MIDDLE EAST TECHNICAL UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE 493-DESIGN STUDIO 1

WEEKLY REPORT VI

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1.SUMMARY OF THIS WEEK'S PROGRESS

This week, components listed below are ordered:

- Raspberry Pi 3
- Arduino Bluetooth Robot Car Kit

Research on LED driver circuit and the utilization of lenses was conducted.

2. RESEARCH ON LED DRIVER CIRCUIT

In the solution of the problem, Revolusys plans to place a Raspberry Pi 3a at the transmitter and receiver terminals. After a photo (data) is uploaded to system as the input, this data will be processed; it will divide into data packets and a compression algorithm will be applied. The resultant data will be modulated and a signal will be produced as one output of Raspberry Pi 3a. At this stage, a driving circuitry will be placed between this output and the corresponding led. A similar circuitry will be necessary at the transmitter part placed on the moving vehicle.

The I-V characteristic of LED is similar to that of normal diode, except that it has steeper slope of If (forward current) vs Vf (forward voltage)in the high current region. As an example to this characteristic, If vs Vf graph of 334-15/T1C1-4WYA 5 mm Round White LED is given in Figure 1.

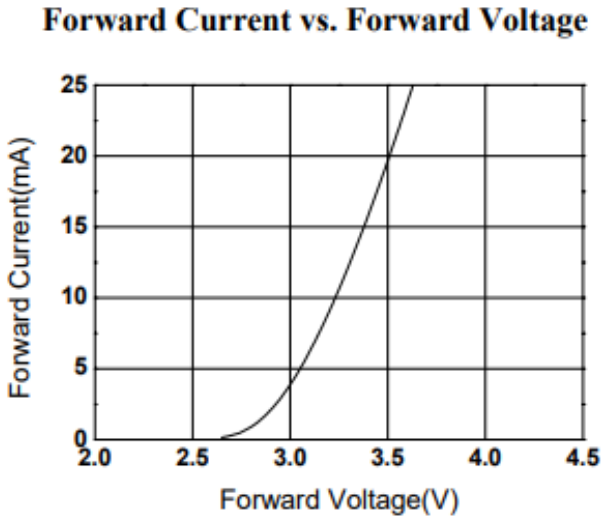

Figure 1: If vs V_f graph of a LED [1]

Since the light intensity of LED varies with forward current, LED circuitry should be designed to be driven by controlled current source rather than controlled voltage source. With

the advancement in semiconductor technology, various suppliers produce constant current LED driver with high output current accuracy.

While designing the driving circuitry for led, it is necessary to provide a current limitation. There are several current limiting methods. These methods along with their advantages and disadvantages are summarized in Table 1.

Table 1: Current limiting methods, their advantages and disadvantages [2]

Current Limiting Method	Advantage	Disadvantage
Resistor (most common in existing automotive circuit design)	• Easy to design. • Inexpensive.	• It cannot control current accurately. • Current varies to some extent with supply voltage. • High power dissipation in the resistor especially on high power LED.
Linear Current Regulator	• Allow dimming through current control. • Linear control-loop circuitry accurately controlled the LED current.	• More expensive than simple resistive current limiter. • High power dissipation. • Might require heat sink for active pass device.
Switching Regulator Control	• Efficient operation over wide range of input voltage. • Able to regulate LED current precisely. • Allow dimming by PWM. • Lower power dissipation.	• More complex design. • More expensive compare to linear current supply. • Need to design for electromagnetic compatibility.

Examples to usage of resistor and usage of linear current regulator are seen in Figure 2(a) and Figure 2(b). Here, in the circuitry seen in Figure 2(b), linear current regulator NUD4001 produced by On Semiconductor is used.

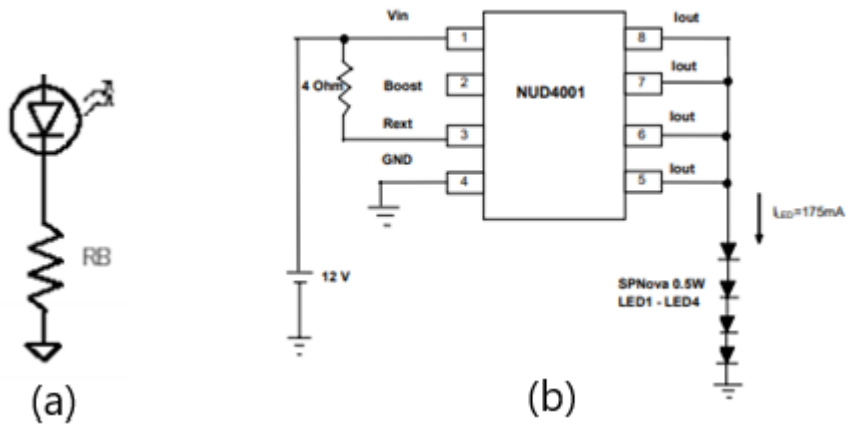

Figure 2: Examples to a resistor (a) and a linear current regulator (b) as current limiting method [2]

There are different switching LED current control drivers with various functionalities and current matching/regulation. While choosing the switching power supply LED current control driver for a design, supply input voltage level versus the output LED load voltage level should be considered. In general, there are 3 types of topologies for switching power supply: buck regulator, boost regulator and buck/boost regulator.

