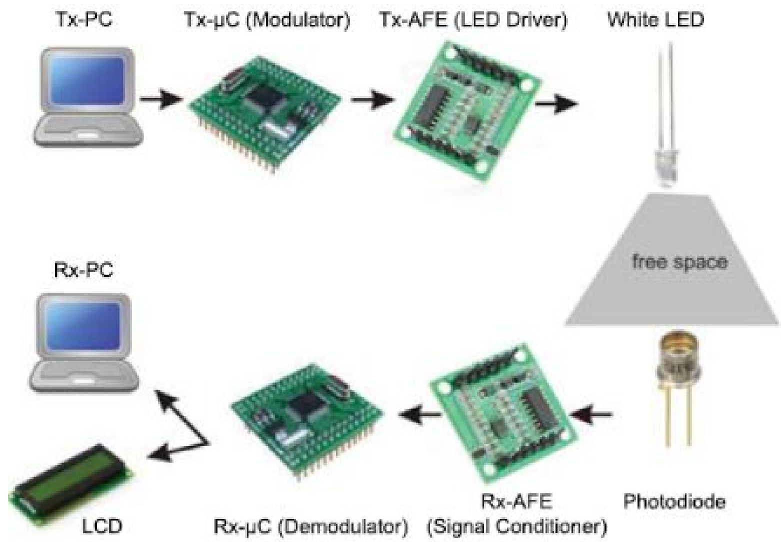
SUBJECT: Project Proposal for EENG 4910-4990

1. The purpose of this memorandum is to submit our group idea for our Senior Design project – Development Kit for Visible Light Communications.

2. The specific purpose of this memorandum is to go over our project with regards to problem definition, concept generation/requirements specification, design, prototype, testing, system integration, project schedule, and deliverables.

3. Problem Definition. Visible light communication (VLC) is transmitting data by modulating the output of light, and receiving it with a light sensitive sensor that limits the noise from ambient light. There are almost no development kits on the market using VLC for students to use and learn from, so we start from scratch and learn VLC to build a develop kit for future research. We will need to understand how wireless communication works as well as extensive signal processing techniques (light modulation, signal analysis, etc.).

4. Concept Generation/Requirements Specification. What we want is one way communication via the light spectrum. On the transmitter side, it would include a microcomputer for receiving user input, an MCU for real time signal processing, an led driver, and an RGB+W led for lighting and data transmission. On the receiver side, it would include an optical splitter/filter, a photodiode receiver, a threshold triggering circuit, an MCU for real time signal processing, and a microcomputer for user interaction.



5. Design. There are a number of factors and any could change based on further research and testing. For Senior Design, we will use UART to send a message on a channel of the LED: a message specifically over red LED, or specifically over green, or specifically over blue. We found, and plan to follow, IEEE 802.15.7 standards for VLC. The IEEE VLC specifications describe many modulations modes, however for simplicity we intend to utilize pulse code modulation (PCM) or possibly Frequency Modulation (FM) for data transmission. For our design, we decided to utilize an MCU (MSP430) for real time data processing which in turn communicates via UART to a Raspberry Pi 3 for user interface and lighting control. RGB+W mixing and dimming will be controlled via a variable current driver which is directly controlled by the Raspberry Pi.

6. Prototype. Our prototype will be very basic and modular so we can use it for testing the different options for each piece. The transmitter section will consist of computer (Raspberry Pi) that graphically accepts user inputs and files which will then be encoded and sent via UART to a TI microcontroller (MSP430). the MCU then parses the data and outputs an accurately timed PCM signal to the LED driver. The receiver will consist of a dichroic prism which splits and filters incoming white light into separate red, green, and blue channels. The filtered light is then detected by a photodiode, amplified, and triggered into a digital signal that is sent to an MCU (MSP430) real time timing measurements. The MCU will then detect the timings between pulses and send bits of data via UART to a computer (Raspberry Pi) for compiling and display to the user.

7. Testing. There's a number of testing that can happen on both the Tx and Rx side to slowly piece together the project. On the Rx, we want to test the photodiodes by themselves with an o-scope to see what we can anticipate for signal. We'll send that low level voltage through a transistor based circuit to amplify it so there is a 0V-3.3V signal. Only after that can we work on signal processing and outputting data through UART. We also want to look into multichannel communication using each color of the RGB LED. We have a dichroic cube to separate the three colors. With three separate photodiode circuits, we can send all signals to the MCU for the first

part of data processing before sending it to the Raspberry Pi for final manipulation and output. For Tx, we need to work on current adjustment since each color can have different specs and we want a constant current driver. We also want to find out how changing the frequency can change our communication capabilities. There are a number of ways to achieve our goal, and it's a matter of more research and testing to find the best solution. Our testing will be done in the lab with the Tx and Rx modules hooked up to a computer for better interface and troubleshooting.

8. System Integration. This system would lay the foundation for students to learn VLC and implement different techniques for future technology. VLC already exists, but it is not developed enough for people to do it on their own time or to learn in a classroom environment. Building a dev kit for VLC provides the opportunity for students everywhere to learn about a relatively young area of communications. The system will be very software intensive. We need to learn and deal with wireless communications along with signal processing. Implementing different communication techniques makes the code significantly more complex going from one level to the next. The parts themselves are easily recyclable to be used in other ways since they are basic shelf components. Software will be very specific in what its goal is and with those specific components.

9. Project Schedule. We will be providing weekly reports on our progress to Dr. Namuduri. We will be meeting at least once per week on Sunday evenings and occasionally on Monday mornings as the project timeline accelerates. Meetings will be subject change as we progress into the second semester of our project but will be established before arrival. We will save all articles and research to give credit and references. Our schedule was again reevaluated after Winter Break (week 18) to be more specific to each person as our project goes into the final stages.

