# First Presentation

Department of Mechanical Engineering
RGB Flow Sensor Team
Gavynn Breed
Ryan Schuster
Yixiang Zhang
Hengling Zhu

# Project Description

Figure 1: Dr. Dou

- The client is Dr. Dou of the NAU Mechanical Engineering Department.
- The goal is to create an array of high powered LEDs that cover the spectrum of visible light to aid in flow visualization.
- The project is meant to aid our client in setting up his laboratory.

# Background

- Light source for use in flow cytometry.
- LEDs represent a cost effective alternative to lasers
- A spectrum of color helps with analysis of different fluids and particles

Figure 2: LED Lens

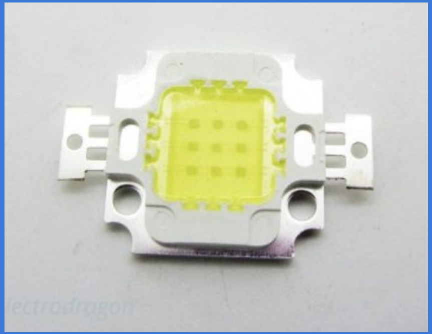


Figure 3: LED Chip

Figure 4: Combined LED

# Benchmarking

- Examples of LED arrays already exist on the market, however they lack the ability to have multiple wavelengths of light.
- Single LED emitters are also used for cytometry to create a single plane of light.
- Traditionally lasers are used, however their cost is prohibitive.


Figure 5: Blue LED Array

Figure 6: Single LED Emitter

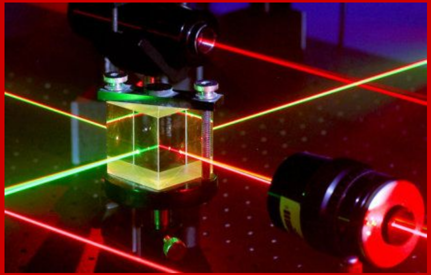


Figure 7: Lasers

Hengling, 9/14/21, RGB Flow Sensor Team, 21F11

# Literature Review (Gavynn Breed)

1. J. Menser, F. Schneider, T. Dreier, and S. A. Kaiser, “Multi-pulse SHADOWGRAPHIC rgb illumination and detection for flow tracking,”[1]
- This article has many explanations about LED usage with flow, including the size of the LED’s for collating particles.
2. B. Stasicki, A. Schröder, F. Boden, and K. Ludwikowski, “High-power led light sources for optical measurement systems operated in continuous and overdriven pulsed modes,” [2]
- This second article describes high power LEDs and the amount of power can be driven to them without causing damage to the system
3. D. Carreres-Prieto, J. T. García, F. Cerdán-Cartagena, and J. Suardiaz-Muro, “Performing calibration of Transmittance by single RGB-LED within the visible spectrum,” [3]
- This article also describes many different aspects of LEDs such as operating power and lengths that the light is visible at.

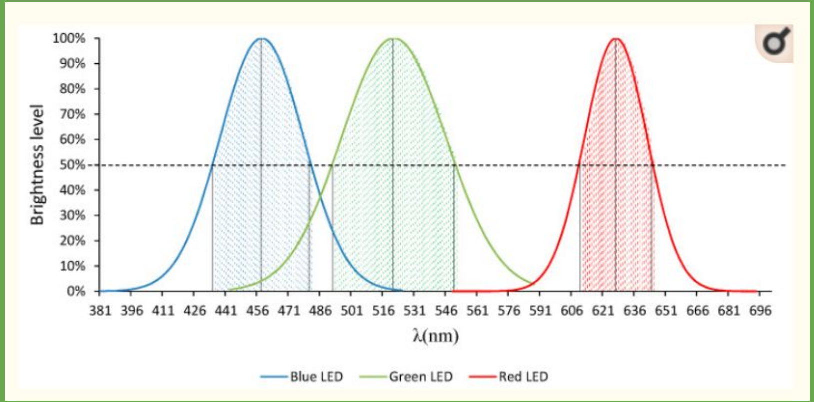



Figure 8: Wavelength Vs. Visibility

# Literature Review (Ryan Schuster)

"Electric Circuits" by Nelson, Riedel.[4]

- Textbook on electrical circuits to help understanding with their design

"Pulsed operation of high-power light emitting diodes for imaging flow velocimetry" by willert et al. [5]

"Characterization and Evaluation of PIV Illumination System Using High Power Light Emitting Diodes for Water Tank Applications" by Chuin et al. [6]

