

# BenQ XL2740 Monitor testing

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# LCDs for Retinal Stabilization

Janis Intoy

APLAB

Updated: February 13, 2019

## Question

Can we do retinal stabilization on LCD monitors with CRT quality?

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Can we do retinal stabilization on LCD monitors with CRT quality?

- Strobing backlight (i.e. Motion Blur Reduction)
- 200 Hz
- NVIDIA G-SYNC compatability



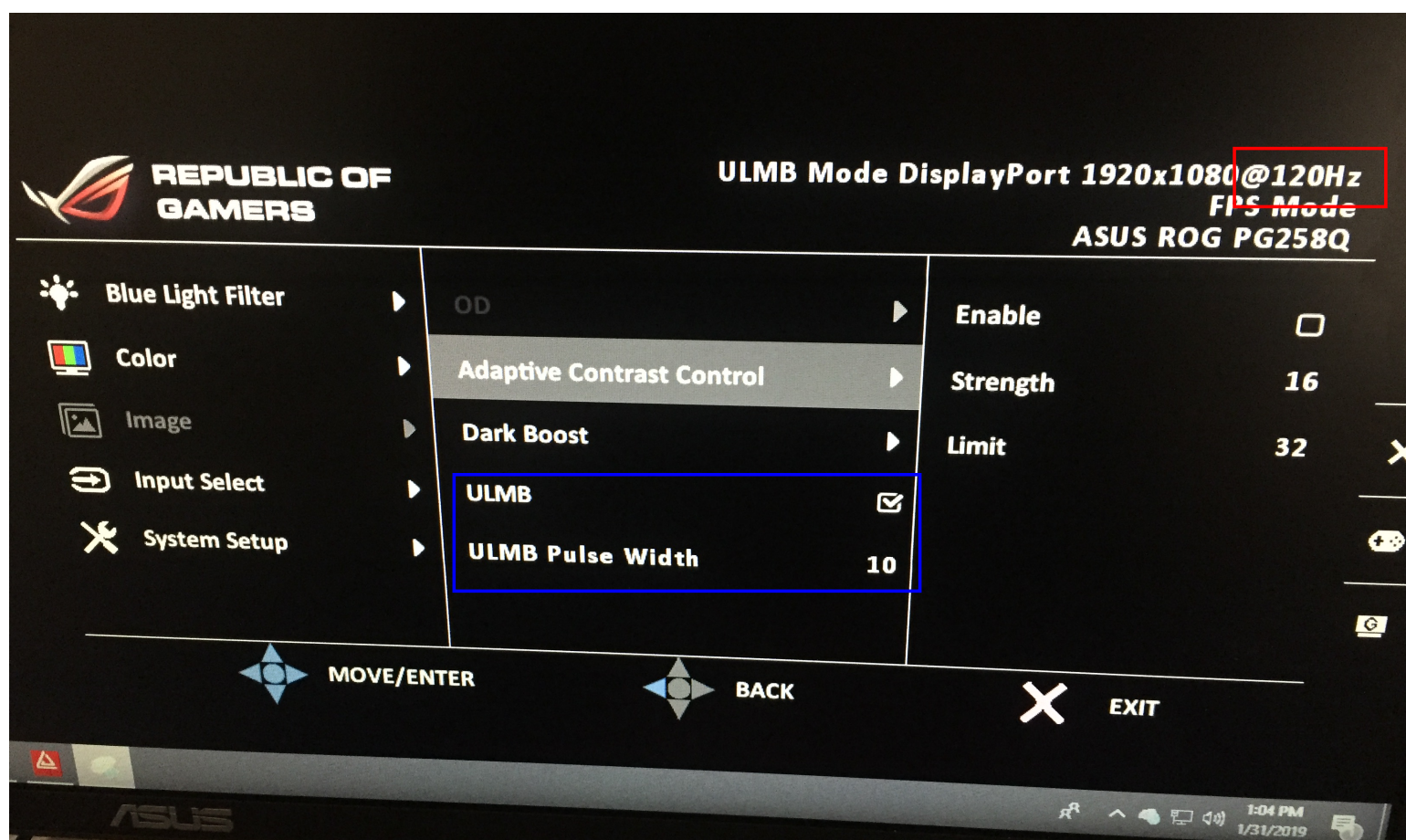
# Getting CRT quality: strobing backlight (motion blur reduction)

<https://www.blurbusters.com/faq/motion-blur-reduction/>

Several monitor manufacturers have released many brands of Motion Blur Reduction modes in recent gaming displays, with names such as:

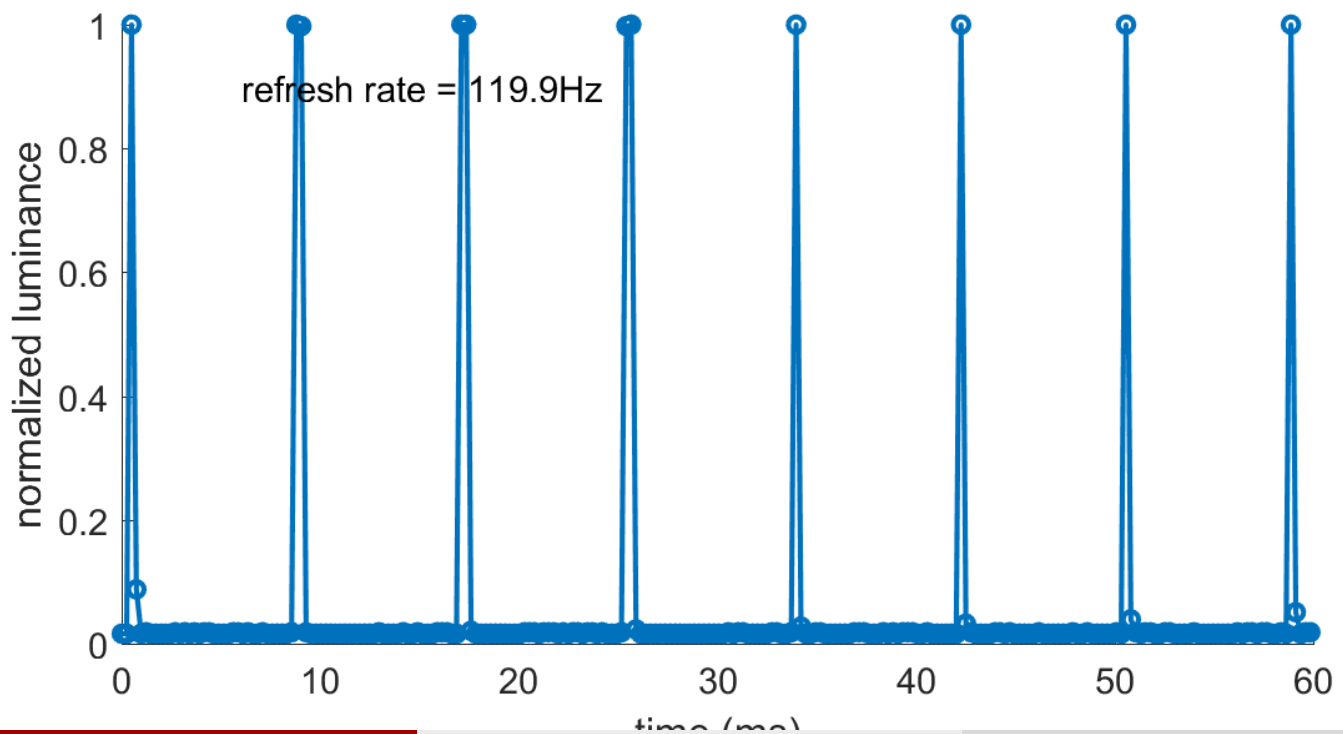
- **Motion Blur Reduction**
- **LightBoost** (by NVIDIA)
- **ULMB** - Ultra Low Motion Blur (by NVIDIA)
- **DyAc** - Dynamic Accuracy (by BenQ ZOWIE)
- **ELMB** - Extreme Low Motion Blur (by ASUS)
- **VRB** - Visual Response Boost (by Acer)
- **MotionFlow Impulse** (by Sony)
- **1ms MPRT** (by LG) — *up to 16x clearer motion than "1ms GtG"!*

## Ultra Low Motion Blur on ASUS 258 (most common monitor in lab)



## Ultra Low Motion Blur on ASUS 258 (most common monitor in lab)

Steady-state presentation of a stimulus. Note the luminance pulses in each frame. ULMB is limited to refresh rates  $< 144\text{Hz}$ .



## Alternatives?

240Hz strobing monitors exist but most are not G-Sync compatible.

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240Hz strobing monitors exist but most are not G-Sync compatible.... until about a month ago!!!

