

## Operator's Manual

**AONano™ Precision – Industrial Nanosecond Laser**

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# Table of Contents

- Introduction .....6
- 1. Safety Instructions .....8
  - 1.1 General Safety Instructions .....8
  - 1.2 Safety Instructions .....8
  - 1.3 Nominal Ocular Hazard Area .....10
  - 1.4 Hazards.....10
  - 1.5 Engineering Controls .....12
    - 1.5.1 Main Power Switch .....12
    - 1.5.2 Interlock .....12
    - 1.5.3 Key Switch.....13
    - 1.5.4 Protective Housing .....13
    - 1.5.5 Location of Controls.....13
  - 1.6 Protective Eyewear.....13
  - 1.7 Electric Safety Precautions .....14
  - 1.8 Warning and Information Labels.....15
- 2. Transport and Unpacking ..... 16
  - 2.1 Packaging.....16
  - 2.2 Unpacking .....16
- 3. Laser Description..... 17
  - 3.1 Intended Use.....17
  - 3.2 Incorrect Use.....17
  - 3.3 Functional Principle .....18
  - 3.1 AONano Compact Configuration .....19
  - 3.2 System Description .....20
    - 3.2.1 Power Supply (Front View – Computer Controlled).....20
    - 3.2.2 Laser Controller (Rear View) .....20
    - 3.2.3 Laser System Dimensions and Weights.....21
    - 3.2.4 Laser Specifications .....22
    - 3.2.5 Electrical Requirements.....22
    - 3.2.6 System Interface Connector/Safety Interlock .....23

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<b>4. Laser System Installation</b> .....	<b>25</b>
<b>4.1 Laser Head Installation</b> .....	<b>25</b>
<b>4.2 Laser Controller Installation</b> .....	<b>24</b>
<b>4.3 Electrical Connections</b> .....	<b>25</b>
<b>4.4 Computer Interface Installation</b> .....	<b>25</b>
<b>4.5 Graphical User Interface – GUI</b> .....	<b>37</b>
4.5.1 Window Section Definitions.....	39
<b>4.6 Window Section Definitions – Engineer Tab (Figure 17)</b> .....	<b>40</b>
<b>5. Laser Operation</b> .....	<b>45</b>
<b>5.1 Initial Startup Procedure</b> .....	<b>45</b>
<b>5.2 Laser Start-up</b> .....	<b>45</b>
5.2.1 Initial Warm-up stage:.....	45
5.2.2 Load Graphical User Interface - GUI .....	46
5.2.3 Verify Harmonic Crystal Temperatures .....	47
5.2.4 Enable Intracavity Shutter.....	48
5.2.5 Diodes .....	48
5.2.1 Enable Q-Switch.....	48
5.2.2 Optimize Crystal Temperatures .....	48
<b>5.3 Laser Standby Mode</b> .....	<b>50</b>
<b>5.4 Laser Shut-down Procedure</b> .....	<b>51</b>
<b>6. Laser Control</b> .....	<b>51</b>
<b>6.1 Power Control – PWF</b> .....	<b>52</b>
<b>6.2 First Pulse Suppression – FPS</b> .....	<b>52</b>
<b>6.3 Dynamic Pulse Energy Controlled by Duty Control</b> .....	<b>56</b>
<b>7. Maintenance</b> .....	<b>57</b>
<b>7.1 Inspection of Output Window for Damage</b> .....	<b>57</b>
<b>7.2 Updating Monthly Maintenance Log</b> .....	<b>58</b>

## List of Figures

Figure 1: Warning Label Locations - <b>AONano</b> Laser Head .....	16
Figure 2: Warning Label Locations - <b>AONano</b> Laser Controller.....	14
Figure 3: Power Supply Front Panel .....	20
Figure 4: Laser Controller Rear Panel (Water Cooled) .....	19
Figure 5: ISO Drawing of Laser Head. AONano Compact.....	22
Figure 6: ISO Drawing of Laser Controller. AONano Compact.....	21
Figure 7: Interface Connector Pin-Outs .....	22
Figure 8: System Connection Diagram.....	24
Figure 11: Opening HyperTerminal Session .....	27
Figure 12: Naming the Connection. ....	28
Figure 13: Connect To Dialog Box - Set to "COM1". .....	28
Figure 14: Connection Properties. ....	29
Figure 15: Controller Properties, Click "ASCII Setup" .....	30
Figure 16: ASCII Setup Window.....	30
Figure 17: Advanced Optowave Graphical User Interface – GUI .....	37
Figure 18: Advanced Optowave Graphical User Interface – GUI Engineer Tab.....	40
Figure 19: Operator Screen .....	46
Figure 20: Engineer GUI Window.....	47
Figure 21: Engineer GUI with Crystal 2 Temperature Section Highlighted .....	43
Figure 22: Examples of using the FPS function to control the first pulse suppression. ....	54
Figure 23: Example of the Fast Response Mode of First Pulse Suppression. ....	55
Figure 24: Example of the Slow Response First Pulse Suppression.....	55
Figure 25: Example of the Dynamic Pulse Energy Controlled by Duty Control .....	56

## Introduction

This documentation contains all the information necessary for the safe operation, maintenance, servicing and disposal of the **AONano Precision** laser system.

Please make sure that this documentation is always kept with the laser system.

This documentation should remain with the laser system if the system is transferred to another location.

Please contact the Advanced Optowave Corporation service department if you do not understand something in this operator manual.

Advanced Optowave Corporation follows a policy of continuous improvement and welcomes any suggestions and/or criticisms. Your suggestions and criticisms will help us make this operators manual more user-friendly and this is appreciated.

### **Target Group**

This manual is directed towards anyone who works with this device or performs service tasks:

#### *Qualified Personnel*

Qualified personnel are considered to be those who have professional training and experience. Additionally, their knowledge of local laws and standards can make a correct assessment of the work assigned to them and clearly identify any possible dangers.

#### *Instructed Personnel*

Instructed personnel are considered to be persons who have been:

- Instructed
- Educated if necessary in the work assigned and the potential dangers arising from improper use and conduct
- Individuals that have been advised about the required protective devices and protective measures








*For your information*

Persons that work on the laser system must be trained at regular intervals regarding laser safety, the dangers of operating laser systems and the correct handling procedures.

**Symbols Used in this Manual**

In this operator's manual, these symbols are used to alert you to information that requires special attention.

Symbol	Note	Meaning
	Danger	Imminent danger. Serious injuries or death are the results.
	Warning	Potentially dangerous situation. Serious injuries or death could be the results.
	Caution	Potentially dangerous situation. Light or minor injuries as well as danger to the laser system and materials could be the result.
	For Your Information	Notes that are required to be followed, in order to guarantee as optimal performance and a secured operation of the laser system.
	Caution	Caution on Electrostatic Discharge (ESD)

The warnings are arranged in the following manner:

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**Danger:**

The type of danger is indicated first. For example: "**Risk of burn injuries!**"

**Cause and effects:**

Here is the cause of the danger or damage and its effects are described.

**Remedy:**

Here measures are described that can be taken to preclude any potential danger from arising.

## 1. Safety Instructions

### 1.1 General Safety Instructions

This section should be reviewed thoroughly prior to operating the *AONano Precision* laser system.

Safety precautions contained herein and throughout the manual must be carefully followed to ensure that all personnel who operate or maintain the laser are protected from accidental or unnecessary exposure to laser radiation and high voltage.



***Warning***

No operation should be permitted if the protective housing is missing or open. Any repairs necessary repairs must be carried out by Advanced Optowave qualified personnel.



***Wear Laser Safety Glasses!***

### 1.2 Safety Instructions

The *AONano Precision* is a high-power Class-IV laser system as described by the **Center for Devices and Radiological Health (CDRH)**.



***Warning***





The accessible laser radiation is very dangerous and can cause serious damage to your eyes and skin. Even diffuse scattered radiation can be dangerous.

---

**Wear Laser Safety Glasses!**

---

The laser radiation generated by this laser system is in the invisible range (1064 nm). If the system is equipped with the second harmonic module, third harmonic or fourth harmonic then the system will also generate laser radiation in the visible range (532 nm) and ultra-violet (355 nm).

### 1.3 Nominal Ocular Hazard Area

The nominal ocular hazard area in terms of the accident prevention regulations is the area in which the value of the maximum permissible radiation can be exceeded.



---

#### **Warning**



Even apparently defused surfaces may reflect laser radiation.

Defuse reflected laser beams and multiple reflected laser beams are hazardous.

Always wear laser safety glasses when working on or with the *AONano Precision*. Your safety glasses should be optically dense at 1064, 532, and 355nm. Please consult your Laser Safety Officer for the correct glasses that conform to your company's requirements.

The laser area must be clearly marked with appropriate warning signs and/or warning lamp or secured with laser safe blinds and/or interlocks.

Make sure there are no flammable or explosive objects and/or materials inside the nominal ocular hazard area.

Laser radiation may cause fires and explosions.

---

### 1.4 Hazards

Hazards associated with lasers typically fall into the following categories:

#### **Hazards generated by laser radiation**

Laser radiation exposure may cause damage to skin and the eyes.

#### **Chemical Hazards**

Exposures to dust and gases released as a result of the laser material processing may cause health related issues.