- Example circuits

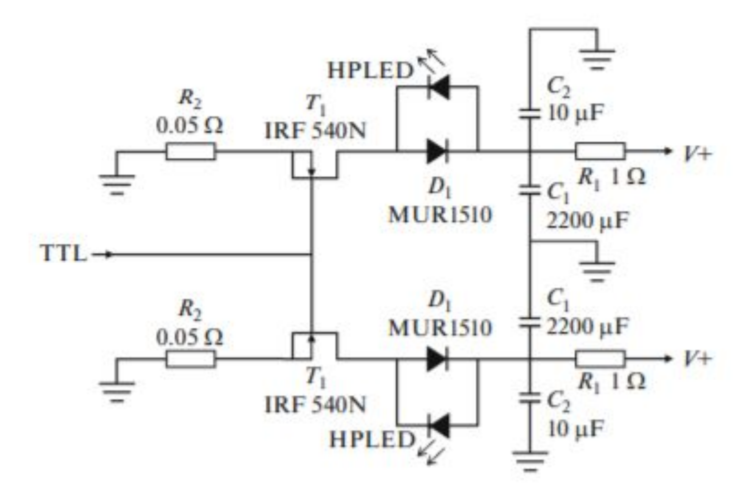



Figure 9: hpLED circuit [5]

# Literature Review (Yixiang Zhang)

"What is Transistor Transistor Logic (TTL) & Its Working"[7]

- the transistor performs two functions like logic as well as amplifying

"TTL (Transistor-Transistor Logic) Applications, Advantages"[8]

- Used for switch(ON/OFF)
- Used for trigger delay
- Used for energy control

"Designing with TTL Integrated Circuits"[9]

- Example circuit

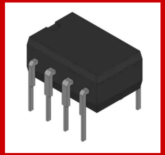


Figure 10: TTL Chip

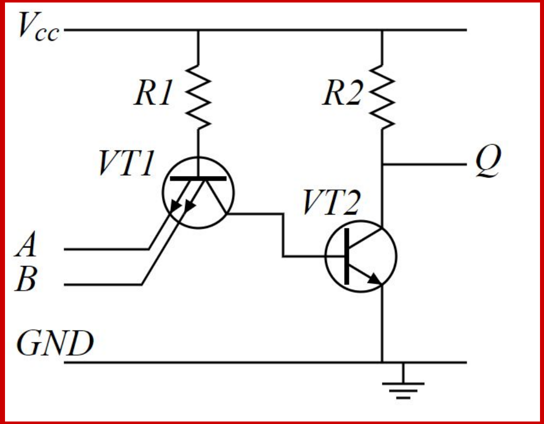



Figure 11: TTL circuit example [9]

# Literature Review (Hengling Zhu)

“Thermal Analysis of LED Arrays for Automotive Headlamp With a Novel Cooling System” [10]

“A Microjet Array Cooling System for Thermal Management of High-Brightness LEDs” [11]

“Structural optimization of a microjet based cooling system for high power LEDs” [12]

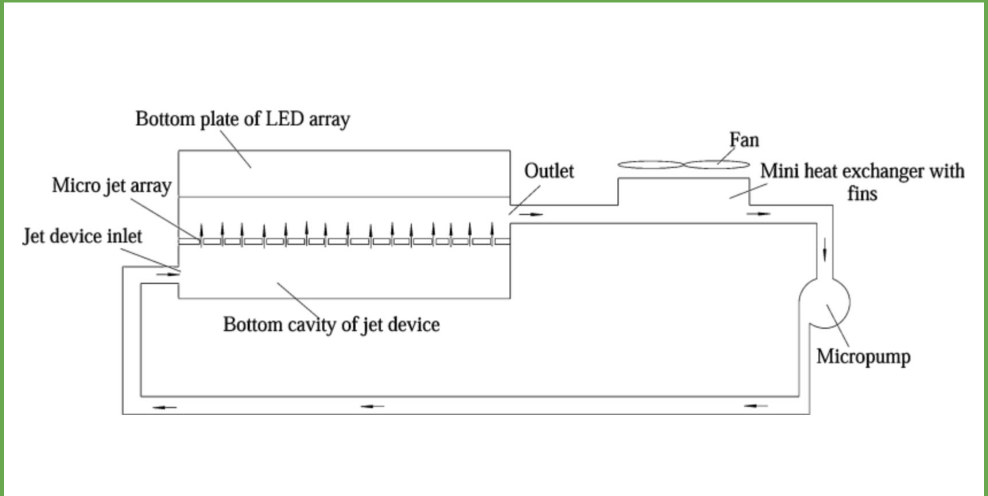



Figure 12: Example cooling system [10]

| |
|---|
| Pulse Width (us) |
| Frequency (KHz) |
| Energy Per Pulse Per Channel (mJ) |
| Trigger Delay(ns) |
| Trigger Jitter (ns) |
| Output Delay(ns) |
| Output Jitter(ns) |
| Light Wavelength (nm) |
| Temperature(degree C) |
| LED Life Span (hr) |