# Nvidia's latest GPU driver expands G-Sync support to FreeSync monitors

By [Paul Lilly](#) 20 days ago

**You might have to enable support manually, depending on which FreeSync monitor you own.**

[f](#) [t](#) [r](#) [e](#) | [c](#) COMMENTS

## Let's try this BenQ monitor

### ZOWIE XL2740 240Hz 27 inch e-Sports Monitor

- **G-Sync compatible** ::: <https://zowie.benq.com/en/product/monitor/xl/xl2740.html>
- **Strobing at 240 Hz** ::: (to be tested further) <https://forums.blurbusters.com/viewtopic.php?f=2&t=3803&start=10>

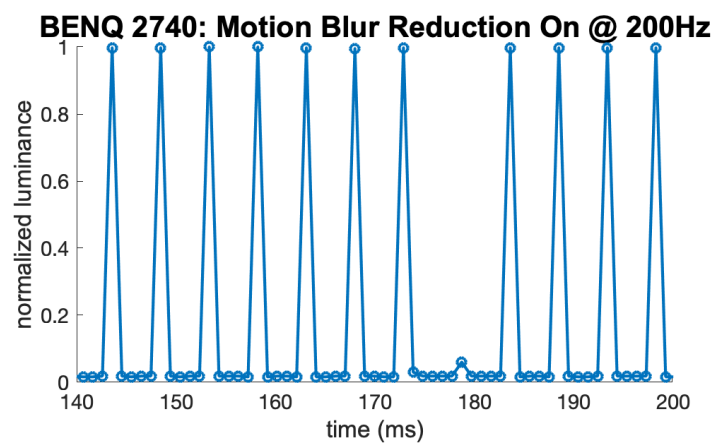
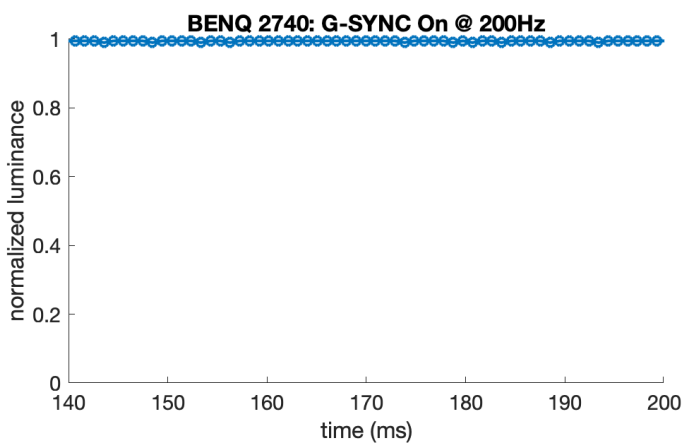
## We tried the BenQ 2740 monitor

### Summary:

- 1 This monitor does not run natively at 200Hz. This is only an issue for the the *dDPI* rig which does not allow custom refresh rates.
- 2 Motion Blur Reduction works at 200 Hz
- 3 Motion Blur Reduction and G-SYNC **cannot** be enabled at this same time. So the trade-off is:
  - We can have G-SYNC on and be sure we aren't skipping frames. This is a good option for experiments that require less precise timing and have long stimulus durations.
  - We can have MBR on at 200Hz, use the photocell to synchronize data, and check offline that frames were not skipped. This is similar to running experiments on a CRT.

## BenQ: backlight comparison

Note that we tested on the dDPI, on which EyeRIS cannot force the monitor to run at 200Hz. So, we recorded luminance dynamics on a steady screen (for now because it's quick).



**Figure:** Luminance during steady state presentation of a white screen when G-SYNC is enabled (left) and when MBR is enabled (right). Note that MBR has the desired pulsing backlight at 200Hz (1ms on, 4ms off), but occasionally misses a frame. (Here we sampled at 1024Hz - we could increase to 4096 to more precisely check how often skipped frames occur)



## 0.1 Introduction

The BenQ monitor was tested with new Photocell designed by Jeff using multiple gain settings. Gain 5 seemed to work best. Note that when Blur Reduction was ON the GSync feature was NOT ON. Even without blur reduction enabled, there was no Gsync available on the monitor.

Blur reduction is used to make the monitor mimic the function of a CRT monitor i.e. have sharp rise and fall in luminance values compared to a slower rise/fall in intensity value.

G-Sync is typically used to prevent missing frames.

The data can be found on OPUS: Monitors/BENQ/PhotoCellBenQ The refresh rate was set to 200Hz when running on the DPI and to 240Hz when running on the dDPI.

## 0.2 DPI

The data was collected using the photocell connected to a labjack when running an experiment with eye tracking on the DPI at 200Hz. The BenQ monitor had its blur reduction from the factory settings enabled. To access the factory settings: Turn off the monitor, then press and hold menu button 2 from the bottom. While holding this button, press the power button to turn the monitor on. The lights will flash, and when the monitor has turned on press button 2 once to enter the service menu. In the service menu, use button 5 (up), 4 (down) and 3 (select) to navigate the menu. 3 one-minute length data were measured for two conditions when the Blur Busters was running in the background and not.

### 0.2.1 With Blur Busters ON

Here the Blur Buster application was running in the background when collecting data with the Blur Reduction in the factory settings ON. **Fig. 1** shows the raw data.

**Fig. 2** shows the distribution of time difference between peaks and the percentage of missed frames. Missed frames were calculated based on the number of occurrences when the time difference between peaks was greater than 0.0105sec (190Hz, 'Time difference more than mean' in Fig 2 meaning signals below 190Hz) and less than 0.0095 sec (210Hz, 'Time difference less than mean' in Fig 2 meaning signals above 210Hz). **As we can see from Fig 2, the number of missed frames was about 30 percent.** In a one-minute interval about 20 trials were conducted (each trial on average having about 3 secs length) so with 30 percent missed frames around 6-7 trials out of 20 trials would have missed frames. If you see the mean time difference value (indicated with vertical line), on average the refresh rate is around 200 Hz

**Fig. 3** shows the single sided amplitude spectrum analysis of the data. The amplitude of the different signals on the y-axis are shown. The 200Hz signals has amplitude 0.58-0.68.

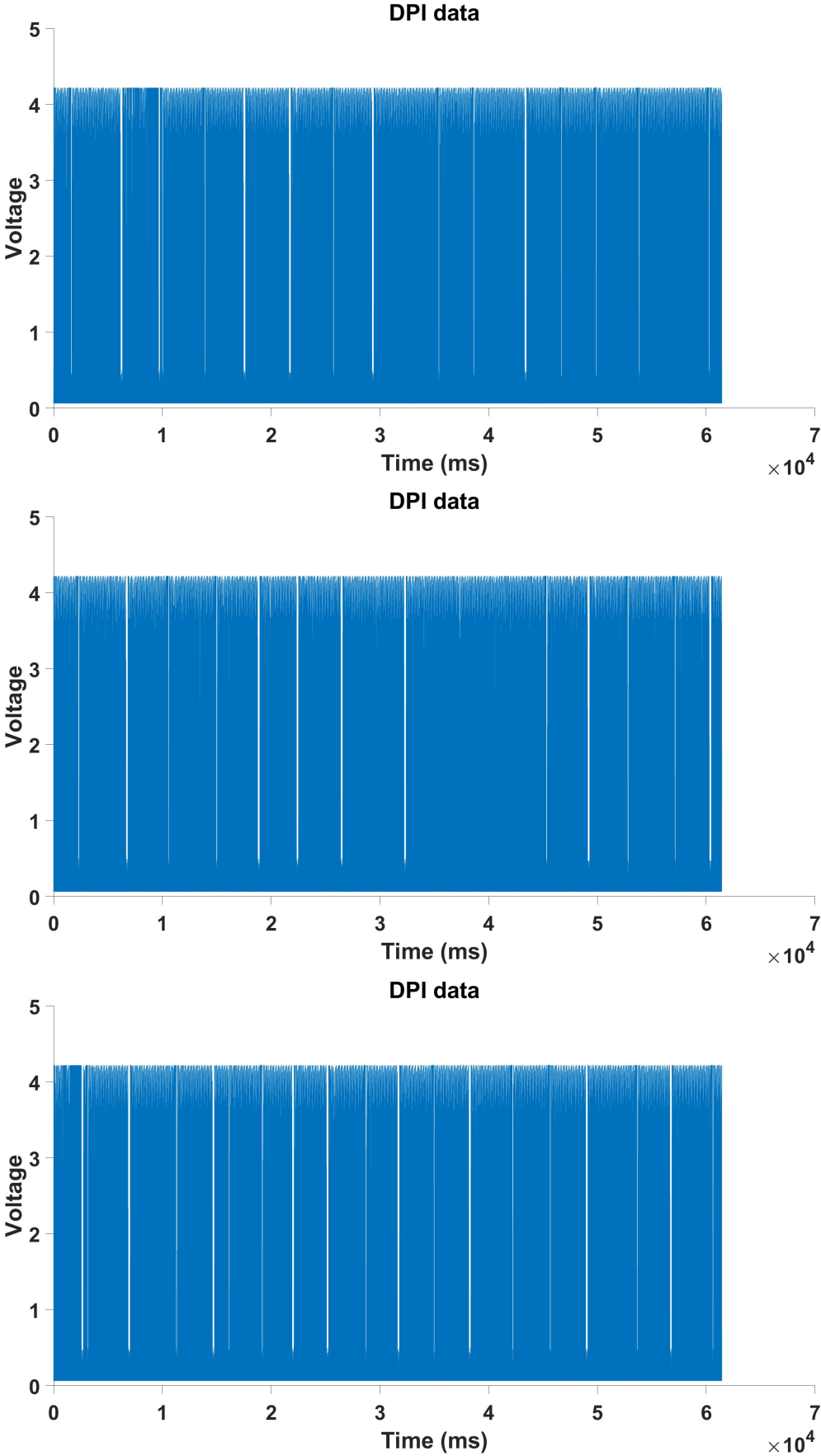


Figure 1: DPI photocell data, for the 3 one-minute long measure intervals.

