Team RGB Flow Sensor

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Design Requirements

Table 1: Labeled Design Requirements

Customer Requirement	Engineering Requirement
CR1-Intensity	ER1-Energy per pulse
CR2-Pulses	ER2-Pulse Width
CR3-Frequency	ER3-Frequency
CR4-Durability	ER4-Temperature
CR5-Variable channels	ER5-Output Delay time
CR6-Synchronization	ER6-Lifespan

Testing Summary

Table 2: Test Summary Table

Test	Relevant Design Requirements
Test 1-Synchronization Test	CR6, ER5
Test 2-Pulses and Frequency Test	CR2,CR3,ER2,ER3
Test 3-Temperature Test	ER4
Test 4-Variable channels	CR5
Test 5-Power Test	ER1
Test 6-Over Pulsing Test	CR2, ER2

Testing Plan

Testing Procedure 1: Synchronization Test

Objective

The goal of this test is to determine how the light source will synchronize with the camera that it will be utilized with. This test will specifically determine the delay that the system will need in order for the image to be properly captured. The only equipment that will be used during the test is the device, the camera and a computer. Other than the delay which will be determined experimentally no other variables need to be isolated or calculated.

Procedure

Steps:

1. Set up the project, camera and computer so that the setup can be observed and the camera is able to capture a surface illuminated by the device.
2. Connect the device and camera to a function generator so that the input for each device is synchronized.
3. Run the camera and red color channel of the device together to collect image results.
4. Repeat step 3, adjusting the delay for the light pulse until the device and camera are synchronized.
5. Repeat steps 3 and 4 for the green, blue and white channels.
6. Record the delays for future use.

Results

The team is looking to find the optimal delay for each channel in order to synchronize the camera with the light pulse so that the image is as bright as possible. Currently there is no expected value for what this delay might be and can only be determined experimentally. The device can adjust the delay between 3 μs to 1 s which will give the team more than enough space to determine the proper delay.

Testing Plan

Testing Procedure 2: Pulses and Frequency Test

Objective

The goal of this test is to determine how fast and how short of pulses that the LED driver actually delivers to the device. This test specifically determines engineering requirements 2 and 3 as well as customer requirements 2 and 3. For this test the device with a function generator, and an oscilloscope are required. The test will determine the exact pulse width and frequency of the device by isolating the outputs of both the function generator and the LED driver with the Oscilloscope.

Procedure

Steps:

1. Set up the project along with an oscilloscope connected to the output of the LED driver as well as the input from the function generator.
2. Set the pulse width to 1 µs.
3. For pulses ranging from 1 Hz to 60 Khz analyze the input and output of the driver to determine if the driver is pulsing at the correct speed as determined by the function generator.
4. Set the function generator to 100 Hz
5. Adjust the pulse width from 1 µs to 100 µs and watch the oscilloscope to determine what the actual pulse width that the LED driver is outputting.

Results

The team is expecting that the device can operate with a minimum of 1 µs pulse width with a 1% tolerance as determined by the manufacturer. The device should also be able to operate between 1 Hz and 60 kHz due to there being no maximum frequency tolerance determined by the manufacturer and this remains above the minimum pulse width.

Testing Plan

Testing Procedure 3: Temperature Test

Objective

The goal of this test is to determine the maximum working temperature of the LED chip and the housing. Once the temperature is higher than the maximum working temperature, the LED chip could have less lifespan or performance. This test will only utilize the device, a thermocouple, an arduino and a computer. The thermocouple will be able to isolate the temperature during this test.

Procedure

Steps:

1. Set up the project and run the device for 30 seconds.
2. Calibrate the thermocouple using boiling and ice water.
3. Use the thermocouple to measure the LED chip temperature and run the temperature data acquisition device to collect the temperature data.
4. Repeat step 2 to measure the temperature inside the box.

Results

The results of this test show that the LEDs operate at a much lower temperature than originally expected, this allows the device to operate for longer periods of time. The measured temperature was shown to be 38 °C.

Testing Plan

Testing Procedure 4: Variable Channels

Objective

The goal of this test is to see if channels in the device can work independently and together. The device should meet CR5 - Variable channels. The only equipment needed for this test is the device itself.