Buck regulator can function if the input voltage always exceeds the sum of the maximum forward voltages in an array of multiple LEDs. It can reduce the output voltage to a lower level to minimize power loss. [2] In Figure 3, a led driving circuitry utilizing LM3402 (0.5A Constant Current Buck Regulator for High Power LED Drivers, Texas Instruments) is seen.

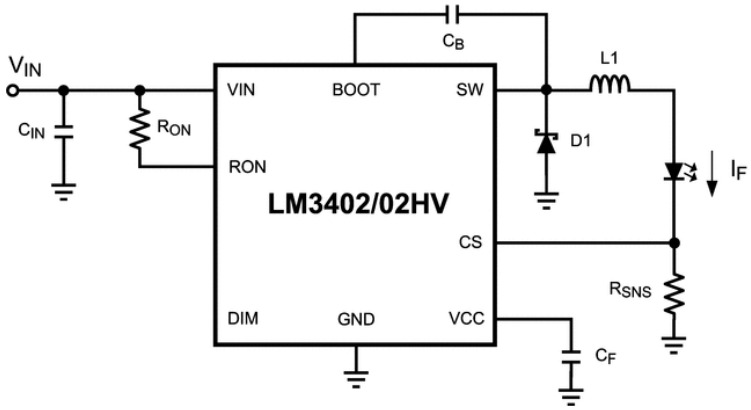

Figure 3: Example to a buck regulator as current limiting method [3]

When the sum of the entire forward voltages drop in an array of LEDs always exceeds the maximum input voltage, a boost regulator is needed to amplify the output voltage to the required range to drive the LED network. [2] In Figure 4, a led driving circuitry utilizing LT3466 (Dual Full Function White LED Step-Up Converter with Built-In Schottky Diodes, Linear Technology) is seen.

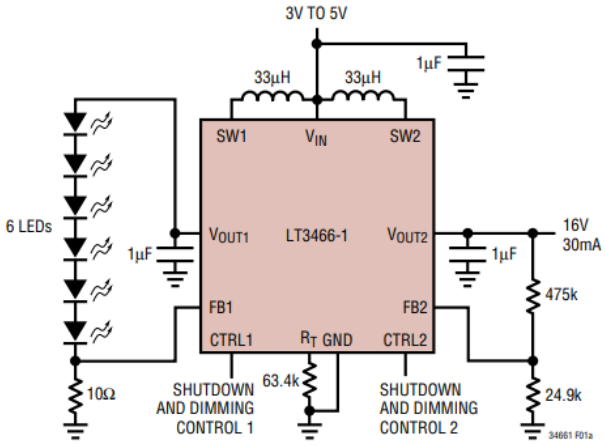

Figure 4: Example to a boost regulator as current limiting method [4]

When the input voltage may swing above or below the sum of all the forward voltage drop in an array of LEDs, then a buck/boost regulator should be use to drive the LED network. [2] In Figure 5, a led driving circuitry utilizing LT3466 (High Efficiency Torch/Flash LED driver, Linear Technology) is seen.

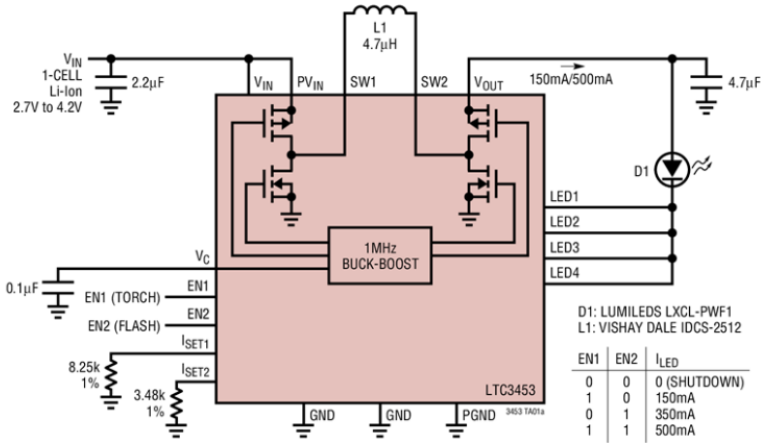

Figure 5: Example to a buck/boost regulator as current limiting method [5]

For the visible light communication applications, switching type LED driver is a general structure. It has high efficiency and potential in lighting market. The conventional structure to regulate the current of LED is floating buck converter with peak current mode control, which seen in Figure 6. This structure also has pulse width modulation (PWM) circuit to process illumination dimming. [6]