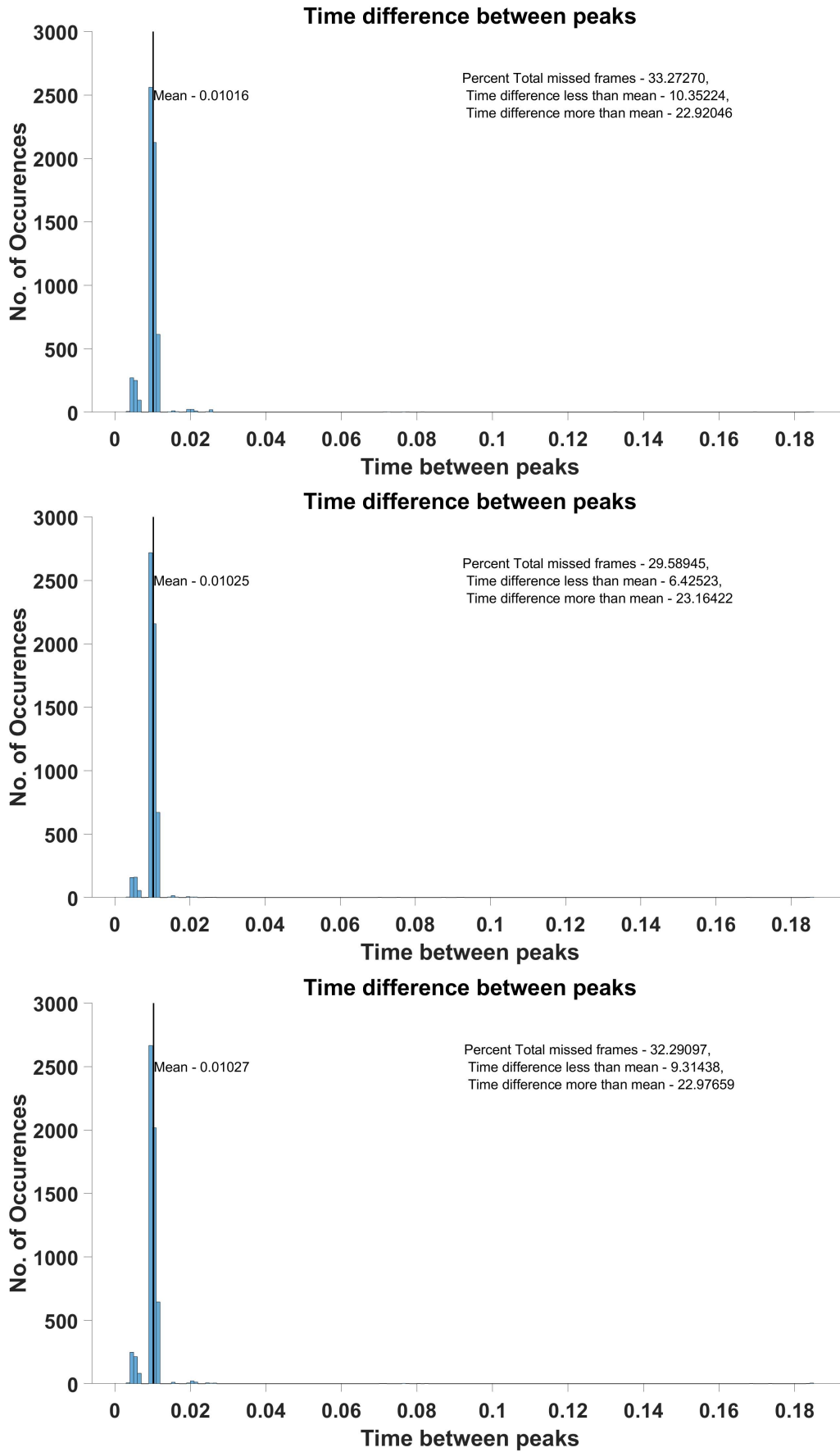


Figure 2: Distribution of time difference between peaks also showing the percentage of total missed frames and how many of them were missed having time difference less/greater than the range [190-210Hz]

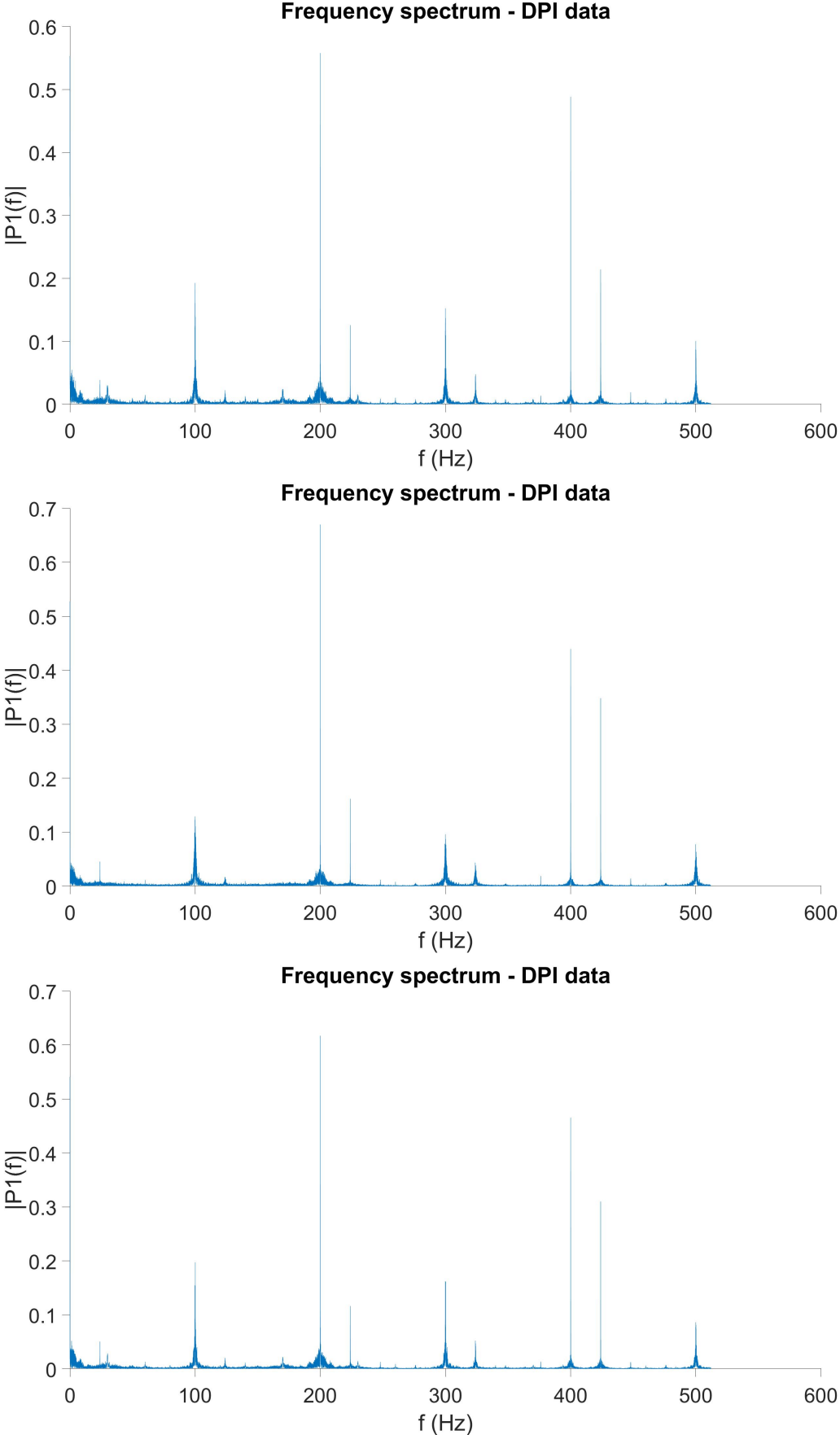


Figure 3: Single sided amplitude spectrum analysis for the data.