Procedure

Steps:

1. Set up the project and make sure the drive is ready to control the device.
2. Run each color channel independently and adjust the pulse to see if that works.
3. Run 2 channels together and adjust the pulse width to see if that works.
4. Run 3 channels together and adjust the pulse width to see if that works.
5. Run all channels together and adjust the pulse width to see if that works.
6. Repeat steps 1-5 utilizing TTL input.

Results

The expected result is each channel can work independently and together with the adjustable pulse width which will allow for the overall color of the light to be adjusted.

Testing Plan

Testing Procedure 5: Power Test

Objective

The goal of this test is to determine how much power is being used by the driver during each pulse. This test will determine the energy used per pulse by the driver with expected values being between 0 and 30 mJ. The equipment needed are the device and a multimeter. The test will isolate the voltage and the current used during each pulse. These variables will be used to calculate the power per pulse as well as the energy per pulse.

Procedure

Steps:

1. Setup the device.
2. connect the multimeter between the positive output of the driver and the LEDs and set it to record current.
3. Record the results
4. Reconnect the device as normal
5. Set up the multimeter between the positive and negative terminal of the LED driver output
6. Record the voltage output during a pulse.
7. Calculate the power and energy of each pulse.

Results

$P = IV$, $P = 20 * 14 = 280$ W, $E = PT$, $E = 280 * (1*10^{-6}) = 0.28$ mJ per pulse, $E_{tot} = 80 * E = 22.4$ mJ per pulse

As can be seen from the equations above, the expected energy per pulse is well within the expected values. This will allow the device to be operated safely and the experiment will ensure what the actual value is.

Testing Plan

Testing Procedure 6: Over Pulsing test

Objective

The goal of this test is to determine the maximum current that the LEDs can withstand. This test will determine the energy used per pulse by the driver with expected values being between 0 and 30 mJ. The equipment needed are the device and a multimeter. The test will isolate the voltage and the current used during each pulse. These variables will be used to calculate the power per pulse as well as the energy per pulse.

Procedure

Steps:

1. Setup the device.
2. Connect a test setup of 3 LEDs to the driver
3. Run the LEDs at 3 A, 1% duty cycle and 1 kHz for 1 min
4. Record the Temperature
5. Repeat the test at 3.5 A and 4 A
6. Run the LEDs at 2 A, 10% duty cycle and 1 kHz for 1 min
7. Record the Temperature

Results

The results of this test showed that with a low enough duty cycle the LEDs can be over-pulsed to a much higher degree than is currently being done. It also showed that the temperature outputted by the system has a higher relation with the duty cycle as compared to the operating current.