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#### **Warning**

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Suitable fume extraction system needs to be connected.

---

## Electric Hazards

Electrical hazards can be generated in the laser power supply or other control electronics.

## Other Hazards

- High noise level
- Pressurized lamps, hoses, gas cylinders, etc.
- Motion platforms
- Engineering Controls

## 1.5 Engineering Controls

The following engineering controls have been designed and added to the system to ensure safety of the user and the laser. Any modification to the **AONano Precision** laser which alters, disables or overrides the functions of these controls discredits the Class IV certification of the laser described in this manual.

### 1.5.1 Main Power Switch

The main switch connects or disconnects the power source from the laser power supply.

### 1.5.2 Interlock

The interlock (*double*) safety circuit prevents the laser from operating if the circuit is open. The user can interface to the interlock safety circuit by accessing the 15 pin D-Connect located on the rear panel of the power supply using pins 2 and 10.



### **For your information**

#### **Once the interlock circuit is open the following occurs:**

Laser shutter will close

Current drive to the pump diodes will be turned off

Audible alarm will sound

---

Graphical User Interface will show Interlock Fault

After the closing, the interlock circuit is closed the user needs to reset the fault and reset the system.

---

### 1.5.3 Key Switch

The laser cannot be operated without the key switch in the "On" position.

---



#### ***For your information***

The Key Switch is part of the interlock circuit. If the Key Switch is in the "Off" Position the interlock circuit is open.

---



#### ***Warning***

Keep the Key for the Key Switch in a safe location to protect the laser system against unauthorized use.

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### **Wear Laser Safety Glasses!**

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### 1.5.4 Protective Housing

The resonator section of the laser is fully enclosed in a protective housing; laser radiation can only emit through the output aperture.

### 1.5.5 Location of Controls

The laser control for operating the **AONano Precision** are located within the Graphic User Interface (GUI), (see section 4 – Laser System Operation, subsection 4.7, on page 39).

## 1.6 Protective Eyewear

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#### ***Warning***

Always wear laser safety glasses when operating or working on the **AONano Precision** laser, the laser radiation generated by this laser system is in the invisible range (1064 nm). If the system is equipped with the second harmonic module, or third harmonic then the system will also generate laser radiation in the visible range (532 nm) and ultra-violet (355 nm).

### **Wear Laser Safety Glasses!**







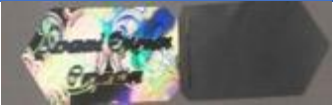


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## **1.7 Electric Safety Precautions**

- Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
- After disconnecting main power, wait at least one minute for the capacitors to discharge before touching any electrical equipment.
- Do not short or ground the power supply output. Positive protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.
- Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.
- When possible, keep one hand away from the equipment to reduce the danger of current flowing through the body if a live circuit is accidentally touched.
- Always use approved, insulated tools when working on equipment
- Special measurement techniques are required for this system, ground references must be selected by a technician who has complete understanding of the system operation and associated electronics.

### 1.8 Warning and Information Labels

System area where there is potential risk are marked with warning and informational labels in their relevant locations. Those labels and their respective locations are shown in the following figures.

NUMBER	DESCRIPTION	LABEL
1	APERTURE LABEL	
2	LASER RADIATION WARNING LABEL	
3	CAUTION	
4	CLASS 4 LASER PRODUCT LABEL	
5	ENERGY & WAVELENGTH LABEL	
6	MANUFACTURING IDENTIFICATION LABEL	
7	TAMPER LABELS	
8	CE LABEL	
9	HIGH VOLTAGE	

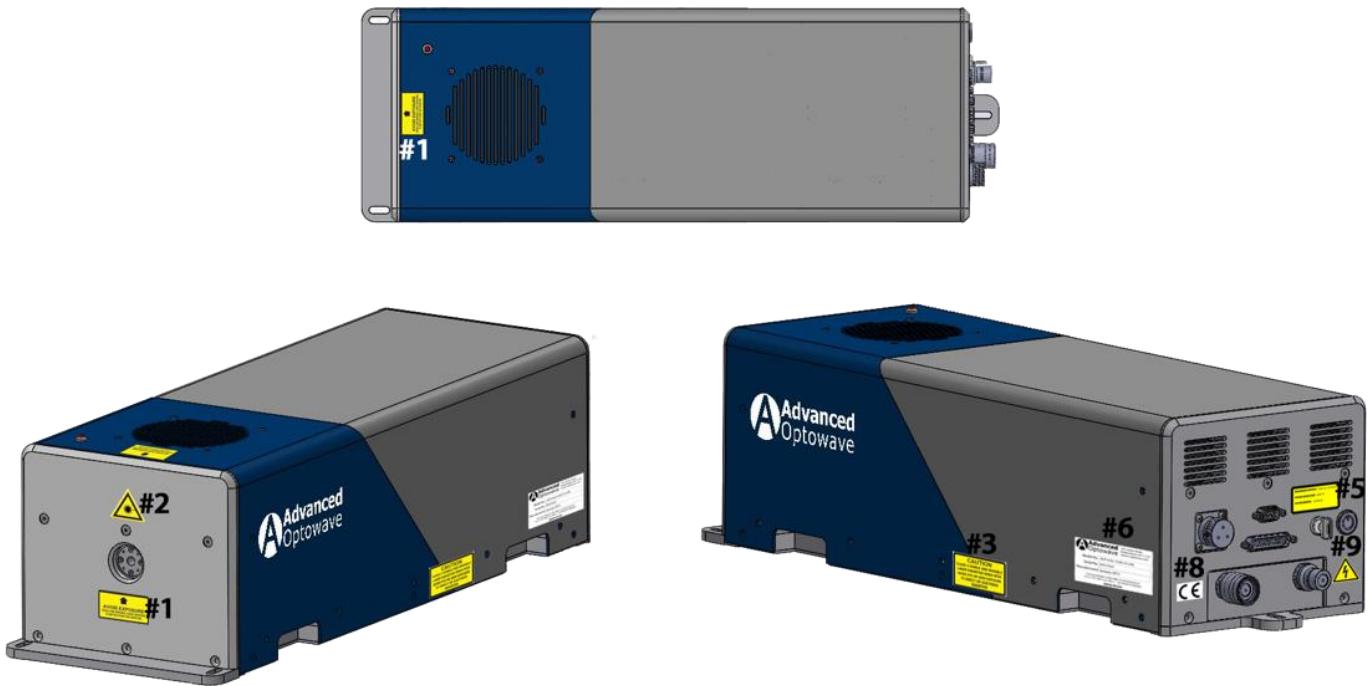


Figure 1: Warning Label Locations **AONano Precision** Laser Head

## 2. Transport and Unpacking

### 2.1 Packaging

The laser system will be delivered by Advanced Optowave in suitable packaging.

### 2.2 Unpacking

#### **Completeness**

Check the packaging and laser system for completeness on the basis of the bill of lading or the packing list and inspect them for any transportation damage.

#### **Transportation Damage**

Prior to unpacking your laser system, please inspect the outside of the packaging and check for any damage. This damage could be water stains, tears or crushed corners. If



damage to the packaging has occurred, please notify your freight forwarder and call Advanced Optowave Customer Service. Please do not refuse the shipment, however, it would be wise to take pictures of the damage before moving forward with the unpacking of the laser system.

For international shipments, please be aware that the packaging may be opened in customs for inspection.

### **Unpacking/inspection**

Proceed with unpacking the laser system by opening the packaging container. Once open, you will see the first layer of packaging material which will then reveal the laser head. Please be aware that the laser head. Please remove the laser from the packaging.

Once the laser system is removed from the packaging container, secure it to a solid surface using ¼-20 (M6) screws to ensure the laser head will not move during the installation process.

## 3. Laser Description

### 3.1 Intended Use

The **AONano Precision** is an electronically controlled laser system that is designed to be integrated into a workstation/equipment for cutting, marking, ablation and/or drilling of various materials. The **AONano Precision** is a highly technical tool that is only for professional use.

### 3.2 Incorrect Use



---

#### **For your information**

The operator shall assume all liability for use of the laser system for anything other than its intended use

---

The **AONano Precision** may not be used for any purpose other than what is described under "Intended Use".

The **AONano Precision** laser beam shall not be pointed or directed towards any living creatures, animal, human or otherwise.

### 3.3 Functional Principle



#### **Danger**

#### **Caution, Laser Beam!**

Laser radiation can cause severe injuries.

Always wear safety glasses while working on or around the laser system.

Do not reach into the working laser beam path or look into the laser beam directly.

A laser is a device that emits light through a process of optical amplification caused by the stimulated emission of electromagnetic radiation. The term "LASER" is an acronym for "Light **A**mplification by **S**timulated **E**mission of **R**adiation".

A laser in its simplest form has three (3) major components they are: (1) A gain medium, this can be a gas, a liquid or more commonly today a solid or semiconductor material. (2) an excitation source, this can be electrical, chemical or optical, (3) mirrors, one highly reflective and one partially reflective.

The excitation source is used to stimulate a large number of atoms in the gain medium, now these atoms that have been stimulated try to revert back to their unstimulated state or ground state. They accomplish this by releasing their extra energy in the form of photons – light particles. This whole process is called spontaneous emission.