### 0.2.2 With Blur Busters OFF

Here the Blur Buster application was NOT running in the background when collecting data with the Blur Reduction in the factory settings ON. **Fig. 4** shows the raw data.

**Fig. 5** shows the distribution of time difference between peaks and the percentage of missed frames. Missed frames were calculated based on the number of occurrences when the time difference between peaks was greater than 0.0105sec (190Hz, 'Time difference more than mean' in Fig 5 meaning signals below 190Hz) and less than 0.0095 sec (210Hz, 'Time difference less than mean' in Fig 5 meaning signals above 210Hz). **As we can see from Fig 5, the number of missed frames was about 33 percent.** In a one-minute interval about 20 trials were conducted (each trial on average having about 3 secs length) so with 33 percent missed frames around 6-7 trials out of 20 trials would have missed frames. If you see the mean time difference value (indicated with vertical line), on average the refresh rate is around 200 Hz

**Fig. 6** shows the single sided amplitude spectrum analysis of the data. The amplitude of the different signals on the y-axis are shown. The 200Hz signals has amplitude 0.7-0.8.

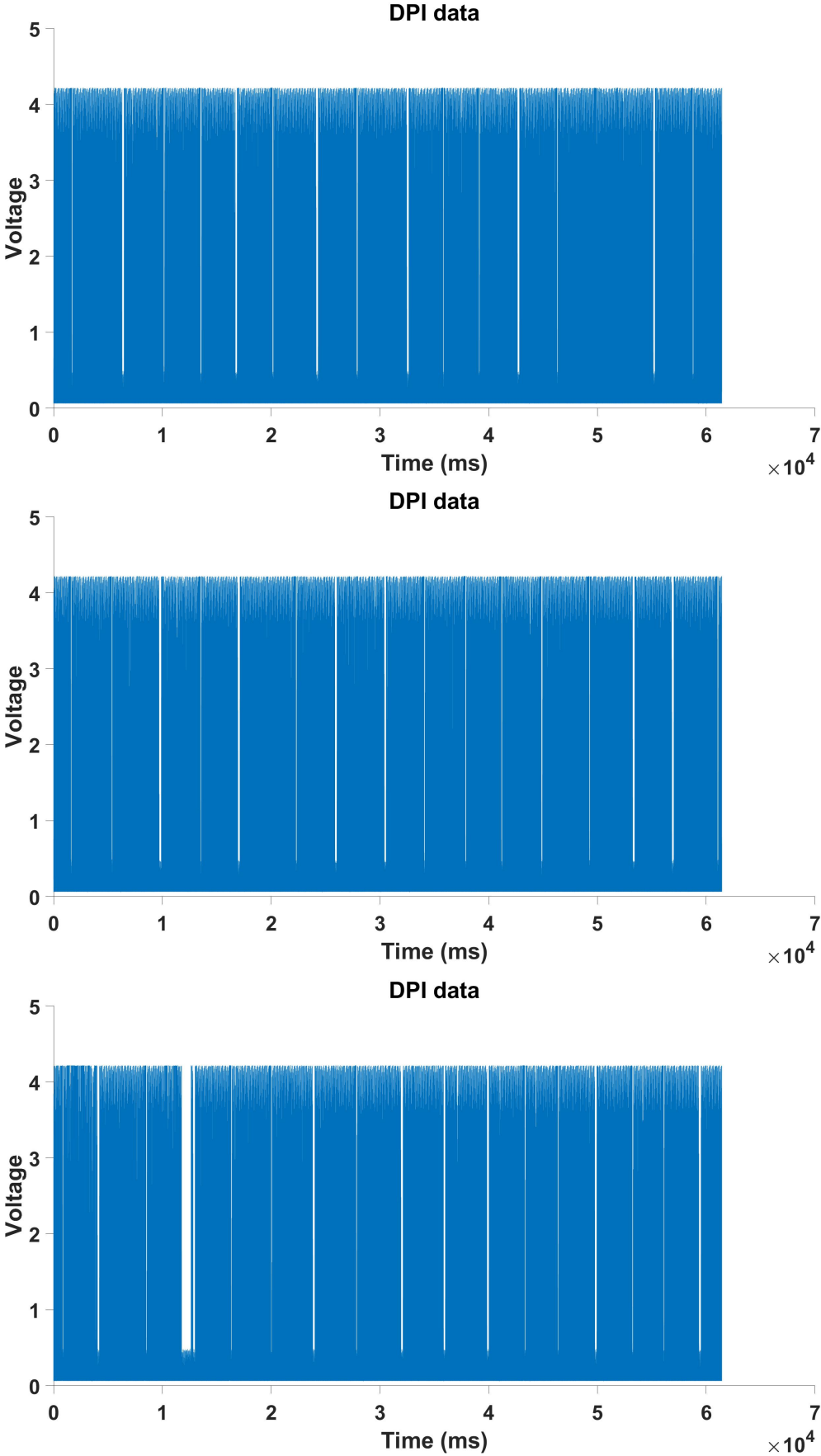


Figure 4: DPI photocell data, for the 3 one-minute long measure intervals.

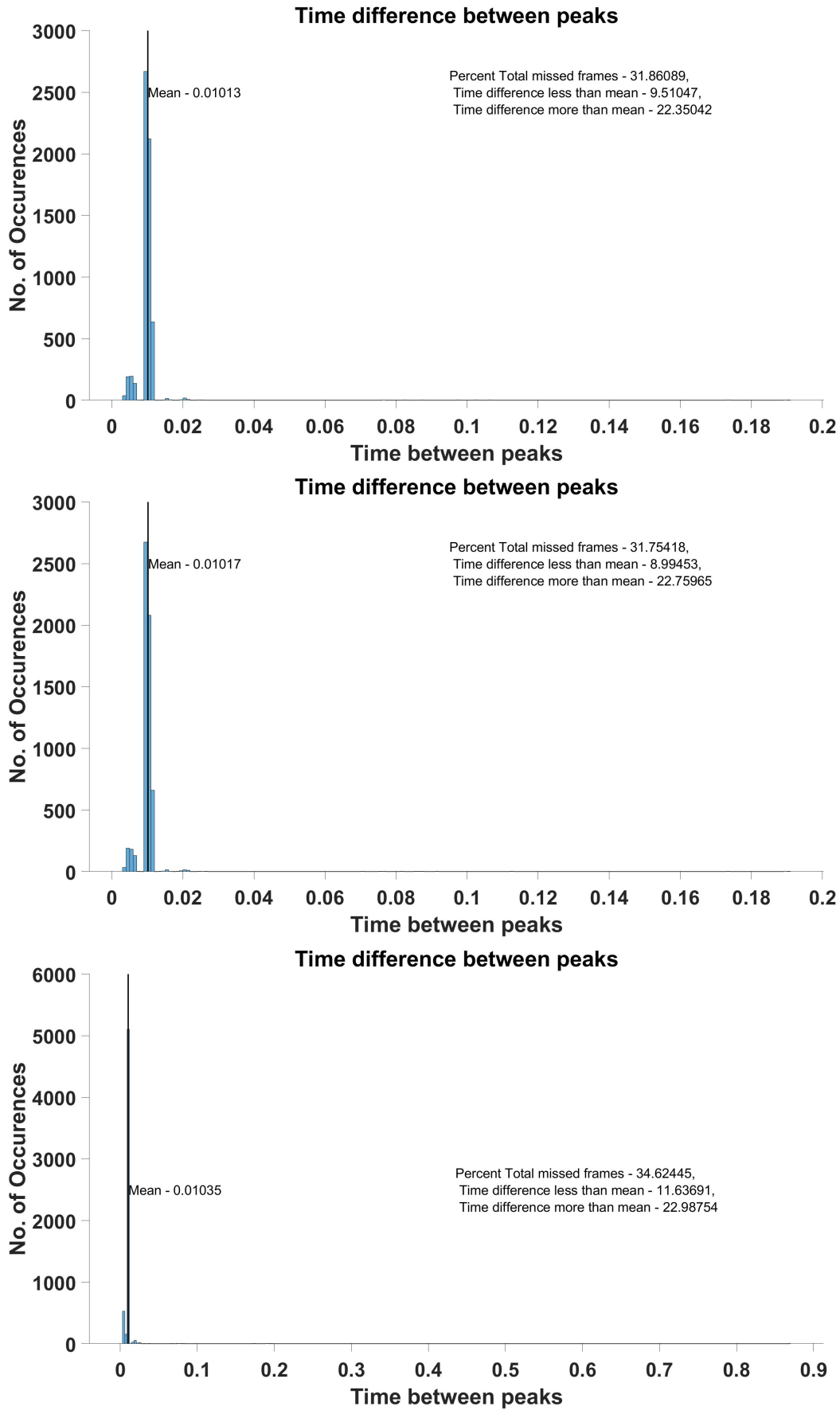


Figure 5: Distribution of time difference between peaks also showing the percentage of total missed frames and how many of them were missed having time difference less/greater than the range [190-210Hz]