Figure 13: Engineering Requirements

# Customer and Engineering Requirements

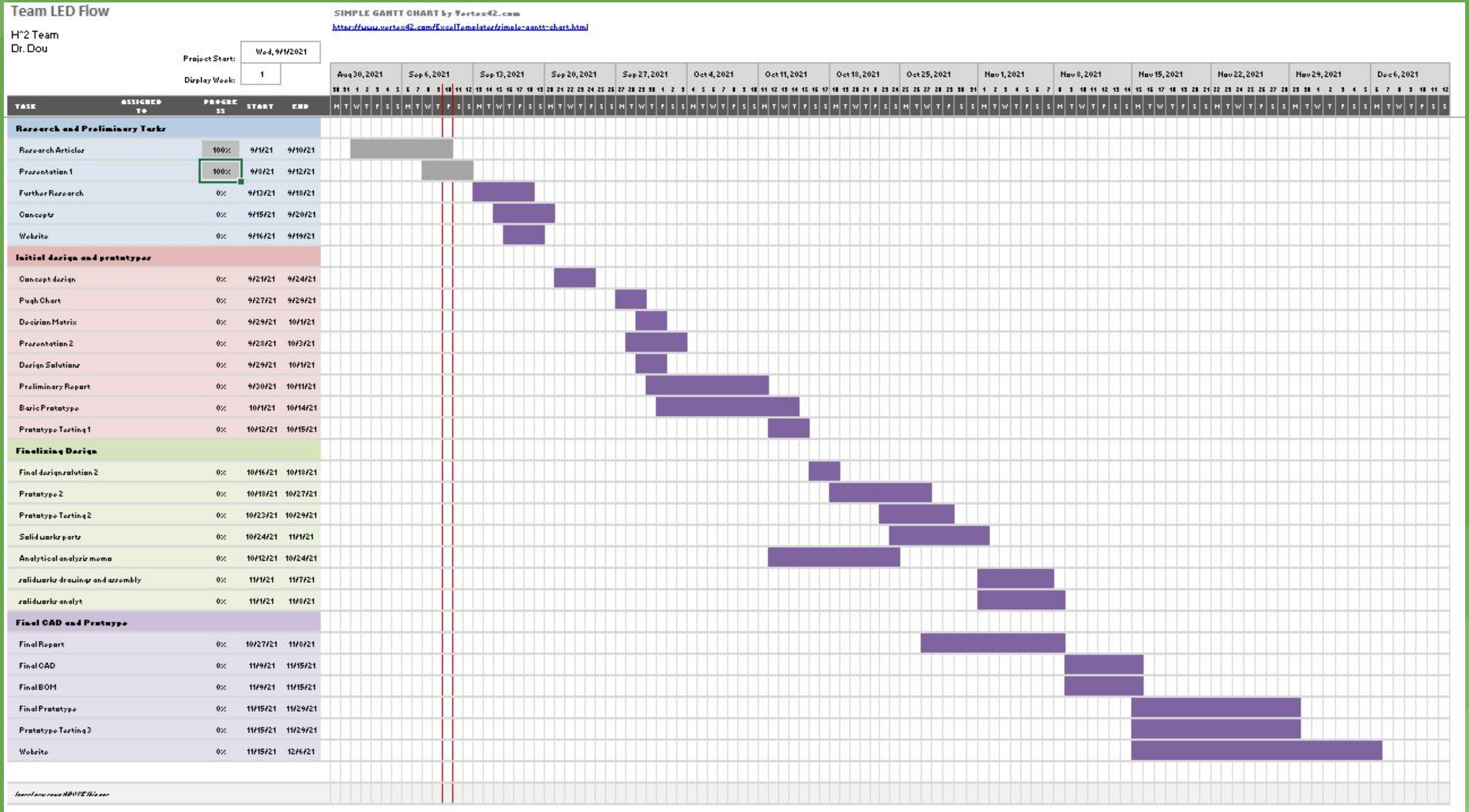
- Most of the Engineering Requirements were given by our client, Dr Dou.
- Customer Requirements were derived from these requirements.
- Temperature, and lifespan are a result of adding a focus on reliability and durability.