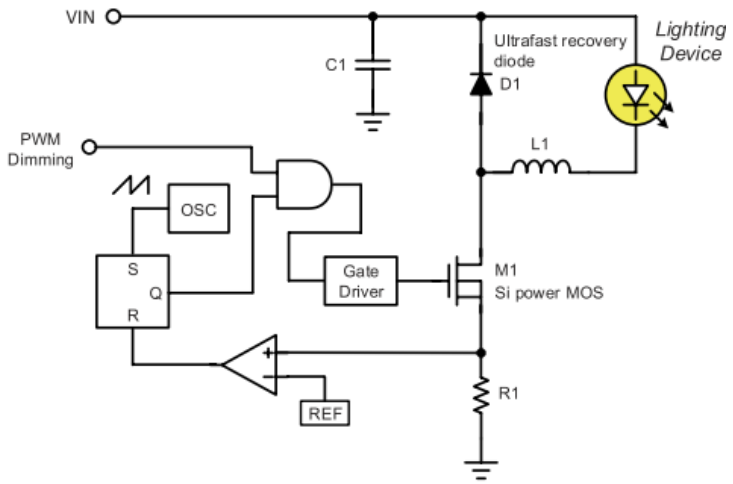

Figure 6: The conventional structure to regulate the current of LED in VLC systems [6]

Although there are mentioned advantages of switching type LED driver, it has a limitation for the transmission speed at the VLC application. This limitation is due to limited switching speed of traditional silicon power device and its significant switching loss. In practice, frequency is usually lower then several hundreds of kHz. In addition to this, there will be current and voltage ripples at the low switching frequencies thus an energy storing passive element is required to be utilized. A large passive device brings about the lower resonance

frequency. Furthermore, the loop bandwidth is usually lower than 10% of switching frequency for stability, which limits the maximum data rate of switching type LED driver to several tens of kb/s. [6]

Lee et al. (2016) proposed the LED driving circuitry seen in Figure 7 to solve the problems mentioned above. To solve the problem of low data rate, the GaN power device is utilized to replace the traditional silicon power device. By exploiting the high switching speed and low switching loss features of GaN, the proposed driving circuit with 10MHz switching frequency is achieved, and available bandwidth for data transmission is increased as well. The maximum of data rate is up to 1Mb/s. [6]

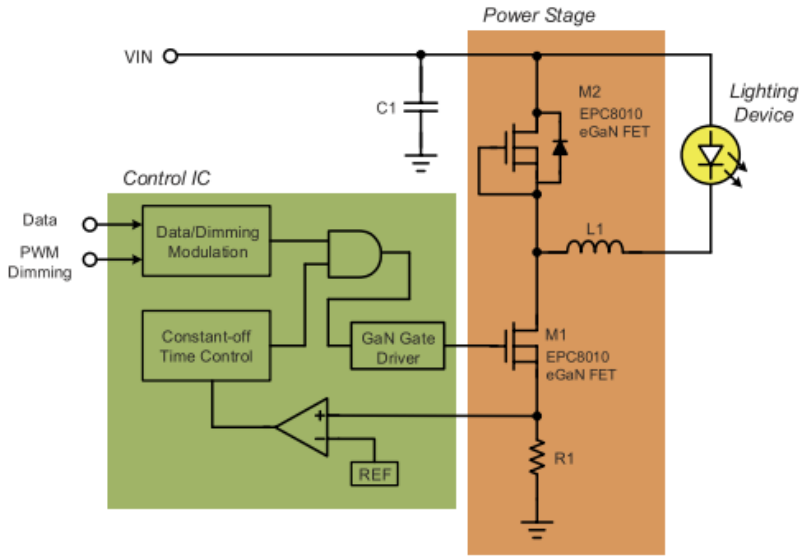

Figure 7: Proposed solution of Lee et al. for the problem arises at the conventional structure to regulate the current of LED in VLC systems [6]

3. UTILIZATION OF LENSES FOR LED TRANSMISSION

At the proposed solution of Revolutionary Systems Inc., it is planned to use 4 LEDs at the transmitter terminal. For very high speed visible light communication, parallel light beams generated via lens between intended transceiver pairs are preferable. To assure the low cross-talk between the transceiver pairs, an optical lens design is required to separate the signals emitted from the transmitting LEDs. [7] The drawback of usage of a lens is decrease at the intensity transmitted to the receiver part. [8]

There are many commercial lens models from different manufacturers. Although, Revolusys can design and produce its own lens, this process would take time and money, which are limited due to nature of the project.

4.CONCLUSION

This week the group members made researches on the electronic part circuitry of the VLC. We are ready to construct the vehicle sub-module since we got the delivery. The next phase of the research is the image compression on Raspberry Pi.

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