The mirrors described above are placed on either side of the gain medium and form what is called the resonator. As the photons are produced through this spontaneous emission process, the mirrors in the resonator reflect those photons back into the gain medium. Now those reflected photons stimulate other atoms in the gain medium to emit photons. These new photons are exactly the same as the reflected photons. This amplification process is called stimulated emission.

Once the amplification process overcomes the loss of the resonator, due to the partial reflector, a beam of light is produced from the spontaneous and stimulated emission. The light produced from both have the same color (wavelength) and resonate synchronously (coherent light).

### 3.1 **AONano Precision Configuration**

The **AONano Precision** laser is a compact, end-pumped, Acousto-optic (AO) Q-Switch nanosecond laser that deploys Advanced Optowave's proprietary frequency conversion technology. This proprietary technology allows for high conversion efficiency, high reliability and long harmonic crystals life times.

The **AONano Precision** has been designed as a air-cooled device, but for more difficult environments Advanced Optowave also offers a water cooling option for the **AONano Precision**

The **AONano Precision** is controlled via a graphical interface that can be loaded onto any industrial PC that has an RS232 communication port or by using the RS232 commands outlined in Section 4 of this manual.

### 3.2 System Description



***For your information***

Depending on the overall system configuration, certain components may not match the figures and descriptions outlined in this manual.

#### 3.2.1 Laser Head



Figure 2: **AONano Precision** Laser Head Rear Panel

Identifier	Description	Function
1	<b>24 VDC Input</b>	The 24 VDC Input connect is used to supply the power to the laser system. Input is 24 VDC @ 20 AMPS
2	<b>RS-232C</b>	Computer control interface.
3	<b>INTERFACE</b>	The Interface connector has a series of pins that can be used for various operational features. It also houses the two pins used for the Safety Interlock.
4	<b>KEY SWITCH</b>	Used to turn enable the laser system

<b>5</b>	<b>On/Off Switch</b>	Power Button – used to turn on the AONano Precision
<b>6 &amp; 7</b>	<b>Water Connections</b>	Cooling water connections

### 3.2.2 Laser System Dimensions and Weights

Description	Dimensions	Weights
<b>Laser Head</b>	22.4" x 7.9" x 6.6" (569 mm x 200 mm x 168 cm)	50 lbs. (23 kg)



#### ***For your information***

Depending on the overall system configuration, certain components may not match the figures and descriptions outlined in this manual.

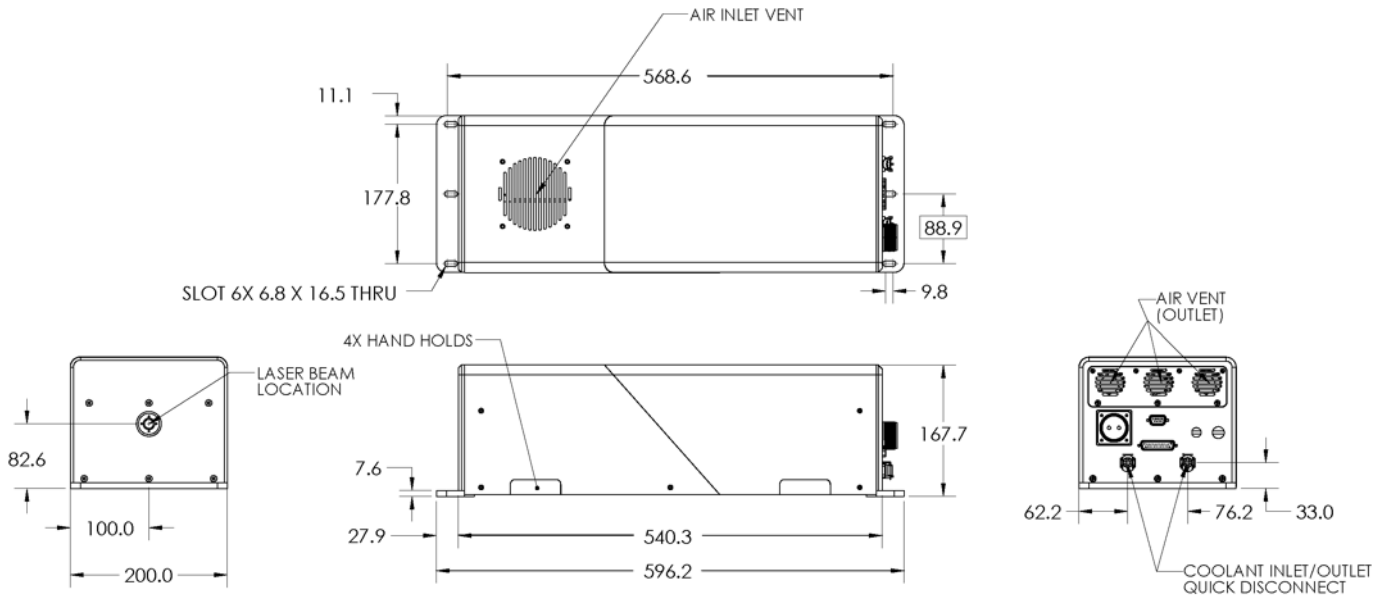


Figure 3: ISO Drawing of Laser Head. **AONano Precision**

### 3.2.3 Laser Specifications

Please visit our website @ [www.a-optowave.com](http://www.a-optowave.com) or contract your Advanced Optowave sales person for the published product datasheets.



#### **For your information**

All specifications are subject to change without notice.

### 3.2.4 Electrical Requirements

The **AONano Precision** laser requires a 24VDC input with a maximum amperage of 20A. A male 3-pin connector is provided with the system, it is the customer's reasonability to soldering their supply cables to the connector, AOC recommends using 12 or 14-gauge wire.

Parameter	Requirement
DC Voltage Input	24 VDC

<b>Maximum Current</b>	20 Amps
------------------------	---------

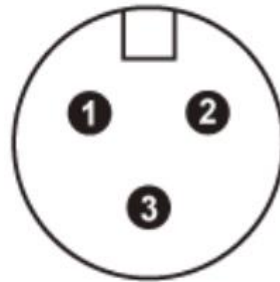


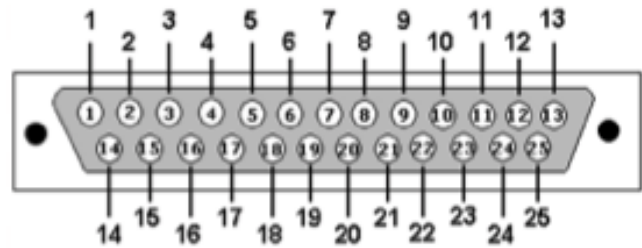
Figure 4: 24 VDC Connect Diagram and Pin-Out

Pin	Description
1	Positive Connection
2	Negative Connection
3	Earth Ground

### 3.2.5 System Interface Connector/Safety Interlock

The laser controller is equipped with a safety interlock feature that is designed to allow users to wire the controller into a complete system interlock circuit. This feature is accessible through the Interface Connector located on the back panel of the laser controller (DB15 Connector). Pins 2 and 15 are accessible for this feature and come from the factory with a shorting connector that needs to be installed for the laser to operate.

Pin #	Description	Paired Connection
1	Gate Input	2
2	GND (Isolated)	
3	Reserved	
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Trigger Input	18
15	Interlock	
16	Reserved	2
17	SYNC Out	18
18	GND (Isolated)	
19	Reserved	
20	Reserved	
21	Reserved	
22	Reserved	
23	Reserved	
24	Reserved	
25	Reserved	



*Figure 5: Interface Connector Pin-Outs*

When circuit between pins 2 and 15 are open, the laser will initiate a full system shutdown and execute the following steps:

1. Close the internal shutter;
2. Disable the pump diode power supply;
3. Disable the RF power supply;



4. The Front panel of the GUI will display a visual fault message and the system will have an audible alarm. Once the fault is cleared, the user must restart the system using the stand turn-on procedure.



---

***For your information***

To clear the fault message, the connection between pins 2 and 15 must be reestablished and the RESET button on the GUI must be pressed. The fault will then be cleared. The user must then follow the standard turn-on procedure to restart the system.

---

## 4. Laser System Installation

### 4.1 Laser Head Installation

The **AONano Precision** laser is designed to be mounted to a flat level surface. The laser head has three (3) mounting locations, they are located on the two front corners of the laser head and then the third is located in the back laser near the electrical connections. They are slotted to allow the use of a ¼-20 or M5 screw, please make sure that you use the appropriate lock washer and flat washer to secure the laser to your work surface. The front screws should be firmly attached while the back screws should be secure but not overly tight.

### 4.2 Electrical Connections

The customer is responsible for supplying the 24-volt DC supply to the system. The DC power supply should be rated for 24 VDC at 20 Amps.



---

***Caution***

Please make sure that the DC power supply in which you are attaching the laser system to is rated for at least 20 Amps @ 24 VDC.