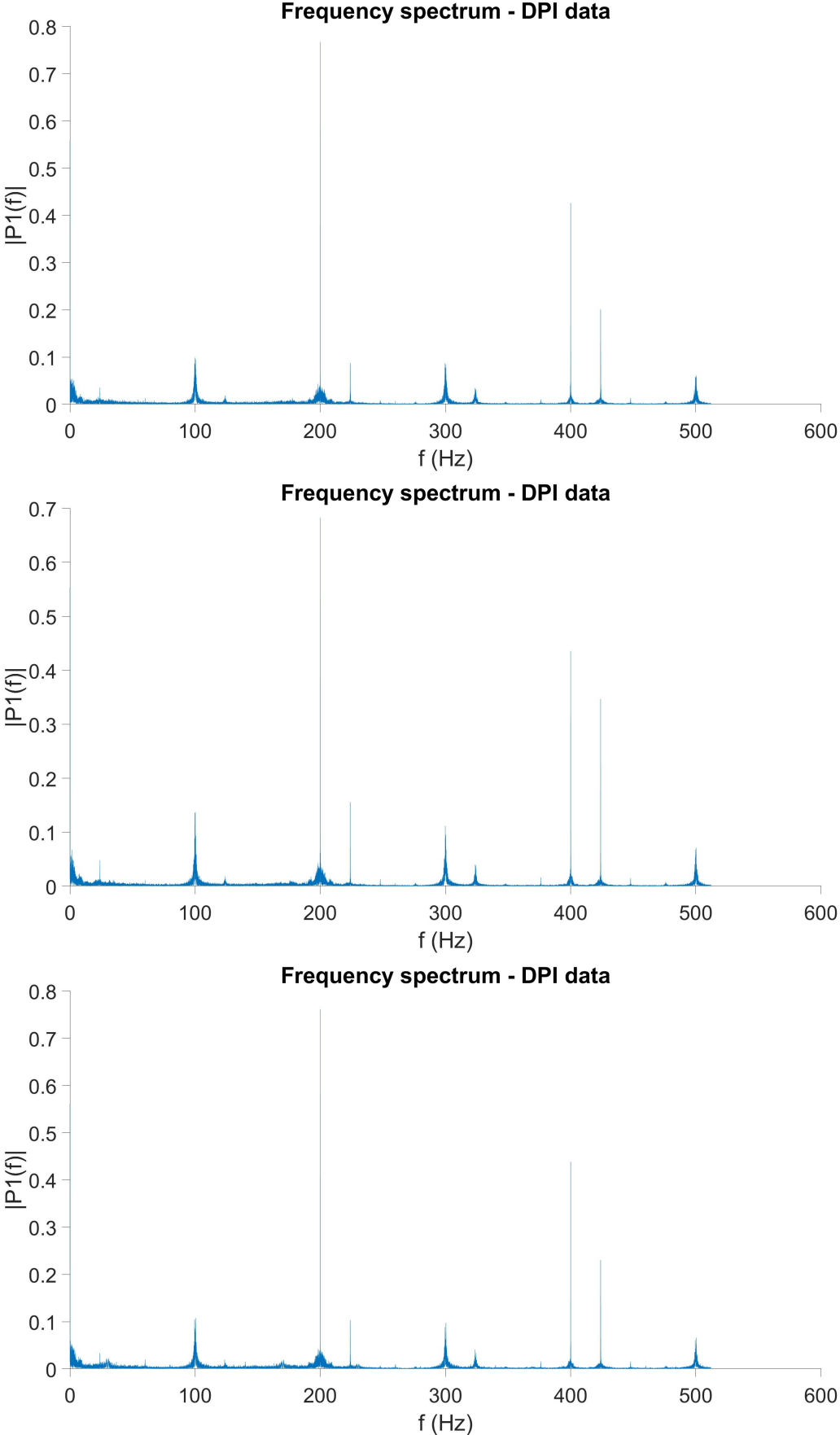


Figure 6: Single sided amplitude spectrum analysis for the data.



The difference between the data when keeping Blur Buster ON vs OFF was minimal in terms of missed frames. When Blur Buster was OFF the number of missed frames was slightly higher but the relative amplitude of the 200Hz signal was better.

### 0.3 DDPI

The data was collected using the photocell connected to a labjack when running an experiment with eye tracking on the dDPI at **240Hz**. We could not run at 200Hz because DDPI EyeRIS doesn't allow custom settings. The BenQ monitor had its blur reduction from the factory settings enabled. To access the factory settings: Turn off the monitor, then press and hold menu button 2 from the bottom. While holding this button, press the power button to turn the monitor on. The lights will flash, and when the monitor has turned on press button 2 once to enter the service menu. In the service menu, use button 5 (up), 4 (down) and 3 (select) to navigate the menu. 3 one-minute length data were measured for two conditions when the Blur Busters was running in the background and not.

#### 0.3.1 With Blur Busters ON

Here the Blur Buster application was running in the background when collecting data with the Blur Reduction in the factory settings ON. **Fig. 7** shows the raw data. NOTE that the first 10 sec of every one-minute length data was omitted to remove the effect of experimenter switching windows between Matlab and Visual Studio.

**Fig. 8** shows the distribution of time difference between peaks and the percentage of missed frames. Missed frames were calculated based on the number of occurrences when the time difference between peaks was greater than 0.0087 sec (230Hz, 'Time difference more than mean' in **Fig. 8** meaning signals below 230Hz) and less than 0.008 sec (250Hz, 'Time difference less than mean' in **Fig. 8** meaning signals above 250Hz). As we can see from **Fig. 8**, **the number of missed frames was about 85 percent. NOTE: If you see the mean time difference value (indicated with vertical line), on average the refresh rate is around 190 Hz which is much less than 240Hz, the refresh rate it was set to run at in the dDPI.**

**Fig. 9** shows the single sided amplitude spectrum analysis of the data. The amplitude of the different signals on the y-axis are shown. The 240Hz signals has amplitude 0.4-0.5.

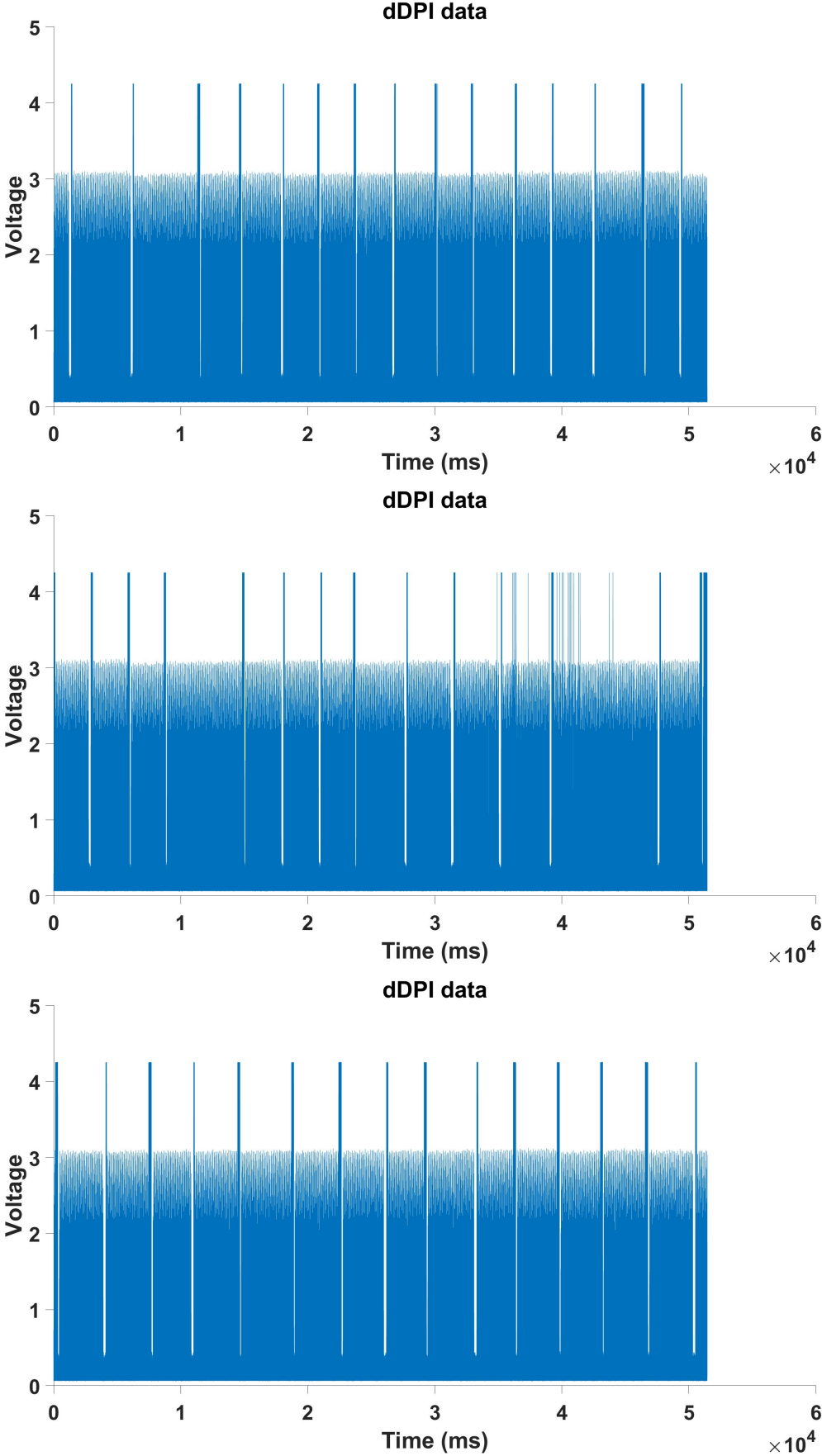


Figure 7: dDPI photocell data, for the 3 one-minute long measure intervals.