Test4 Video

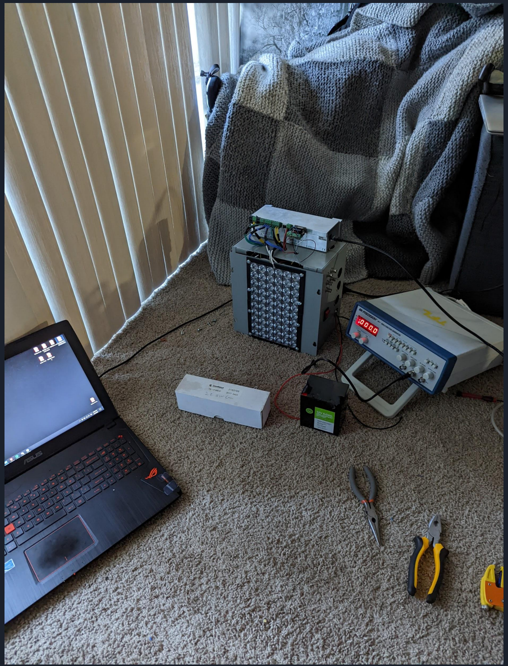

Figure 1. Test device

Test 2 Pictures

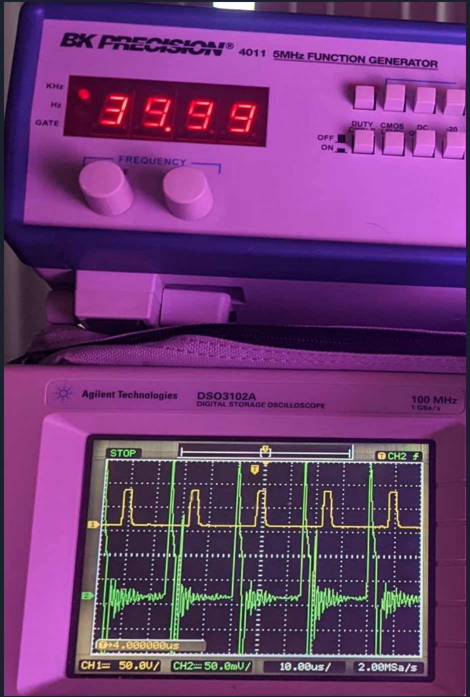

Figure 2: 40Hz

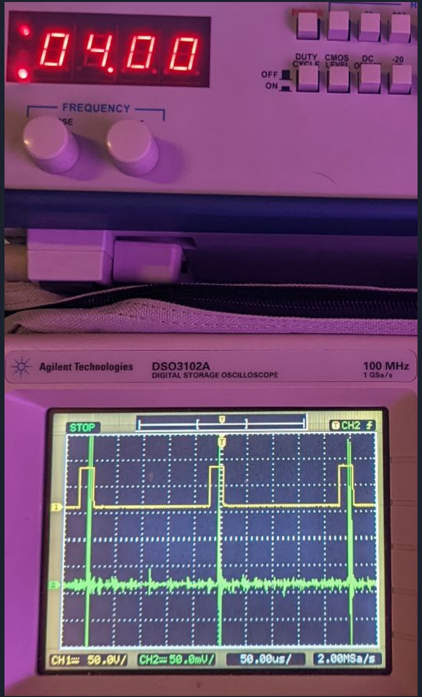

Figure 3: 4Hz

Specification Sheet

Table 3: CR Summary

Customer Requirement	CR met (Yes/No)	Client Acceptable (Yes/No)
CR1-Brightness	Yes	Yes
CR2-Short pulses	Yes	Yes
CR3-High frequency	Yes	Yes
CR5-Variable channels	Yes	Yes
CR6-Synchronization	Yes	Yes

Specification Sheet

Table 4: ER Summary

Engineering Requirement	Target	Tolerance	Measured/ Calculated value	ER met (Yes/No)	Client Acceptable (Yes/No)
ER1-Energy	30mJ per pulse	10%	21.6 mJ per pulse	No	Yes?
ER2-Pulse Width	1us	1%	1us - 300 ms and Continuous	Yes	Yes
ER3-Frequency	1Hz – 60kHz	-	1 Hz - 40 kHz	No	Yes
ER4-Temperature	65°C	Up to 75° C	38°C	Yes	Yes
ER5-Output Delay time	100ns	-	3 us - 300 ms	No	Yes

Testing Status

Table 5: Current Test Status

Test	Relevant Design Requirements	Hardware acquired (Y/N)	Completion Status
Test 1-Synchronization Test	CR6, ER5	Yes	100%
Test 2-Pulses and Frequency Test	CR2,CR3,ER2,ER3	Yes	100%
Test 3-Temperature Test	ER4	Yes	100%
Test 4-Variable channels	CR5	Yes	100%
Test 5-Power Test	ER 1	Yes	100%

QFD

House of Quality (HoQ)

Customer Requirement	**Customer Weights**	Pulse Width (us)	Frequency (KHz)	Energy Per Pulse Per Channel (mJ)	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
5. Durability	3	1	1	1				9	9
6. Adjustable Color	5			3			9		
7. Minimal jitter and Delay	3				9	9			
8. Cost	4	1	1	9	1	1		9	9
Absolute Technical Importance (ATI)		103	103	102	58	58	45	129	103
Relative Technical Importance (RTI)		14.7%	14.7%	14.6%	8.3%	8.3%	6.4%	18.4%	14.7%
Target ER values		1us	1Hz-60KHz	0-30mJ	75ns	0ns	380-700 nm	70C	5*10^5 hrs
Tolerances of Ers		1%	-	5mJ	25ns	5ns	-	5C	1*10^4 hrs
Testing Procedure (TP#)		TP2	TP2	TP5	TP1	TP1	TP4	TP3	-

DEMONSTRATION

Thank You

Are there any questions?