---

### 4.3 Computer Interface Installation

All of Advanced Optowave's lasers can be controlled using a Windows based PC running our supplied graphical user interface and GUI that uses the RS232 serial communication

port on the computer. This section of the manual is designed to aid in setting up the communication link between the computer and the laser if the supplied Graphical User Interface is not functioning. If you are using the supplied GUI, please skip to subsection 4.7 – Graphical User Interface – GUI. If you plan to develop your own graphical user interface or integrate laser controls into your operating software, the following section outlines the command and queries available for this activity.

The communication protocol currently on the Advanced Optowave lasers is an ASCII based protocol. All communication between the computer and the laser will be an ASCII character. The simplicity of this protocol is a major advantage.

Simple ASCII strings are sent using a HyperTerminal communication link between the computer and the laser controller. This protocol makes it easy for software developers to develop high level application-specific software packages to best suit their needs.

The laser controller is interrupt driven, which allows for timely responses to user commands or queries even when the controller is executing higher priority tasks.

### **HyperTerminal Configuration**

This section of the manual will help you set up the HyperTerminal Port so that you can communicate with the Advanced Optowave laser controller. Advanced Optowave strongly recommends using a PC configured with Windows 10.

1. Open a HyperTerminal session by using the following steps and as shown in Figure 6.
  - 1.1. Click Start | Programs | Accessories | Communications | HyperTerminal.

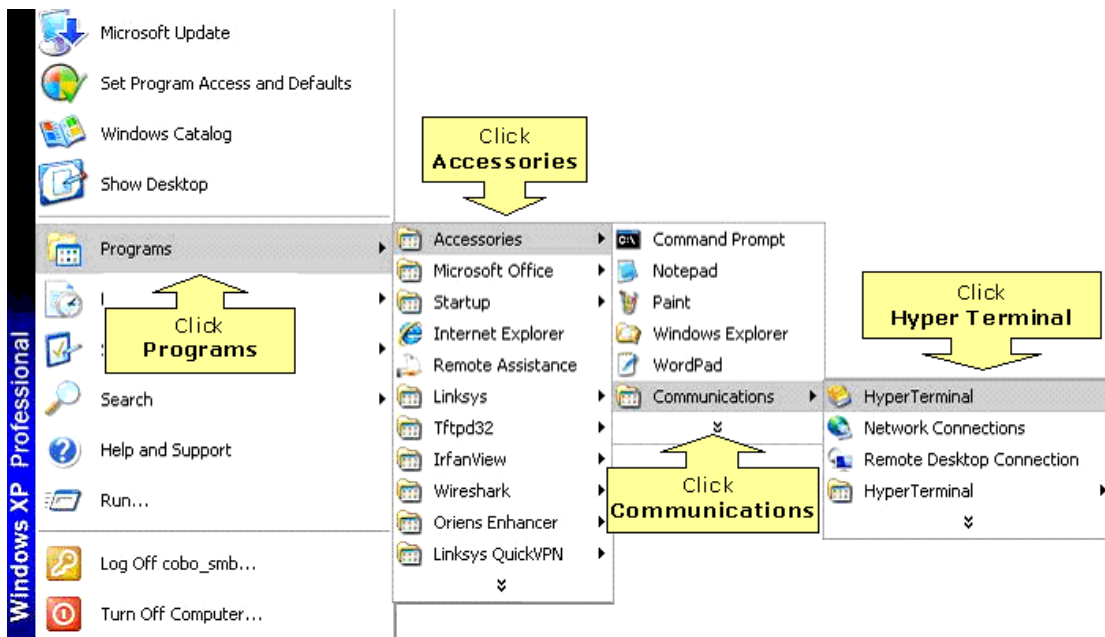


Figure 6: Opening HyperTerminal Session

- Once HyperTerminal opens, it will automatically prompt you to create a new connection if none exist. If no connection(s) exists, you can click File | New Connection to create a new one, we suggest that you pick a unique name such as "AOC Laser Controller" see Figure 7.

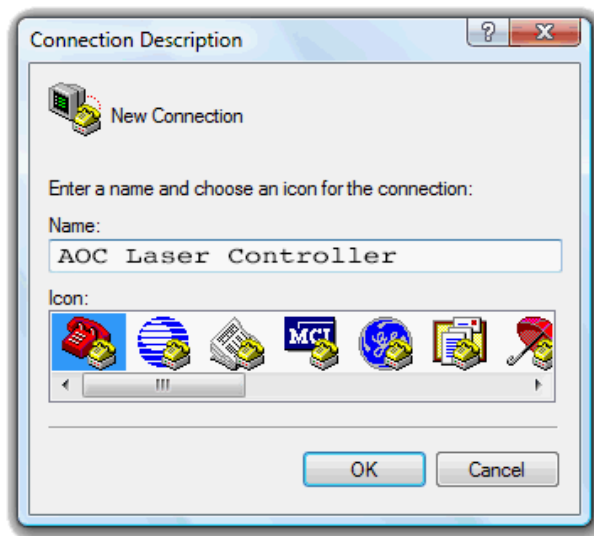


Figure 7: Naming the Connection.

3. Specify a name for the connection, choose an icon, and click OK.
4. In the "Connect To" dialog box, choose the COM port being used by your modem (usually COM1 or COM2) from the Connect Using drop-down list and click OK. See Figure 8.



Figure 8: Connect To Dialog Box - Set to "COM1".

5. In the port property sheet that appears, choose a port speed. (bits per second) For the AOC lasers please use Baud Rate = 9600, Data Bits = 8, Parity = None, Stop Bit = 1 and Flow Control = None. Please see Figure 9.

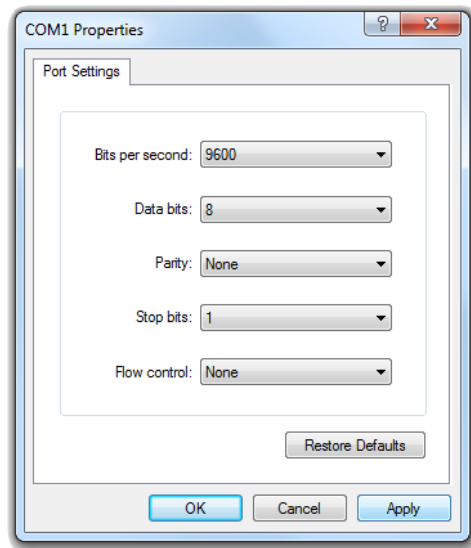


Figure 9: Connection Properties.

6. To make the communication between the controller and computer easier to watch, it is recommended to send line ends with line feeds and echo typed characters locally. These two functions can be enabled in Window by going to the setting window in the HyperTerminal Session as shown in figures 10 and 11.

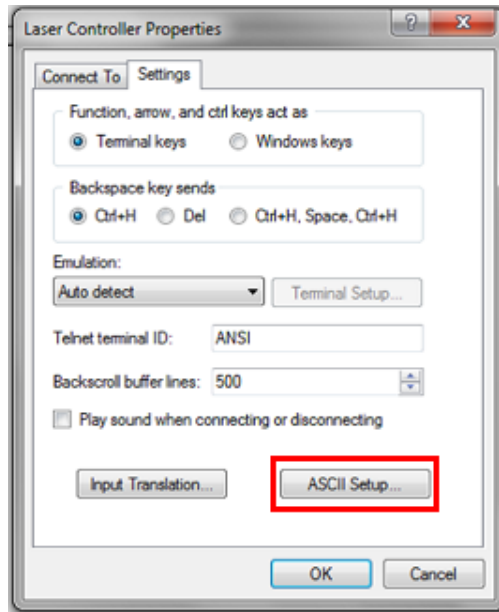


Figure 10: Controller Properties, Click "ASCII Setup"

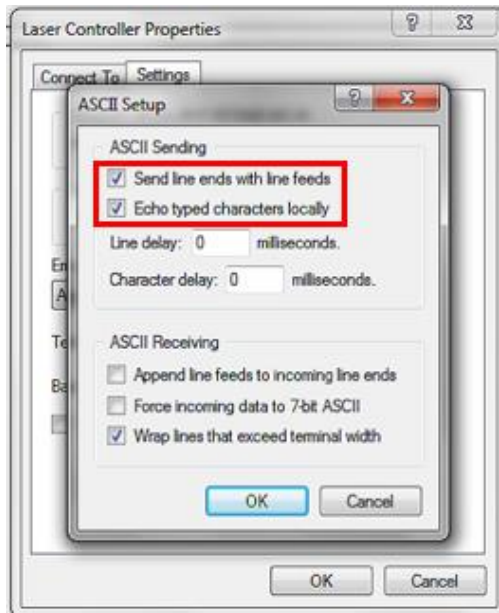


Figure 11: ASCII Setup Window

7. The computer sends two types of messages to the controller: command messages

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and query messages. The commend messages set up or change a laser operation or parameter. The query messages get information about the laser system, such as laser operation parameters. The following tables are a complete list of commands and queries; the tables include each command or query has the corresponding response that the controller will return from the controller. Each message ends with an end of line character (0xD) and a line feed character (0xA). The response from the controller is always six characters and an end of line character (0xD) and a line feed character (0xA).

8. For each message sent from a PC, the controller is required to respond accordingly. The normal responses are listed in Tables 1 and 2. However, if the driver is in a special status mode, it should notify the PC. These modes could be an error message caused by PC software or could be caused by the RS232 bit error rate (BER). Table 3 outlines those various special responses from the controller.