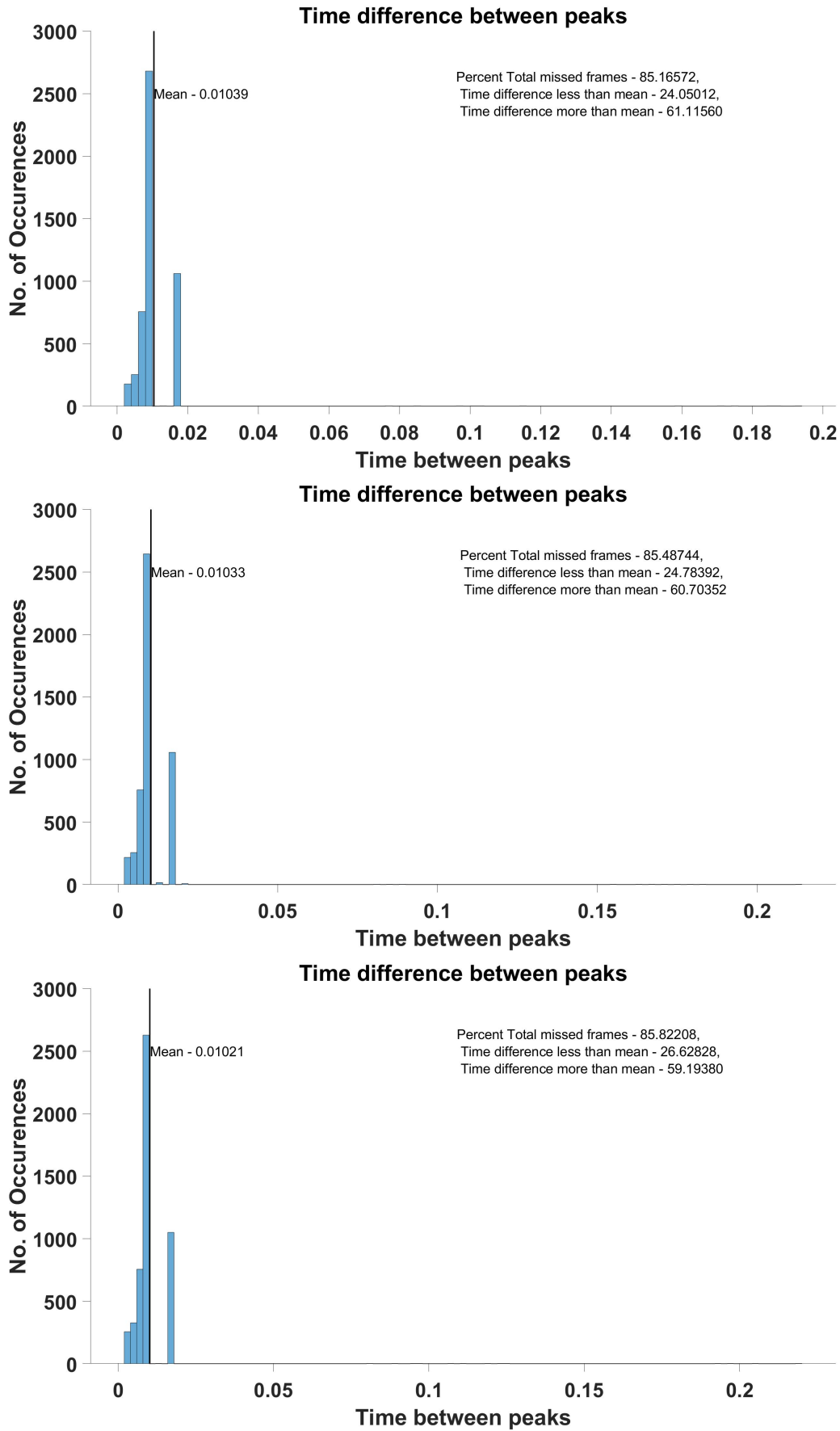


Figure 8: Distribution of time difference between peaks also showing the percentage of total missed frames and how many of them were missed having time difference less/greater than the range [230-250Hz]

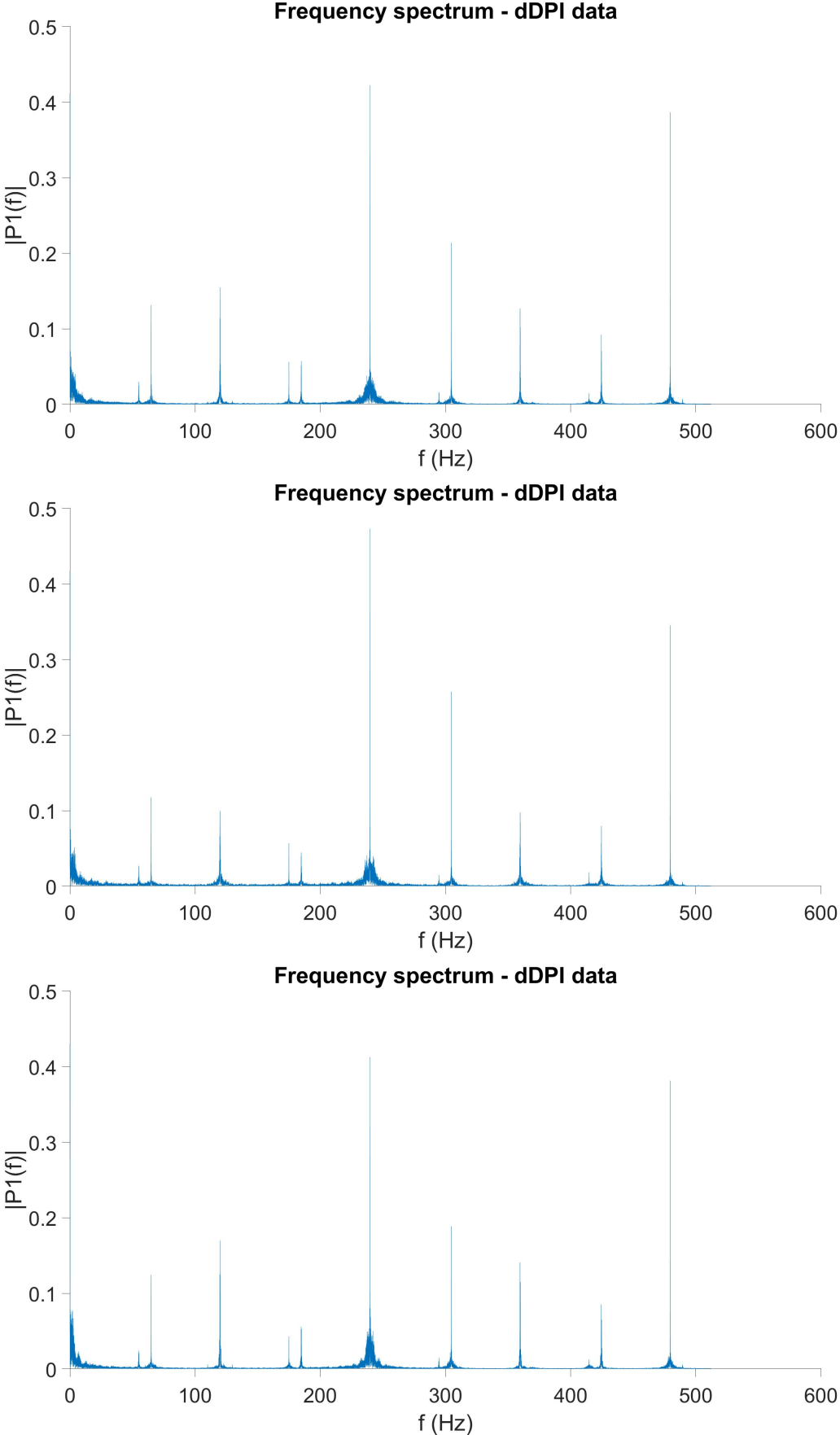


Figure 9: Single sided amplitude spectrum analysis for the data.