| Customer Requirement | Customer Weights | Pulse Width (us) | Frequency (KHz) | Energy Per Pulse Per Channel (mJ) | Trigger Delay(ns) | Trigger Jitter (ns) | Output Delay(ns) | Output Jitter(ns) | Light Wavelength (nm) | Temperature(degree C) | LED Life Span (hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. High Frequency | 4 | 3 | 9 | | | | | | | 3 | 1 |
| 2. Short Pulses | 4 | 9 | 3 | | | | | | | 3 | 1 |
| 3. Adjustable intensity | 5 | 9 | 9 | 9 | | | | | | 3 | 1 |
| 4. Reliability | 3 | 1 | 1 | 1 | 9 | 9 | 9 | 9 | | 9 | 9 |
| 5. Durability | 3 | 1 | 1 | 1 | | | | | | 9 | 9 |
| 6. Adjustable Color | 5 | | | 3 | | | | | 9 | | |
| 7. Minimal jitter and Delay | 3 | | | | 9 | 9 | 9 | 9 | | | |
| 8. Cost | 4 | 1 | 1 | 9 | 1 | 1 | 1 | 1 | | 9 | 9 |
| **Absolute Technical Importance (ATI)** | | 103 | 103 | 102 | 58 | 58 | 58 | 58 | 45 | 129 | 103 |
| **Relative Technical Importance (RTI)** | | 12.6% | 12.6% | 12.5% | 7.1% | 7.1% | 7.1% | 7.1% | 5.5% | 15.8% | 12.6% |
| **Target ER values** | | 0.5us | 1Hz-60KHz | 0-30mJ | 400ns | 0ns | 75ns | 0ns | 380-700 nm | 70C | 5*10^5 hrs |
| **Tolerances of Ers** | | - | - | 5mJ | 100ns | 5ns | 25ns | 5ns | - | 5C | 1*10^4 hrs |
| **Testing Procedure (TP#)** | | | | | | | | | | | |

Figure 14: House of Quality

# Customer Requirement (QFD)

# Schedule



Team LED Flow

H^2 Team
Dr. Dou

SIMPLE GANTT CHART by Vertex42.com

https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: Wed, 9/1/2021

Display Week: 1

| TASK | ASSIGNED TO | PROGRESS | START | END |
|---|---|---|---|---|
| **Research and Preliminary Tasks** | | | | |
| Research Articles | | 100% | 9/1/21 | 9/10/21 |
| Presentation 1 | | 100% | 9/8/21 | 9/12/21 |
| Further Research | | 0% | 9/13/21 | 9/18/21 |
| Concepts | | 0% | 9/15/21 | 9/20/21 |
| Website | | 0% | 9/16/21 | 9/19/21 |
| **Initial design and prototypes** | | | | |
| Concept design | | 0% | 9/21/21 | 9/24/21 |
| Pugh Chart | | 0% | 9/27/21 | 9/29/21 |
| Decision Matrix | | 0% | 9/29/21 | 10/1/21 |
| Presentation 2 | | 0% | 9/28/21 | 10/3/21 |
| Design Solutions | | 0% | 9/29/21 | 10/1/21 |
| Preliminary Report | | 0% | 9/30/21 | 10/11/21 |
| Basic Prototype | | 0% | 10/1/21 | 10/14/21 |
| Prototype Testing 1 | | 0% | 10/12/21 | 10/15/21 |
| **Finalizing Design** | | | | |
| Final design solution 2 | | 0% | 10/16/21 | 10/18/21 |
| Prototype 2 | | 0% | 10/18/21 | 10/27/21 |
| Prototype Testing 2 | | 0% | 10/23/21 | 10/29/21 |
| Solid works parts | | 0% | 10/24/21 | 11/1/21 |
| Analytical analysis memo | | 0% | 10/12/21 | 10/24/21 |
| solidworks drawings and assembly | | 0% | 11/1/21 | 11/7/21 |
| solidworks analyt | | 0% | 11/1/21 | 11/8/21 |
| **Final CAD and Prototype** | | | | |
| Final Report | | 0% | 10/27/21 | 11/8/21 |
| Final CAD | | 0% | 11/9/21 | 11/15/21 |
| Final BOM | | 0% | 11/9/21 | 11/15/21 |
| Final Prototype | | 0% | 11/15/21 | 11/29/21 |
| Prototype Testing 3 | | 0% | 11/15/21 | 11/29/21 |
| Website | | 0% | 11/15/21 | 12/6/21 |