Table 1: System Control Commands

COMMAND FROM PC	RESPONSE FROM CONTROLLER	COMMENTS
MCH	000001	000001: remote mode
DI1=0	000000	Diode off
DI1=1	000001	Diode on
QSW=0	000000	Q-switch off
QSW=1	000001	Q-switch on
SHT=0	000000	Shutter off
SHT=1	000001	Shutter on
EXT=0	000000	Internal trigger
EXT=1	000001	External trigger
PRF=xxxxxx	xxxxxx	Pulse rate set up to 300KHz. Unit is HZ.
Examples: PRF=12345	012345	Set pulse rate to 12345HZ (shown on display as 12.3KHZ)
PRF=123456	123456	Set pulse rate to 123456HZ (shown on display as 123KHZ)
PWF=xxxx (x: digits 0-9.)	xxxxxx	Set power control factor. Range 1-1000 corresponding to Minimum-Maximum power output.
Examples: PWF=500	000500	Set laser power output to approximately 50% of Maximum power
PWF=950	000950	Set laser power output to approximately 95% of Maximum.
IS1=xxx (x: digits 0-9)	xxxxxx	Diode current set. Unit: 0.1A.
Examples: IS1=50	000050	Set diode current to 5.0A
IS1=21	000021	Set diode current to 2.1A
PWS=xxx (x: digits 0-9)	xxxxxx	Functions only with optional power monitor. Power calibration setting. Unit: 1mW/0.1W/0.01W (Unit depends on Power Monitor Type.)
Example: PWS=888	000888	Set calibration power to 8.88W (Power monitor for laser power <10W )
T1S=xxxxxx	0004751	Set the crystal 1 set temperature. Example 4751 = 47.51C
TS2=xxxxxx	0005200	Set the crystal 2 set temperature. Example 5200 = 52.00C



GTR=0	000000	Set the Gate logic to TTL high is lasing
GTR=1	000001	Set the Gate logic to TTL low is lasing
MOD=xxxxxx	000012	Set the laser operation mode. Example 000012 = Mode 12

Table 2: System Query Commands

QUERY FROM PC	RESPONSE FROM CONTROLLER	COMMENTS
?DI1	000000 000001	Diode off Diode on
?QSW	000000 000001	Q-switch off Q-switch on
?SHT	000000 000001	Shutter Closed Shutter Open
?EXT	000000 000001	Internal trigger mode External trigger mode
?PRF Example: ?PRF	xxxxxx 023456	Pulse rate set. Unit HZ. Pulse rate is 23456HZ (23.4 kHz)
?IS1 Example: ?IS1	xxxxxx 000050	Diode current setting. Unit: 0.1A. Diode current setting is 5.0A
?IDI Example: ?IDI	xxxxxx 000050	Actual diode current set. Unit: 0.1A. Actual diode current is 5.0A
?PWF Example: ?PWF	xxxxxx 000950	Power control factor (Range: 1—980. 980 for highest laser power output) Example, laser output set to Maximum. Note the maximum PWF value will vary from model to model. Please refer to your laser test report for your systems maximum PWF value.
?AOW Example: ?AOW	xxxxxx 000123	Hour meter reading. Unit: 1 hour. Hour meter reading is 123 hours.
?OKK		Firmware version number

?TK1	xx4751	Query Crystal 1 Actual temperature in units of 0.01 degC. Example 4751 = 47.51C
?T1S	xx4751	Query Crystal 1 Set temperature in units of 0.01 degC. Example 4751 = 47.51C
?TK2	xx5000	Query Crystal 2 Actual temperature in units of 0.01 degC. Example 5000 = 50.00C
?T2S	xx5000	Query Crystal 2 Set temperature in units of 0.01 degC. Example 5000 = 50.00C
?TLA		Query Actual laser head temperature in units of 0.01 degC.
?TDI		Query Diode 1 Actual temperature in units of 0.01 degC.
?GTR		000000: gate High trigger 000001: gate Low trigger
?MOD		Query the laser operation mode. Example 000012 = Mode 12
?STA	000000 000001 000002 000003 000004 000005 000006 000007 000008 000009 000010 000011 000012 000013 000014 000015 000016 000017 000018 000019 000020 000021 000022 000023	Normal Diode 1 Temperature High Diode 1 Temperature Low Laser Head Temperature High Laser Head Temperature Low Environmental Temperature High Environmental Temperature Low Interlock Open Fiber error Diode 2 Temperature High Diode 2 Temperature Low Diode 3 Temperature High Diode 3 Temperature Low Crystal 1 Temperature High Crystal 1 Temperature Low Crystal 2 Temperature High Crystal 2 Temperature Low Crystal 3 Temperature High Crystal 3 Temperature Low Crystal 4 Temperature High Crystal 4 Temperature Low Not used Not used Not used

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	000024	Emergency button
	000025	Not used

Table 3: Special Controller Messages

SPECIAL CASE	RESPONSE FROM CONTROLLER	COMMENTS
" Null Command " ( Press "Enter" from keyboard ) <i>(Used to check laser mode)</i>	ERROR	Driver is in Remote mode
	LOCAL	Driver is in Local mode
Any error message: wrong message, wrong message ending (0xD, 0xA), or incorrect value range.	ERROR	Need to check the message, the ending and value. If it is caused by RS232 bit error rate, PC needs to resend message.
PC tries to send a message to laser controller when it is busy with other high priority task.	BUSY	Wait for laser driver to finish its task.
When laser alarms any command sent to laser driver will be ignored and the system will send back "ALARM", followed by the alarm condition code.	Example:  ALARM 000007	Indicates laser is alarming because of interlock open
When alarm condition is cleared, the laser will require user to enter the command RTS=1 button the front panel, this is required before any commands can be sent to the laser controller.	RESET	RESET by user required

#### 4.4 Graphical User Interface – GUI

The **AONano Precision** laser is operated directly by using the graphical user interface supplied with the laser. The GUI program operates on a standard computer running the latest version of Windows and communicates with the laser controller through the RS232 port on the computer. The GUI is designed to automatically configure the RS232 serial ports on the computer to ensure proper communication to the laser controller. The GUI will allow the users to do the following tasks:

The GUI will allow the users to do the following tasks:

- Open and Close the system shutter
- Turn on and off the pump diodes
- Adjust the repetition rate
- Adjust the number of pulses contain in burst when running burst mode
- Adjust the output power of the laser

Figure 12 shows the “User” window of the graphical user interface.

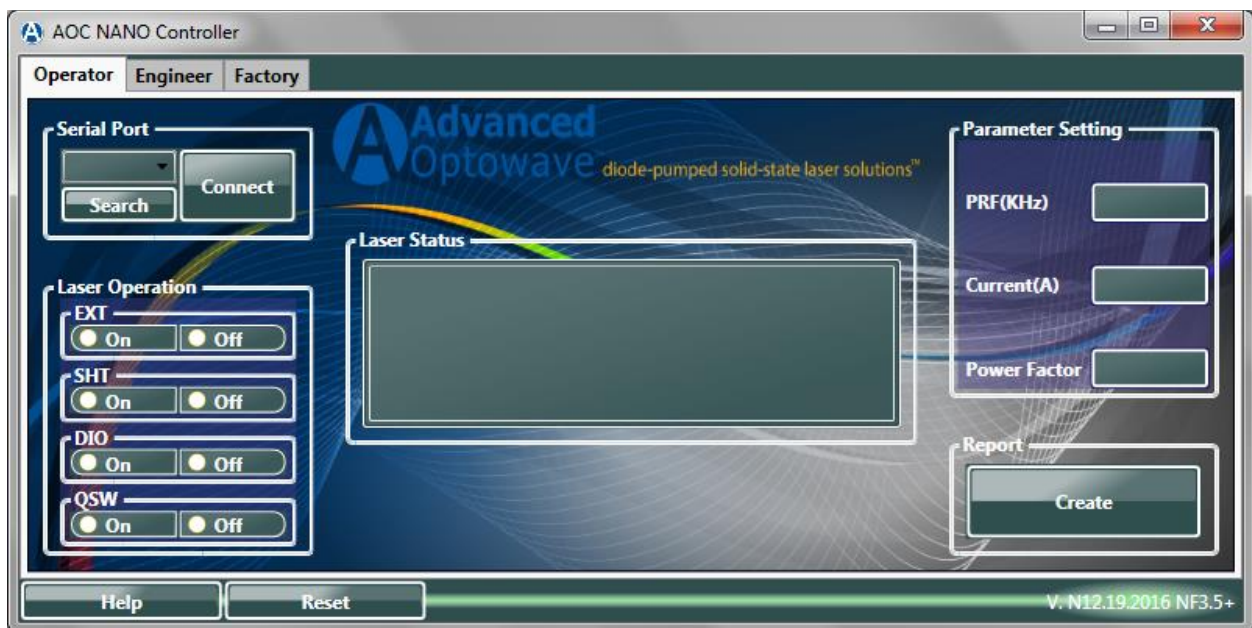


Figure 12: Advanced Optowave Graphical User Interface – GUI



Load the software provided from Advanced Optowave on a suitable computer and then connect the RS-232 port on the back of the laser controller to a suitable serial port on the computer. To connect the computer to the laser controller the front panel "Key Switch" must be in the "On" position. Once the Key Switch is in the On position, press the "Open Serial Port" button on the User window and the software automatically connects the computer to the laser controller. Once connection is established the Red icon will turn Green.