### 0.3.2 With Blur Busters OFF

Here the Blur Buster application was NOT running in the background when collecting data with the Blur Reduction in the factory settings ON.

**Fig. 10** shows the raw data. NOTE that the first 10 sec of every one-minute length data was omitted to remove the effect of experimenter switching windows between Matlab and Visual Studio.

**Fig. 11** shows the distribution of time difference between peaks and the percentage of missed frames. Missed frames were calculated based on the number of occurrences when the time difference between peaks was greater than 0.0087 sec (230Hz, 'Time difference more than mean' in **Fig. 11** meaning signals below 230Hz) and less than 0.008 sec (250Hz, 'Time difference less than mean' in **Fig. 11** meaning signals above 250Hz). As we can see from **Fig. 11**, the number of missed frames was about 85 percent. NOTE: If you see the mean time difference value (indicated with vertical line), on average the refresh rate is around 190 Hz which is much less than 240Hz, the refresh rate it was set to run at in the dDPI.

**Fig. 12** shows the single sided amplitude spectrum analysis of the data. The amplitude of the different signals on the y-axis are shown. The 240Hz signals has amplitude 0.4-0.5.

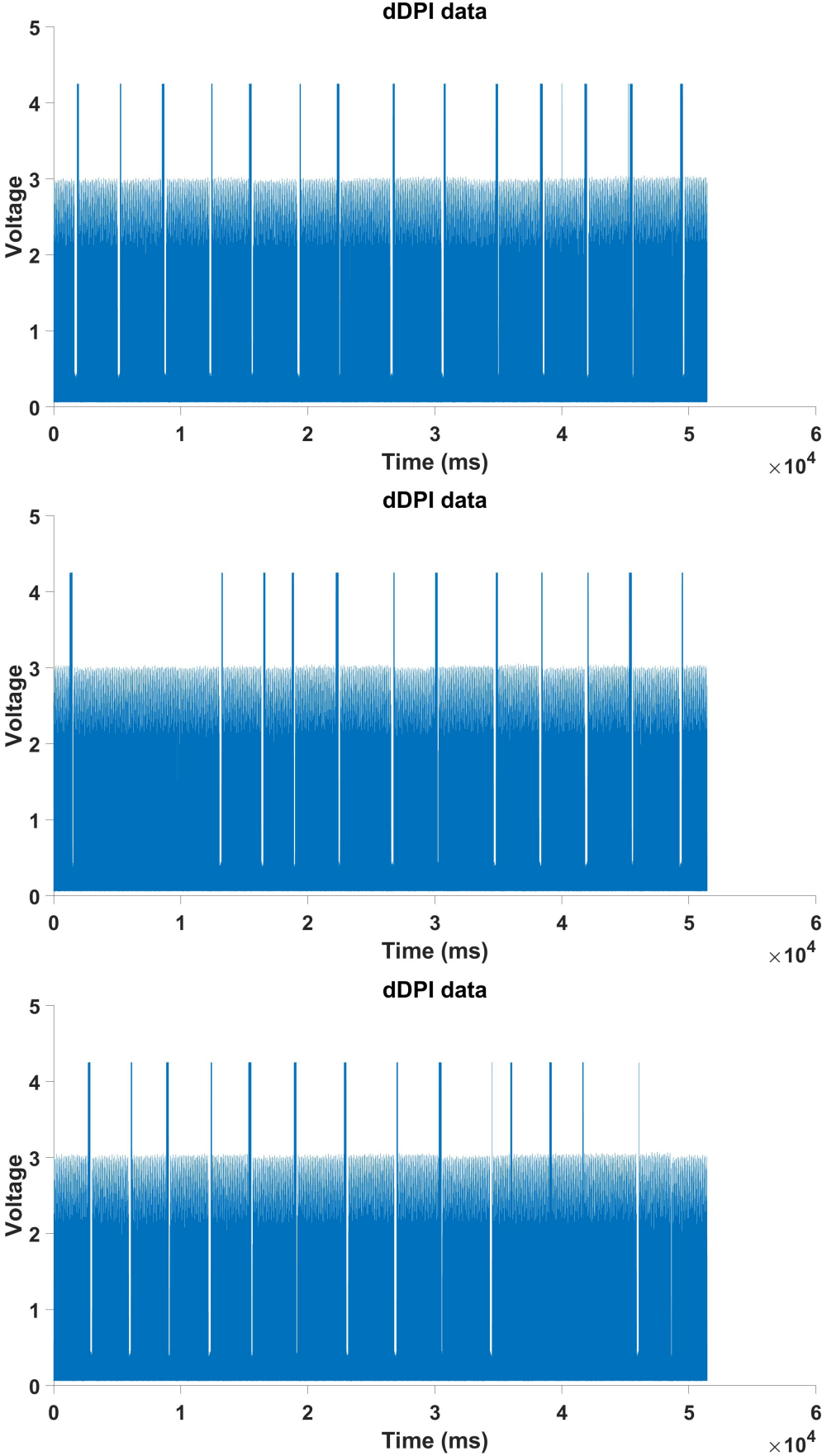


Figure 10: dDPI photocell data, for the 3 one-minute long measure intervals.

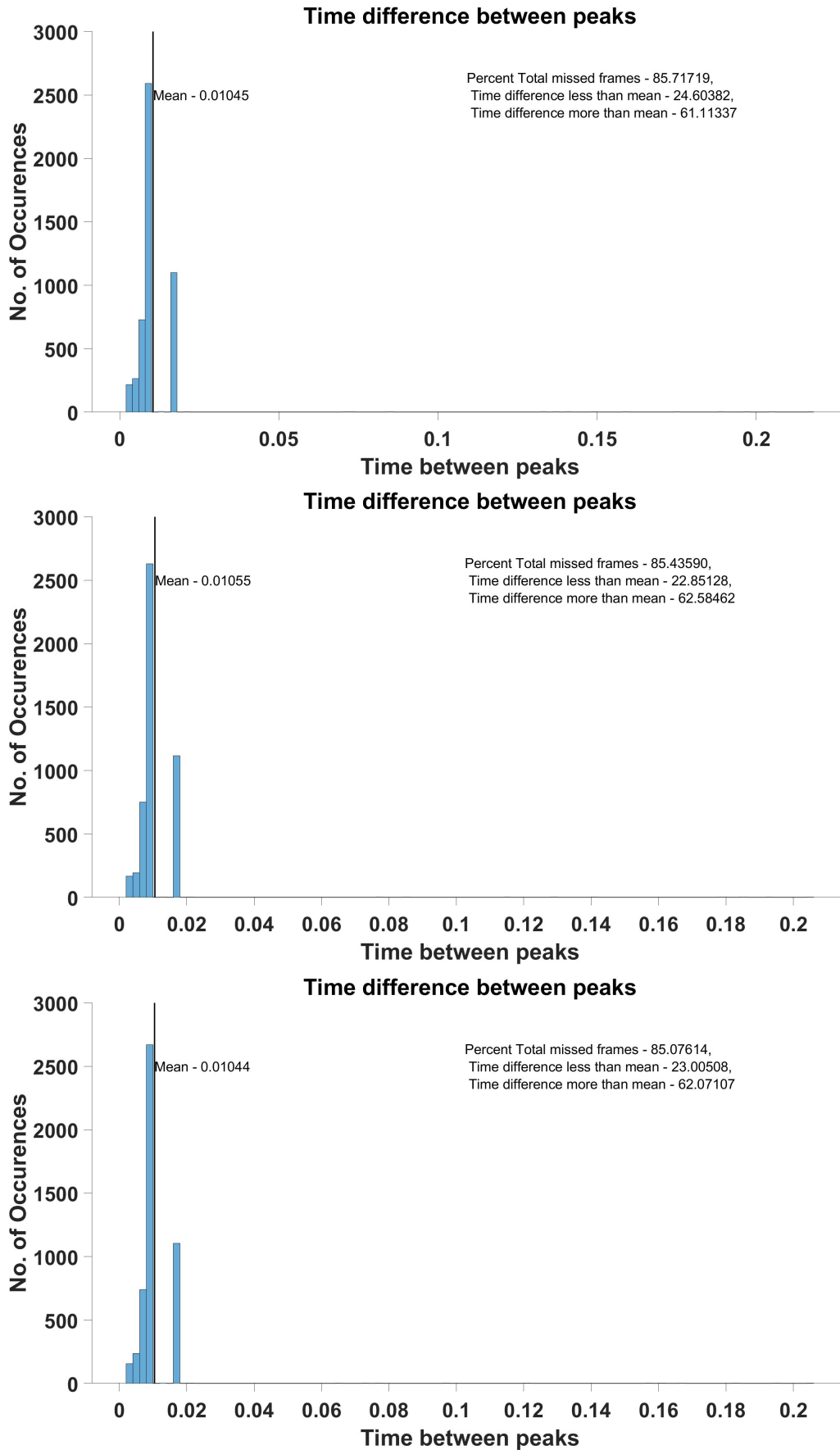


Figure 11: Distribution of time difference between peaks also showing the percentage of total missed frames and how many of them were missed having time difference less/greater than the range [230-250Hz]