Figure 15: Gantt Chart

# Schedule

Phase 1:

| TASK | ASSIGNED TO | PROGRESS | START | END |
|---|---|---|---|---|
| **Research and Preliminary Tasks** | | | | |
| Research Articles | | 100% | 9/1/21 | 9/10/21 |
| Presentation 1 | | 100% | 9/8/21 | 9/12/21 |
| Further Research | | 0% | 9/13/21 | 9/18/21 |
| Concepts | | 0% | 9/15/21 | 9/20/21 |
| Website | | 0% | 9/16/21 | 9/19/21 |

Figure 16: Gantt Chart Phase 1

Phase 2:

| | | | |
|---|---|---|---|
| **Initial design and prototypes** | | | |
| Concept design | 0% | 9/21/21 | 9/24/21 |
| Pugh Chart | 0% | 9/27/21 | 9/29/21 |
| Decision Matrix | 0% | 9/29/21 | 10/1/21 |
| Presentation 2 | 0% | 9/28/21 | 10/3/21 |
| Design Solutions | 0% | 9/29/21 | 10/1/21 |
| Preliminary Report | 0% | 9/30/21 | 10/11/21 |
| Basic Prototype | 0% | 10/1/21 | 10/14/21 |
| Prototype Testing 1 | 0% | 10/12/21 | 10/15/21 |

Figure 17: Gantt Chart Phase 2

# Schedule

Phase 3:

| Finalizing Design | | | |
|---|---|---|---|
| Final design solution 2 | 0% | 10/16/21 | 10/18/21 |
| Prototype 2 | 0% | 10/18/21 | 10/27/21 |
| Prototype Testing 2 | 0% | 10/23/21 | 10/29/21 |
| Solid works parts | 0% | 10/24/21 | 11/1/21 |
| Analytical analysis memo | 0% | 10/12/21 | 10/24/21 |
| solidworks drawings and assembly | 0% | 11/1/21 | 11/7/21 |
| solidworks analytic | 0% | 11/1/21 | 11/8/21 |

Figure 18: Gantt Chart Phase 3

Phase 4:

| Final CAD and Protoype | | | |
|---|---|---|---|
| Final Report | 0% | 10/27/21 | 11/8/21 |
| Final CAD | 0% | 11/9/21 | 11/15/21 |
| Final BOM | 0% | 11/9/21 | 11/15/21 |
| Final Prototype | 0% | 11/15/21 | 11/29/21 |
| Prototype Testing 3 | 0% | 11/15/21 | 11/29/21 |
| Website | 0% | 11/15/21 | 12/6/21 |