#### 4.4.1 Operator Window Section Definitions – (Figure 12)

**Laser Status** – This section of the GUI is a system status window that will display the last setting for the Shutter Status, Pump Diode Status, Repetition Rate (PRF), and Output Power Setting (PWF).

**Parameter Setting** – This section of the GUI is for making parameter related changes to the **AONano Precision** operational performance. In this section, the user can make adjustments to the Repetition Rate (PRF), Output Power Setting (MCS) and the First Pulse Suppression (MCS).

**Repetition Rate (PRF)** – *This allows the user to set the laser's repetition rate. The input is in kHz and the minimum input is 30 kHz and the maximum is 300 kHz. If a lower rep rate is required, please contact the Advanced Optowave Customer Service Department.*

**Output Power Setting (PWF)** – *This allows the user to set the laser's output power. The is a value from 0 to 990, with zero being no output and 990 being maximum power. Each laser ships with a calibrate lock-up sheet that can be used to set the desired output power.*

**Pump Diode Currents** – *This allows the user to enter specific currents for the pump diodes. Note: The laser system is designed to operate at a set operating current which will allow the system to operate at its optimum performance. Please do not any*

When using the GUI, to change one of these parameters all the user has to do is enter the new desired value in the specific space and hit the "Enter or Carriage Return". Once the command is accepted, the new value for that parameter will be displayed in the "Laser Status" Section.

**Laser Operation** – This section of the GUI is for turning on the laser and controlling the state of the shutter. In the laser window, the user can simply click the "On" checkbox and the laser will start or conversely click the "Off" checkbox and the laser will shut off. The same is true for the shutter window.

**4.4.2 Engineer Window Section Definitions – (Figure 13)**

The engineer window, as show in Figure 18 is password protected, the standard default password is "AOC". In order to access the Engineer window, to access this window the authorized operator needs to input the password. The password change be changed by following the steps outlined

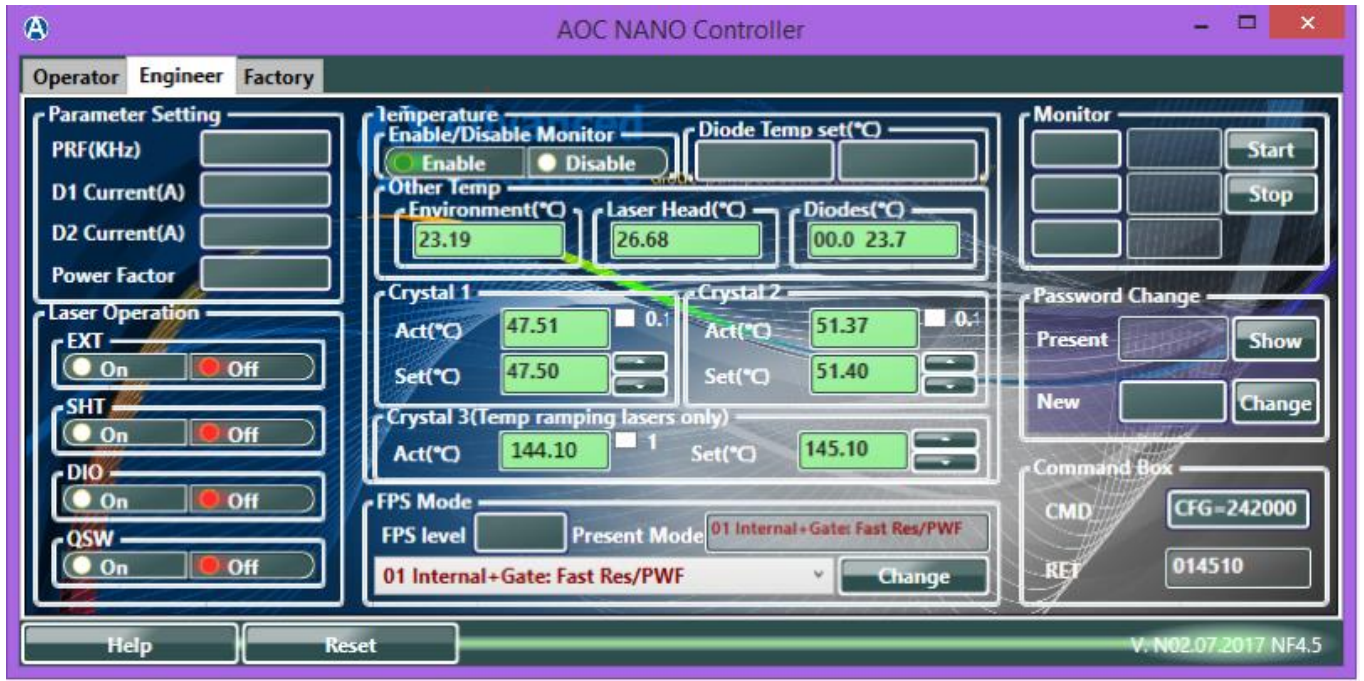


Figure 13: Advanced Optowave Graphical User Interface – GUI Engineer Tab



**Parameter Setting** – This section of the GUI is for making parameter related changes to the **AONano Compact** operational performance. In this section, the user can make adjustments to the Repetition Rate (PRF), Power Factor Setting (MCS) and the Pump Diode Currents.

**Repetition Rate (PRF)** – *This allows the user to set the laser's repetition rate. The input is in kHz and the minimum input is 30 kHz and the maximum is 300 kHz. If a lower rep rate is required, please contact the Advanced Optowave Customer Service Department.*

**Power Factor (PWF)** – *This allows the user to set the laser's output power. The is a value from 0 to 990, with zero being no output and 990 being maximum power. Each laser ships with a calibrate lock-up sheet that can be used to set the desired output power.*

**Pump Diode Currents (Current)** – *This allows the user to enter specific currents for the pump diodes. However, it should be noted that the controller will remember the last current setting. Note: The laser system is designed to operate at a set operating current which will allow the system to operate at its optimum performance. Please do not any adjustments the diode current without first contacting the Advanced Optowave Customer Service Department.*

**First Pulse Suppression (FPS)** – All AOC nanosecond controllers have the FPS function. "FPS" is a function is used for controlling the first pulse omitted from the laser in both Internal trigger mode and external trigger mode.

There is a number of different preset modes that the customer can choose based on their application requirements. Each of these modes can operate under different conditions as shown below:

- Internal Trigger or External Trigger
- Fast Thermal Response or Slow Thermal Response
- PWF (Power Factor) control or Duty Control
- Gate enabled or disabled

Listed below is the different modes that the FPS function can be used in and are accessible using the pull-down function in the FPS Mode section of the Engineer GUI:

Table 4: FPS Modes

Mode	Trigger	Gate Status	FPS Mode	Power control type
<b>0</b>	INTERNAL TRIGGER	GATE ENABLED	SLOW RESPONSE (RAMP)	PWF
<b>1</b>	INTERNAL TRIGGER	GATE ENABLED	FAST RESPONSE	PWF
<b>2</b>	INTERNAL TRIGGER	GATE ENABLED	FPS not enabled	PWF
<b>3</b>	INTERNAL TRIGGER	GATE DISABLED		PWF
<b>4</b>	EXTERNAL TRIGGER	GATE ENABLED	SLOW RESPONSE (RAMP)	PWF
<b>5</b>	EXTERNAL TRIGGER	GATE ENABLED	SLOW RESPONSE (RAMP)	DUTY
<b>6</b>	EXTERNAL TRIGGER	GATE ENABLED	FAST RESPONSE	PWF
<b>7</b>	EXTERNAL TRIGGER	GATE ENABLED	FAST RESPONSE	DUTY
<b>8</b>	EXTERNAL TRIGGER	GATE ENABLED	FPS DISABLED	PWF
<b>9</b>	EXTERNAL TRIGGER	GATE ENABLED	FPS DISABLED	DUTY
<b>10</b>	EXTERNAL TRIGGER	GATE DISABLED	SLOW RESPONSE (RAMP)	PWF
<b>11</b>	EXTERNAL TRIGGER	GATE DISABLED	SLOW RESPONSE (RAMP)	DUTY
<b>12</b>	EXTERNAL TRIGGER	GATE DISABLED	FAST RESPONSE	PWF
<b>13</b>	EXTERNAL TRIGGER	GATE DISABLED	FAST RESPONSE	DUTY
<b>14</b>	EXTERNAL TRIGGER	GATE DISABLED	FPS DISABLED	PWF
<b>15</b>	EXTERNAL TRIGGER	GATE DISABLED	FPS DISABLED	DUTY

Using the FPS Level function on the GUI the user can set the amplitude of the first pulse. To set the FPS Level the user needs to enter a number between 0 and 1000, the higher the input the higher amplitude of the first pulse.

In order to set the appropriate FPS operating mode, the user needs to follow the steps below:

- Turn off the Q-Switch
- Using the drop-down menu choose the operating mode for the FPS function
- Press change to load the new settings
- Turn on the Q-Switch.