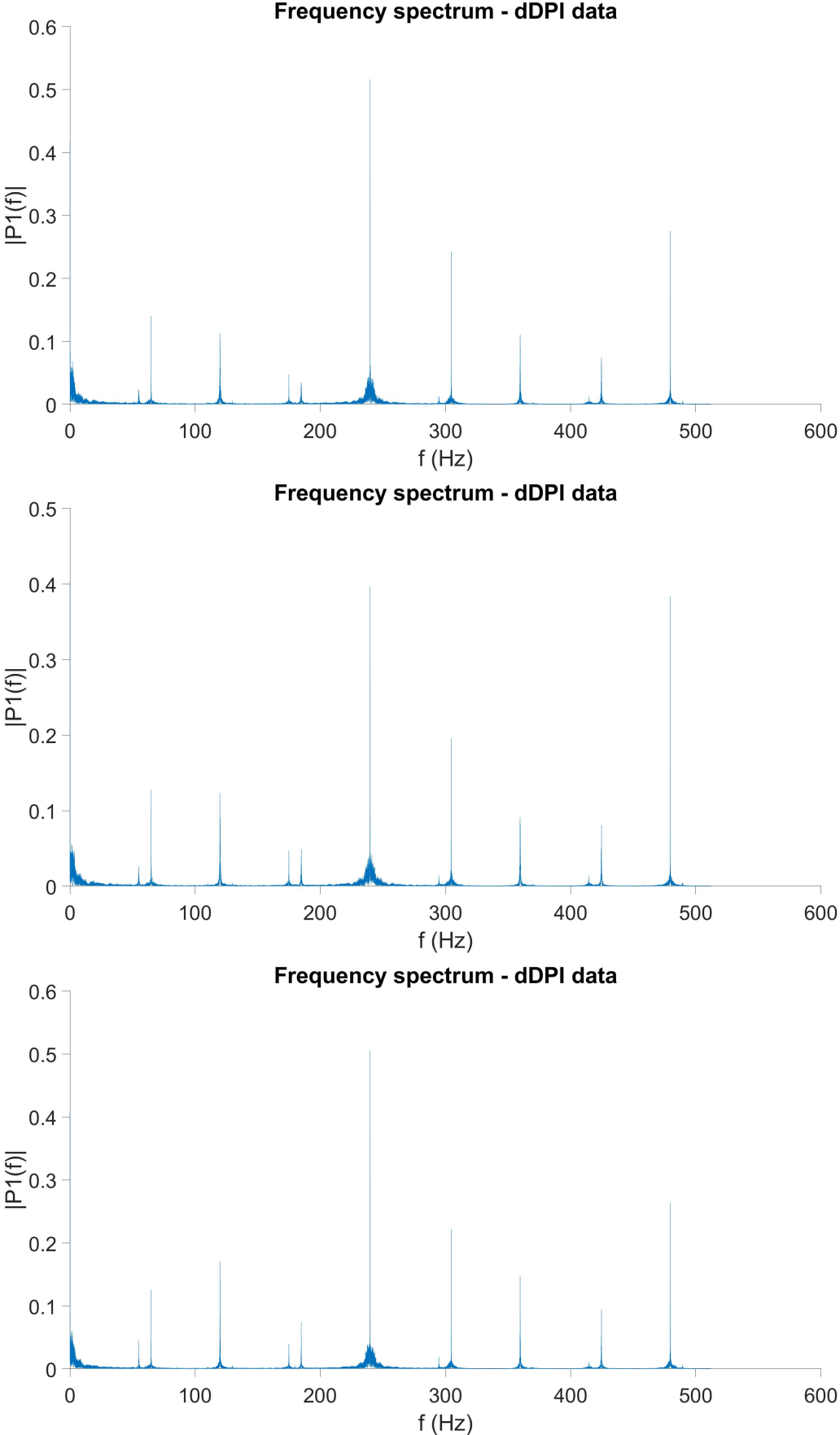


Figure 12: Single sided amplitude spectrum analysis for the data.



The difference between the data when keeping Blur Buster ON vs OFF was minimal in terms of missed frames. In both conditions, the number of missed frames in the DDPI was very high at 85 percent.

#### **0.4 Possible DPI DSP Box issue**

The data was collected using the photocell when running an experiment with eye tracking on the DPI at 200Hz. About 136 trials were collected. The photocell data is obtained through the DSP box.

As you can see the photocell data from consecutive trials below the signal seems to be considerably varying with time from trial to trial. NOTE that this is not seen when collecting photocell data using the LabJack and this artifact is probably resulting from the noise in DSP Box.

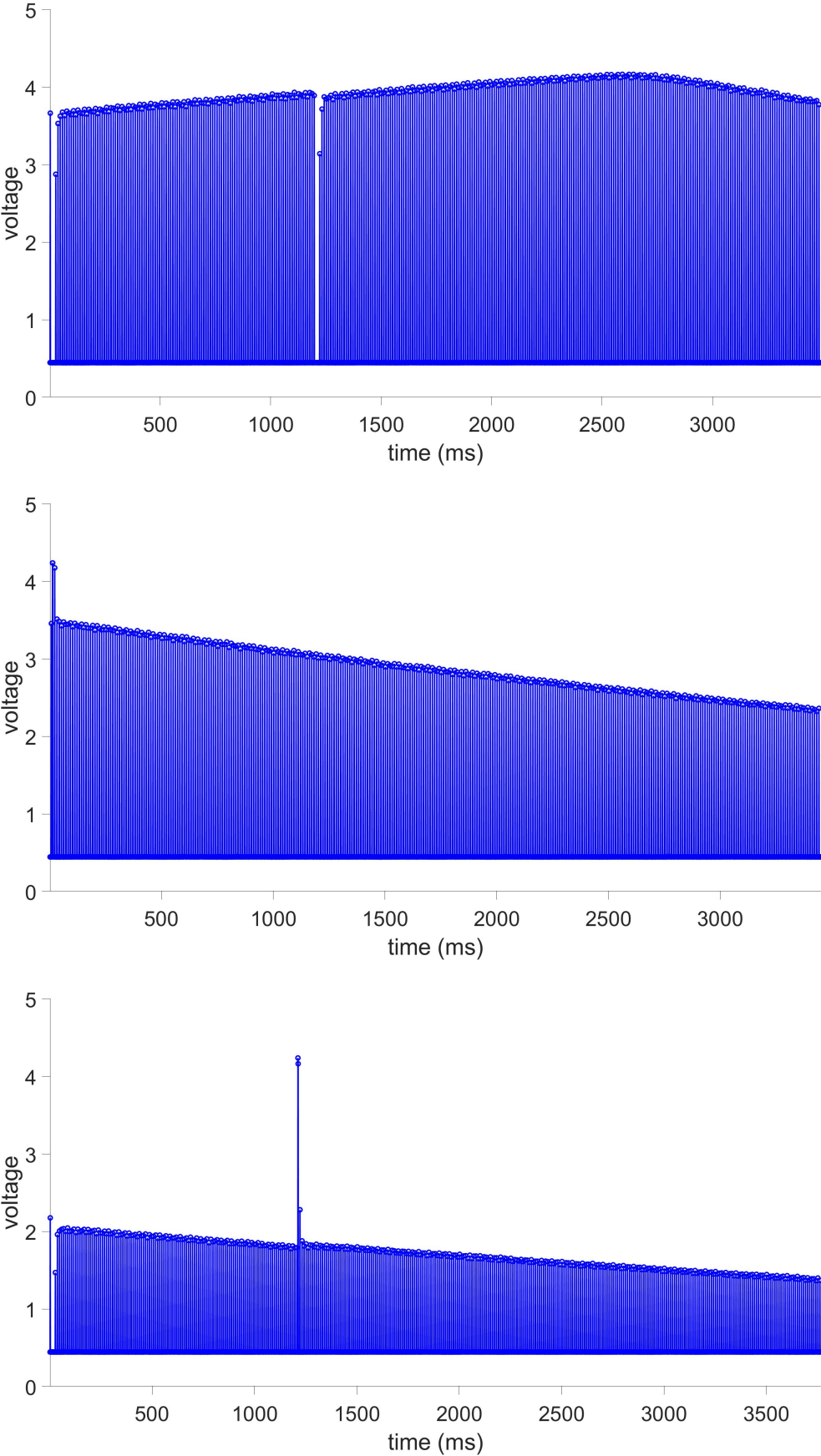


Figure 13: DPI photocell data