Week	*Date*	*Projected Goals*	*Comments*
1	9/25/16	Research: Street lamp standards Li-Fi standards Current traffic prediction techniques	Physical and electrical requirements of streetlamps. Do current Li-Fi standards exist? What regulations would we have to follow to broadcast Li-Fi? How are traffic patterns predicted and modified to improve flow. Basics of how Li-fi works.
2	10/2/16	Research: Photo receivers RGB LED's/LED drivers Optical filters (color prism)	Photo receiver types and specifications. LED technologies and specifications. Optical filter/splitter options Rx side sensor.
3	10/9/16	Research: Microcontrollers/Microcomputers Light modulation techniques	Is there a standard for Li-fi modem technology? What type of microcontroller/microcomputer would best for light modulation? What computer

			language? Details on how light modulation is commonly implemented.
4	10/16/16	Research: Photo receivers RGB LED’s/LED drivers Optical filters (color prism) Choose/Buy Components for basic prototype	Advanced Li-fi research. Select hardware for initial prototype construction Choose specifics components to use for prototype
5	10/23/16	Test Components Code: Code familiarization Template code	Small scale component construction. Verify component specs in the real world. Become familiar with coding on the microcontroller and microcomputer.
6	10/30/16	Revamp Proposal Test Components Code: Code familiarization Template code	Rewrite proposal with TA feedback. Small scale component construction. Verify component specs in the real world. Become familiar with coding on the microcontroller and microcomputer. Dissect source code.
7	11/6/16	Revamp Proposal Prototype 1 Code T0: Tx portion of source code using PWM Code R0: Rx portion of source code using PWM	Rewrite proposal with TA Feedback Build a Tx and Rx circuit. Run source code with separate Tx and Rx (vary Rx LED brightness depending on Tx LED) Separate source code so 2 launch pads can be used. One as Rx, and the other as Tx.
8	11/13/16	Prototype 1 Code T0: Tx portion of source code using PWM Code R0:	Build a Tx and Rx circuit. Run source code with separate Tx and Rx (vary Rx LED brightness depending on Tx LED) Separate source code so 2 launch pads can be used. One as Rx, and the other as Tx.

		Rx portion of source code using PWM	
9	11/20/16	*(Thanksgiving Break)* Reevaluate Prototype 1 Code T1: Modify T0 to send bits Code R1: Modify R1 to receive bits	Reevaluate parts being used for the circuit. Look at other options depending on findings. Make T1 send bit values with the RGB on a fixed time Make Rx launch pad blink LED to show bit value received.
10	11/27/16	Build Prototype 2 Code T2: T1 with UART Code R2: T2 with UART Project Progress Report due 8 Dec 16	Implement UART to choose the bit being sent (hit the 0 or 1 key on Tx) and showing the received bit on the Rx side. Report on progress done so far due to faculty mentor (Dr. Namuduri).
11	12/4/16	Build Prototype 2 Code T2: T1 with UART Code R2: T2 with UART	Implement UART to choose the bit being sent (hit the 0 or 1 key on Tx) and showing the received bit on the Rx side.
12	12/11/16	Finals Week	
13	12/18/16	Winter Break	(buffer to reevaluate and catch up)
14	12/25/16	Winter Break	(buffer to reevaluate and catch up)
15	1/1/17	Winter Break	(buffer to reevaluate and catch up)
16	1/8/17	Winter Break	(buffer to reevaluate and catch up)
17	1//15/17	Refamiliarize with past research and code	Potentially retest system and verify points as to how to improve the system.
18	1/22/17	Chris:	Continue individual projects

		Tx MCU talking with Rasp Pi via UART Nathan: Rx receive all data on MCU and send to Rasp Pi via UART Forrest: Rx Rasp Pi code. Receiving user input in GUI	
19	1/29/17	Chris: Test direct Rasp Pi UART to hardware Nathan: MCU of Rx done to include UART to Rasp Pi Forrest: RX Rasp Pi code. Determine action via file input	Continue individual projects
20	2/5/17	Chris: Tx hardware reeval and work on Pi comms Nathan: Rx hardware reeval and Rasp Pi code Forrest: Finalization of RX Rasp Pi code and testing	Chris: revise TX led driver to reduce low current duty cycle reduction and instability. Add rasp pi current control to driver. Work on getting mcu to read data from pi. Nathan: Increase frequency response on hardware and finalize Rasp Pi code to output data in correct format Forrest: Once completed, finding a way to loop program for constant data access and save file
21	2/12/17	" "	
22	2/19/17	Finalize code and testing. Decide on final product parts.	

23	2/26/17	Order parts for final product	Build prototype 3
24	3/5/17	Other capabilities	Sending audio over a channel, CSK modulation, daylight operations, 2 way communication, etc.
25	3/12/17	*(Spring Break)*	
26	3/19/17	Build final on protoboard	
27	3/26/17	Test and confirm results	
28	4/2/17	Completed/constructed system	Verify entire system is working at full capacity.
29	4/9/17	Test/Reevaluate/Deliverables	Final testing and evaluating to confirm it works under all conditions
30	4/16/17	“ “	
31	4/23/17	“ “	
32	4/30/17	Project Presentation: Final Semester	After presentation, discuss project preservation. Write formal thank you notes to all staff involved. Pending graduation!

We know there will be unforeseen problems and will need more time on some topics compared to others. We put multiple weeks for the same topic to allow for spillover as well as weeks set aside for catching up and evaluating what we have. To split up the project, Chris will be in charge of the Tx circuit and be the subject matter expert (SME) for UART communications. Nathan will be in charge of the Rx circuit and be the SME for coding using the MSP430. Forrest will be in charge of testing / evaluating.

10. If you have any questions, comments, or concerns, please feel free to contact us at:

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