**Temperature** – This section of the GUI is used for monitoring the systems temperatures, and setting the harmonic crystal temperatures

**Monitor** – This section is used to enter a command for a parameter then the GUI will provide constant feedback for that parameter.

**Password Change** – The section allows the user to set a password for accessing the Engineer Tab. To change the password, enter the current password in the Present field. Then enter your new password in the New field. Press the change button for the new password to take affect

**Command Box** – This section is used to send approved RS232 commands to the laser controller to set parameters, quarry the laser and special commands – please refer to Tables 1 – 3.

When using the GUI, to change one of these parameters all the user has to:

- Turn off the Q-Switch
- Using the drop-down menu choose the operating mode for the FPS function
- Press change to load the new settings
- Turn on the Q-Switch

Please refer to Section 6 – Laser Control, for a more detailed description of Output Power Control, First Pulse Suppression, Duty Control and Gate Mode.

## 5. Laser Operation



### **Warning**

The laser radiation generated by this laser system is in the invisible range (1064 nm). If the system is equipped with the second harmonic module, third harmonic or fourth harmonic then the system will also generate laser radiation in the visible range (532 nm), and ultra-violet (355 nm).

**Wear Laser Safety Glasses!**

### 5.1 Initial Startup Procedure

Before progressing further at this time, please take a moment to review the following items to make sure the following items are correct and true:

- The laser is secured and there is a correctly rated power meter located in front of the laser output aperture.
- The laser controller is secured and there is adequate clearance in the front and rear for air circulation.
- Ensure the electrical connections are still correct as shown in figure 9.
- Ensure the interlock is installed
- The main power switches on the laser control and chiller are in the "On" position.
- **Please make sure the output beam is contained with beam blocks or external power meter and laser safety glasses on being used.**

### 5.2 Laser Start-up

#### 5.2.1 Initial Warm-up stage:

With the key switch turned to the right and in the "On" position, allow the system to warm-up for at least 10 minutes. (This assumes the main power Switch is in the "On" position) During this 10-minute warm-up period if the system is equipped with a chiller it will be running which allows the system to thermally stabilize.



**For your information**

It is important that the system is allowed to thermally stabilize for 10 minutes when AC power is first applied to the system. The system will maintain a stable harmonic temperature as long as there is DC applied to the controller and the main power switch located on the back of the controller is left in the "ON" position.

**5.2.2 Load Graphical User Interface - GUI**

Launch the Advanced Optowave GUI on your computer. On the GUI click "Connect Button" to connect the computer to the laser controller.

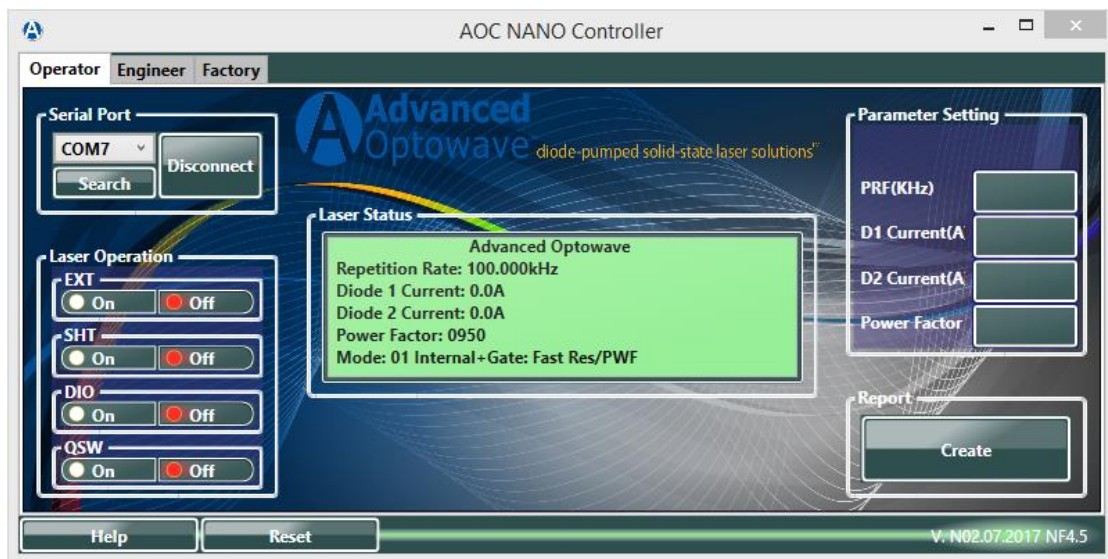


Figure 14: Operator Screen



**For your information**

Every time the Key Switch is on the laser system will run a diagnostic program to make sure the laser is operating properly.

### 5.2.3 Verify Harmonic Crystal Temperatures

During the first initial turn-on procedure, it is important to verify that the harmonic crystal temperatures are close to the factory set temperatures prior to using the system. You can monitor these temperatures using the "Engineer Tab" in GUI. The Engineer Tab is password protected, please click the Engineer Tab and then when prompted please enter the case sensitive password "AOC". Once in the Engineer GUI, please enable the Temperature Monitoring Feature by clicking the enable button as shown in Figure 15.

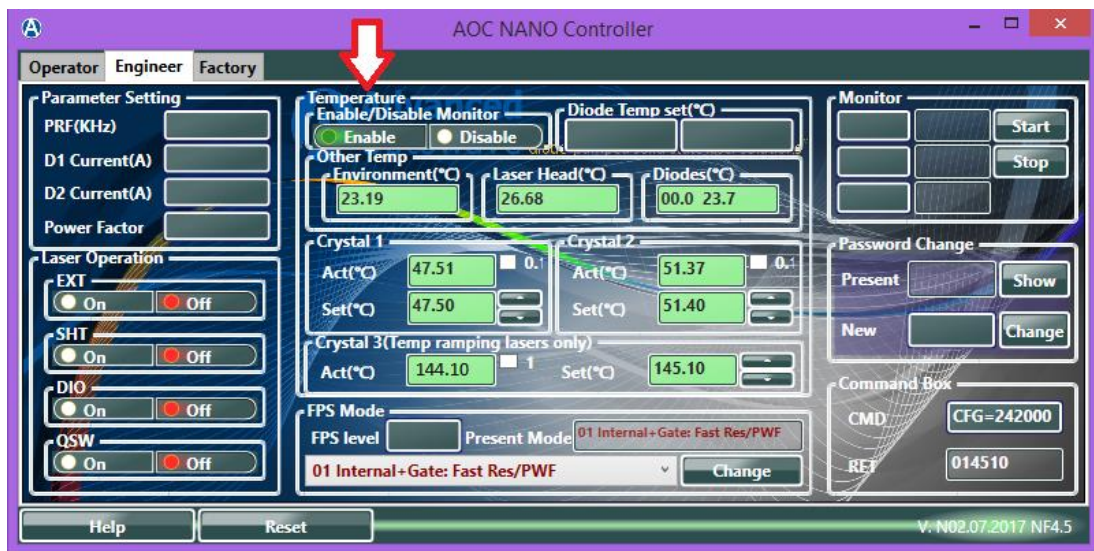


Figure 15: Engineer GUI Window

With the temperature monitor feature enabled please check the actual temperatures of Crystal 1 and 2 and make sure the delta between the set temperature and actual temperatures is no more than 0.5°C. If both Crystal 1 and Crystal 2 temperatures are within these ranges, please move to the next step. If the temperatures deltas are outside these ranges, please give the system some more time to have these temperatures stabilize.

### 5.2.4 Enable Intracavity Shutter

Before you open the shutter please make sure there is a beam dump or power meter located in front of the output window.

You can open the shutter by clicking on the "On" button located in the Laser Operation section and is titled "SHT". Once clicked the "On" indicator will turn green and the Off indicator will turn off.

### 5.2.5 Diodes

You can enable the pump diode by clicking on the "On" button located in the Laser Operation section and is titled "DIO". Once clicked the "On" indicator will turn green and the Off indicator will turn off.

The current(s) will automatically ramp up to the last set value. Allow the laser to operate in CW mode for approximately 5 minutes, this will allow the optical components time to thermally stabilize.



---

#### **Caution**

Please make sure that you only operate the laser at the diode current settings as they are indicated in the test data report supplied with your shipment.

---

### 5.2.1 Enable Q-Switch

After the 5-minute warm-up period, please enable the Q-Switch by clicking on the "On" button located in the Laser Operation section and is titled "QSW". Once clicked the "On" indicator will turn green and the Off indicator will turn off. The laser is now ready to use.

