TIRF Lock Manual

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IMPORTANT

All Technical Information, recommendations, and examples related to Mad City Labs Products made in this manual are based on information believed to be correct. The purchaser or user should determine the suitability of each product before using. The purchaser or user assumes all risks and liability whatsoever in connection with the use of any and all Mad City Labs, Inc. products or services.

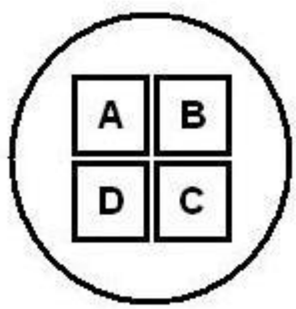
CONTENTS

1. INTRODUCTION

The TIRF Lock system is used to measure the displacement of a TIRF alignment beam and maintain via software feedback a TIRF signal. The TIRF Lock system includes a quadrant photodiode (QPD) head and TIRF Lock controller. The TIRF Lock is compatible with the Mad City Labs MicroMirror TIRF system and is supplied with a LabVIEW based VI.

2. THE QUADRANT PHOTODIODE (QPD) HEAD

The TIRF Lock system uses a QPD head to measure a displacement of the TIRF alignment beam. The QPD head measures the light intensity on each of the four quadrants (A,B,C,D) and converts it to an analog voltage. These analog signals are then sent to the TIRF-Lock controller where the X and Y values are computed as determined by the equations below. The TIRF-Lock controller also measures the total beam intensity (SUM) by summing the voltages from all four quadrants. The X, Y and SUM values are all monitored with ADCs in the TIRF-lock controller.



$$X = (A+D) - (B+C)$$

$$Y = (A+B) - (C+D)$$

$$SUM = (A+B+C+D)$$

It is strongly recommended that the X and Y signals be divided by the SUM signal in software. This ensures that the X and Y readings will not change due to fluctuations in the power of the beam which could give the false impression that the beam is moving.

3. RECOMMENDED BEAM SIZE

It is important that the size of the beam incident on the QPD head be the right size. If the beam is too small, then the SUM measurement will not be accurate as a large portion of the beam will be on the gap between quadrants and will not be measured. It is recommended that the beam size be no smaller than 300 micrometers. It is also important that the beam size not be larger than the active area of the QPD otherwise the QPD cannot track the X and Y movement of the beam accurately. It is recommended that the largest beam size be less than 1.5 millimeters.

4. HOW TO ALIGN THE SYSTEM

Adjust the beam position visually so that it appears to be centered on the QPD. Check that the SUM measurement is at or near its maximum value of 10 Volts to confirm that the entire beam is hitting the QPD. Adjust the beam position further so that the X and Y readings are as close to 5V as possible. This step ensures that the beam is centered on the QPD. Next the “X Gain” and “Y Gain” adjustment knobs on the front panel of the TIRF Lock controller can be set. These knobs adjust the gain of the X and Y signals. To begin, slowly move the beam position in the X axis as far as you expect it to move during the experiment. If the beam ever goes above 9V or goes below 1V, then decrease the X Gain by turning the “X Gain” knob counter-clockwise. If you have finished moving the beam position and the X signal is still between 1V and 9V, increase the X Gain until the 1V or 9V limits is reached or until the X Gain knob cannot be turned clockwise any further. Now re-center the beam and repeat this process with Y axis beam movement and the Y Gain knob.

5. BEAM POWER MEASUREMENT

The SUM reading from the TIRF Lock controller provides a way to measure the power of the beam hitting the QPD. The beam power can be calculating with the following formula

$$\text{Beam Power} = \text{SUM}/(G*R)$$

Beam Power = power of laser beam hitting the active area of the QPD [Milliwatts]

SUM = SUM reading from TIRF Lock controller [Volts]

G = transimpedance gain of photodiode amplifer [Kilovolts/Amps]

R = Responsivity of photodiode as a function of wavelength in units of [Amps/Watts].