Figure 19: Gantt Chart Phase 4

# Budget

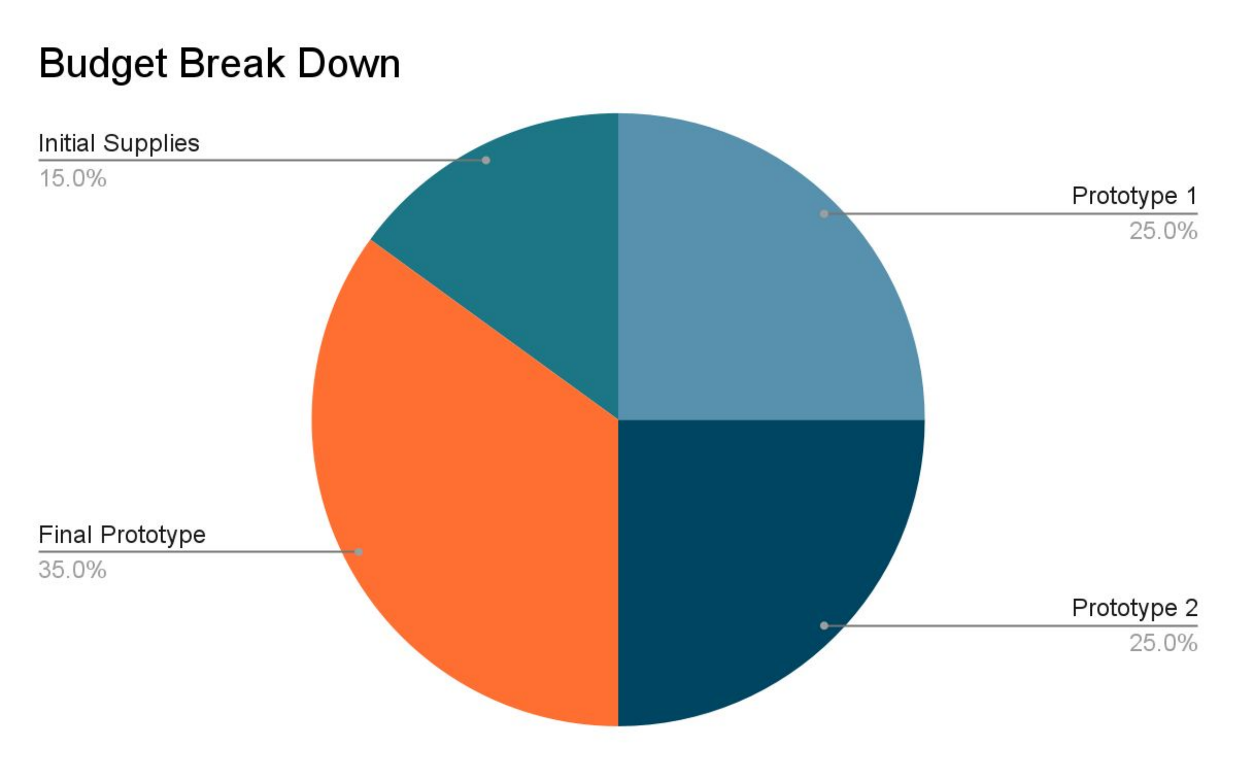



Figure 20: Budget Pie Chart

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[1] J. Menser, F. Schneider, T. Dreier, and S. A. Kaiser, “Multi-pulse SHADOWGRAPHIC rgb illumination and detection for flow tracking,” *Experiments in Fluids*, 10-May-2018. [Online]. Available: https://link.springer.com/article/10.1007/s00348-018-2541-0. [Accessed: 12-Sep-2021].

[2] B. Stasicki, A. Schröder, F. Boden, and K. Ludwikowski, “High-power led light sources for optical measurement systems operated in continuous and overdriven pulsed modes,” *SPIE Digital Library*, 26-Jun-2017. [Online]. Available: https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10329/103292J/High-power-LED-light-sources-for-optical-measurement-systems-operated/10.1117/12.2270304.full. [Accessed: 12-Sep-2021].

[3] D. Carreres-Prieto, J. T. García, F. Cerdán-Cartagena, and J. Suardiaz-Muro, “Performing calibration of Transmittance by single RGB-LED within the visible spectrum,” *MDPI*, 20-Jun-2020. [Online]. Available: https://www.mdpi.com/1424-8220/20/12/3492. [Accessed: 12-Sep-2021].

[4] J. W. Nilsson and S. A. Riedel, *Electric circuits*. Boston: Pearson, 2015.

[5] C. Willert, B. Stasicki, J. Klinner, and S. Moessner, “Pulsed operation of high-power light emitting diodes for imaging flow velocimetry,” *Measurement Science and Technology*, vol. 21, no. 7, p. 075402, 2010.

[6] L. H. Chuin, A. F. Omar, M. Z. Abdullah, and N. A. Razak, “Characterization and evaluation of PIV illumination system using high power light emitting diodes for WATERTANK APPLICATIONS,” *Instruments and Experimental Techniques*, vol. 61, no. 3, pp. 436–444, 2018.

# Reference

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[8] DO, H., WORKS, H. and Q, I., 2021. TTL (Transistor-Transistor Logic) Applications, Advantages. [online] ETechnoG - Electrical, Electronics and Technology. Available at: <https://www.etechnog.com/2019/09/ttl-transistor-transistor-logic.html> [Accessed 13 September 2021].

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[11] X. Luo and S. Liu, "A Microjet Array Cooling System for Thermal Management of High-Brightness LEDs," in *IEEE Transactions on Advanced Packaging*, vol. 30, no. 3, pp. 475-484, Aug. 2007, doi: 10.1109/TADVP.2007.898522.

[12] S. Liu, J. Yang, Z. Gan and X. Luo, "Structural optimization of a microjet based cooling system for high power LEDs", *International Journal of Thermal Sciences*, vol. 47, no. 8, pp. 1086-1095, 2008. Available: 10.1016/j.ijthermalsci.2007.09.005.

# Thank you

Question & Answer