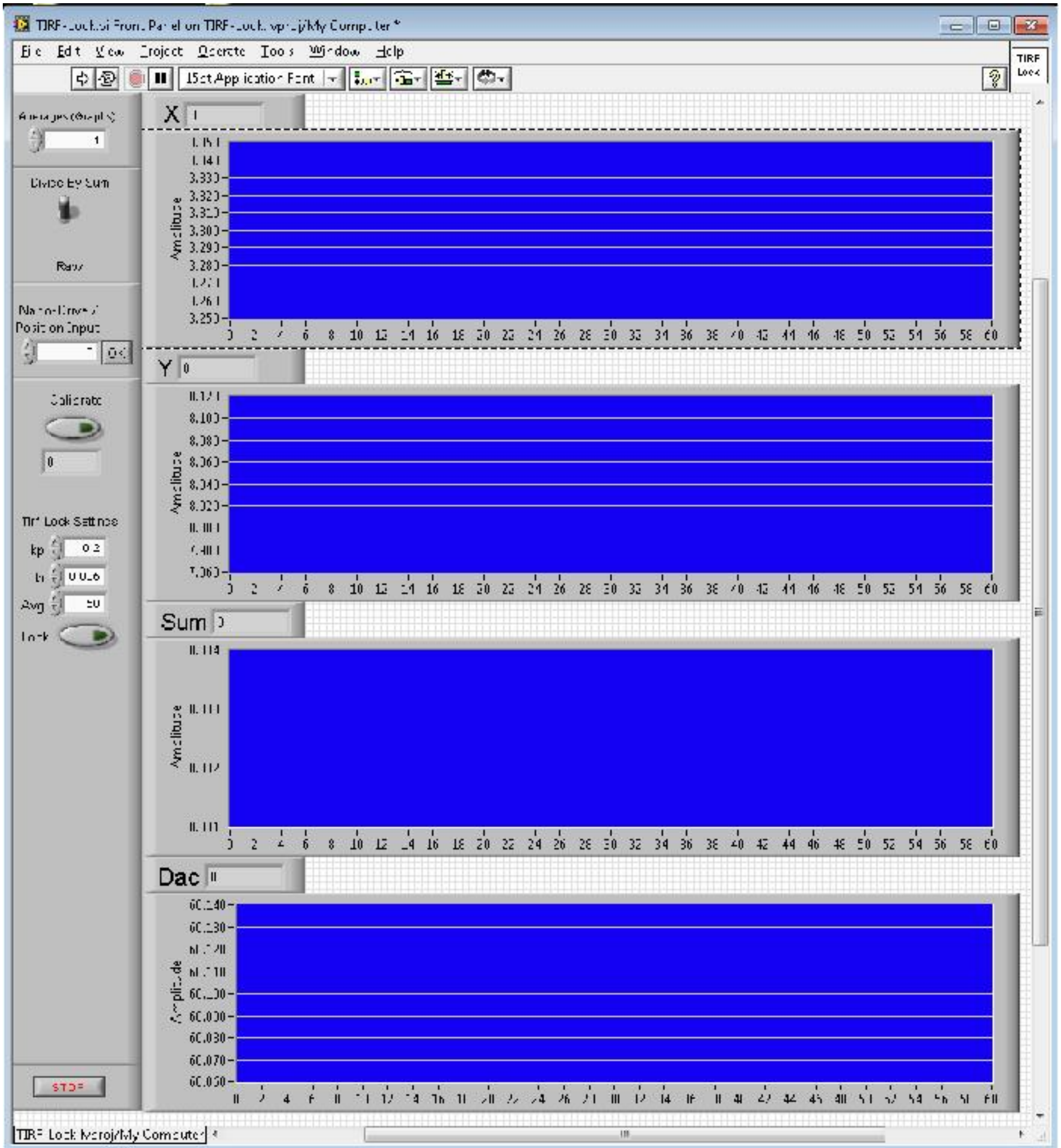
The responsivity at 23°C for the QPD as a function of wavelength is shown in the spectral response graph in the Specifications section.

The beam power should be kept low enough so that the SUM voltage does not reach 10V. This is to prevent the electronics from becoming saturated and limiting the ability of the TIRF Lock controller to measure the QPD head signal.

6. SUPPLIED SOFTWARE

The TIRF-Lock option is supplied with a LabVIEW based VI and the necessary dynamic link libraries (tirf-lock.dll and madlib.dll). The tirf-lock.vi is compatible with LabVIEW 2009 or later.
Features:

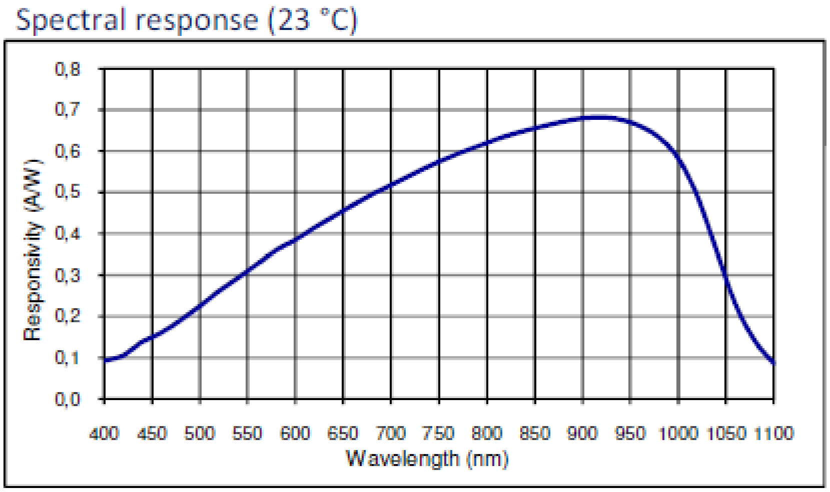
- The Tirf-Lock.vi allows you to view the x, y, and summed amplitude values of the TIRF-Lock system
- You can specify number of points to average in the charts
- You can specify if the X-Y charts are raw values or if they are divided by the sum
- Graphs the DAC command of the Z axis nanopositioner
- You can enter a value in the “Nano-Drive Z Position Input” box to command the Z axis nanopositioner
- Calibration routine
- Ability to lock the signal using a proportional integral (PI) loop. The parameter values can be modified by the user


X
Y
Sum
Dac
Amplitude
Divide By Sum
kp
Avg
STOP

7. SPECIFICATIONS

ELECTRICAL SPECIFICATIONS	
Wavelength Range	400nm – 1100nm
Peak Responsivity	0.4A/W @635nm
	0.67A/W @900nm
Transimpedence gain	2kV/A
SUM voltage range	0-10 V
Bandwidth	10 Hz
Recommended incident beam size	300µm to 1.5mm
Photodiode model	QP5.8-6 TO

HARDWARE SPECIFICATIONS	
Sensor size	2.4mm x 2.4mm
Clear aperture diameter 0.5”	0.5 inches (1.25mm)
Aperture thread	SM05 (#0.535-40)
Mounting Thread	8-32
QPD Cable length	6 feet
Power supply	90-260V
Controller dimensions	8.375 x 3.5 x 12 inches
PC connections	USB 2.0
Operating System (32 bit/64 bit)	Windows XP Pro/Vista/7/Windows 8



Spectral response plot taken from QP5.8-6 TO datasheet