### 5.2.2 Optimize Crystal Temperatures

Now that this system is fully operational, the harmonic crystals may need to be optimized for best performance. The system is equipped with two (2) harmonic crystals (UV systems), please start the optimization process with Crystal 2 first and then move to Crystal 1. For Green only systems please use the same process



below but please only optimize Crystal 1, as green systems don't have a Crystal 2. It should be also noted this crystal might need to be optimized again after some usage. Below are the steps to optimizing the respective crystal temperatures. *(It should be noted that for IR only systems there is no harmonic crystals in the system, while the GUI will display temperatures, but making any adjustments to these temperatures will not affect the performance of the system.)*

- While in the Operator GUI please hit the Engineer Tab and then the password provided with your system when prompted. Once the Engineer GUI is opened locate the Crystal 2 Temperature Adjustment Section, see figure 20.
- During this procedure please make sure that there is a power meter in front of the laser and that you are monitoring the power as you make the following adjustments.
- The default setting for the temperature adjustment of the crystals to be 0.01°C steps, this can be changed to 0.1°C steps, at this time please check the box label 0.1°C located just above the adjustment arrows in the Crystal 2 Window.
- Using the "UP" arrow located to the right of the set temperature make small 0.1°C changes to the set temperature. It will take a few seconds for the crystal to respond to the change.
- If the power on the power meter showed an increase in power, continue to make 0.1°C adjustments until you see the output power decrease, at this point you have past the optimal crystal temperature.
- Once the maxima temperature has been passed please start lowering the set temperature in 0.01°C steps, (this can be done by unchecking the 0.1°C box) until the laser has reached its peak performance.
- Once Crystal 2 is fully optimized, using the same optimization process please now optimize Crystal 1 for optimum performance.

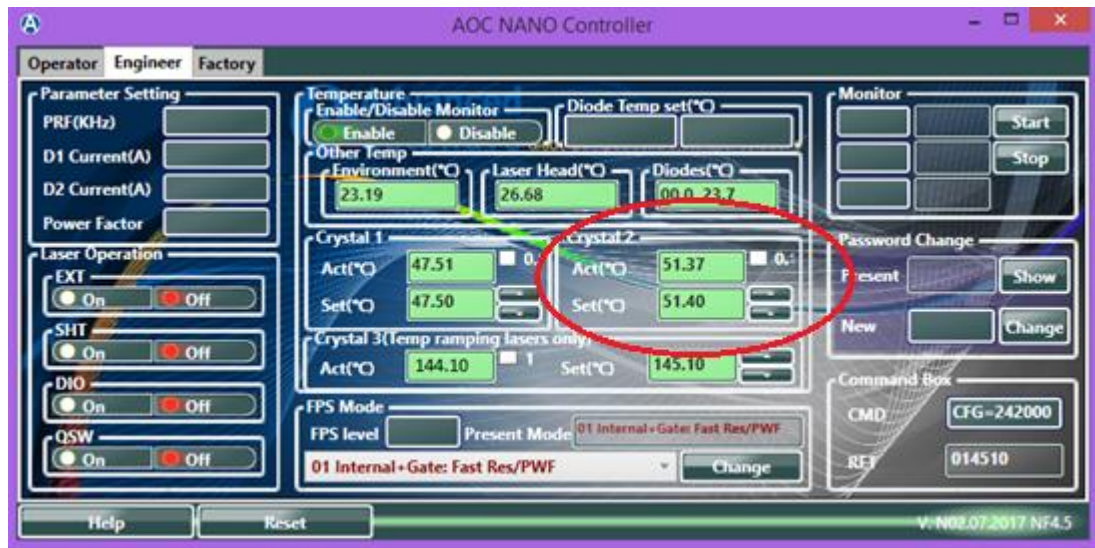


Figure 16: Engineering GUI with Crystal 2 Temperature Section Highlighted



### For your information

Please contact Advanced Optowave's Service Department if you are unable to achieve the specified output power by adjusting the harmonic Crystals.

#### 5.2.1 Final System Warm-up

Now that this system is fully operational, open the shutter by clicking the Open checkbox in the Shutter section of the GUI. **Please make sure the output beam is contained in the external power meter and laser safety glasses are being used.** Allow the system to warm-up and thermal stabilize for another 20 minutes before using the laser for your given application.

### 5.3 Laser Standby Mode

For short periods (<5 hours) of non-operational use, it is recommended to turn off the QS and to close the external shutter. In this state the system will be running in CW mode

as this puts the laser into "Standby Mode". Standby Mode allows the system to set at a stabilized temperature, with the pump diodes on and the system ready for a fast response to full power in roughly 1  $\mu$ s without having to cycle the pump diodes on and off. It has been well documented that cycling the pump diodes many times a day can shorten their expected lifetimes.

If the laser is going to be in Standby Mode for longer than 5 hours, it is recommended to shut-down the laser using the procedure outlined in subsection 5.4 – Laser Shut-down Procedure.

## 5.4 Laser Shut-down Procedure

Below are the steps for shutting down the laser correctly and should be performed any time the laser is going to be idle for more than 5 hours. For periods shorter than 5 hours, it is recommended to put the laser in Standby Mode as described in subsection 5.3 – Laser Standby Mode.

- Using the AOC GUI close the shutter by clicking the "Closed" checkbox located in Shutter window in the Laser Operation section of the AOC GUI.
- Using the AOC GUI turn the laser off by clicking the "Off" checkbox located in Laser window in the Laser Operation section of the AOC GUI.
- On the front panel of the laser controller rotate the Key counter-clockwise to turn the Key Switch to the off position



### ***For your information***

It is recommended to leave the main power switch located on the laser controller in the "On" position at all times. This will aid in the overall system stability. Laser Control.

## 6. Laser Control

The **AONano Precision** can be controlled via two (2) different methods; (1) Using the supplied Graphical User Interface –GUI or (2) Using a HyperTerminal session.

The **AONano Precision** comes equipped with four (4) unique operating commands/functions that have been developed to aid in the process development and deployment of applications using this unique form of light. This section of the manual discusses each of the four commands.

## 6.1 Power Control – PWF

The Power Control or PWF allows for fast control of the out power of the laser without causing stability or beam quality related issues. The command operates by using a PWF value to determine the different output powers the laser will operate at. During the final test process, Advanced Optowave will calibrate the PWF values and provide them with a lookup chart showing the different laser output power for different PWF values. Maximum output power is achieved at a PWF Value of 990. Conversely the minimum output power is achieved at a PWF Value of 1. (NOTE: The actual Low limit and high limit will vary from laser model to model.) These values can be inputted into the Power Factor (PWF) window in the Laser Parameter section of the AOC GUI. If you are using your own GUI and communicating directly to the laser control via the RS232, then you would use the PWF Command as described in Table 1 –System Control Commands.

## 6.2 First Pulse Suppression – FPS

First Pulse Suppression (FPS) – All AOC nanosecond controllers have the FPS function. “FPS” is a function is used for controlling the first pulse omitted from the laser in both Internal trigger mode and external trigger mode.

There are a number of different preset modes that the customer can choose based on their application requirements. Each of these modes can operate under different conditions as shown below:

- Internal Trigger or External Trigger
- Fast Thermal Response or Slow Thermal Response
- PWF (Power Factor) control or Duty Control
- Gate enabled or disabled

Listed below is the different modes that the FPS function can be used in and are accessible using the pull-down function in the FPS Mode section of the Engineer GUI:

Table 5: FPS Modes

Mode	Trigger	Gate Status	FPS Mode	Power control type
0	INTERNAL TRIGGER	GATE ENABLED	SLOW RESPONSE (RAMP)	PWF
1	INTERNAL TRIGGER	GATE ENABLED	FAST RESPONSE	PWF
2	INTERNAL TRIGGER	GATE ENABLED	FPS not enabled	PWF
3	INTERNAL TRIGGER	GATE DISABLED		PWF
4	EXTERNAL TRIGGER	GATE ENABLED	SLOW RESPONSE (RAMP)	PWF
5	EXTERNAL TRIGGER	GATE ENABLED	SLOW RESPONSE (RAMP)	DUTY
6	EXTERNAL TRIGGER	GATE ENABLED	FAST RESPONSE	PWF
7	EXTERNAL TRIGGER	GATE ENABLED	FAST RESPONSE	DUTY
8	EXTERNAL TRIGGER	GATE ENABLED	FPS DISABLED	PWF
9	EXTERNAL TRIGGER	GATE ENABLED	FPS DISABLED	DUTY
10	EXTERNAL TRIGGER	GATE DISABLED	SLOW RESPONSE (RAMP)	PWF
11	EXTERNAL TRIGGER	GATE DISABLED	SLOW RESPONSE (RAMP)	DUTY
12	EXTERNAL TRIGGER	GATE DISABLED	FAST RESPONSE	PWF
13	EXTERNAL TRIGGER	GATE DISABLED	FAST RESPONSE	DUTY
14	EXTERNAL TRIGGER	GATE DISABLED	FPS DISABLED	PWF
15	EXTERNAL TRIGGER	GATE DISABLED	FPS DISABLED	DUTY

Using the FPS Level function, the GUI the user can set the amplitude of the first pulse. To set the FPS Level value in the Engineer GUI by entering a number

between 2 and 1000, the higher the input the higher amplitude of the first pulse. See Figure 21 for an example of this feature.

To select a specific mode of operation please use the following steps:

- Turn off the Q-Switch
- Using the drop-down menu choose the operating mode for the FPS function
- Press change to load the new settings
- Turn on the Q-Switch



*Figure 17: Examples of using the FPS function to control the first pulse suppression.*

### **Fast Response First Pulse Suppression**

In fast response mode (for both internal trigger mode and external trigger mode) the first trigger pulse signal is used for first pulse suppression, so the delay to the first optical pulse is as short as possible. The addition of the FPS Mode will also enable the use of DUTY control.

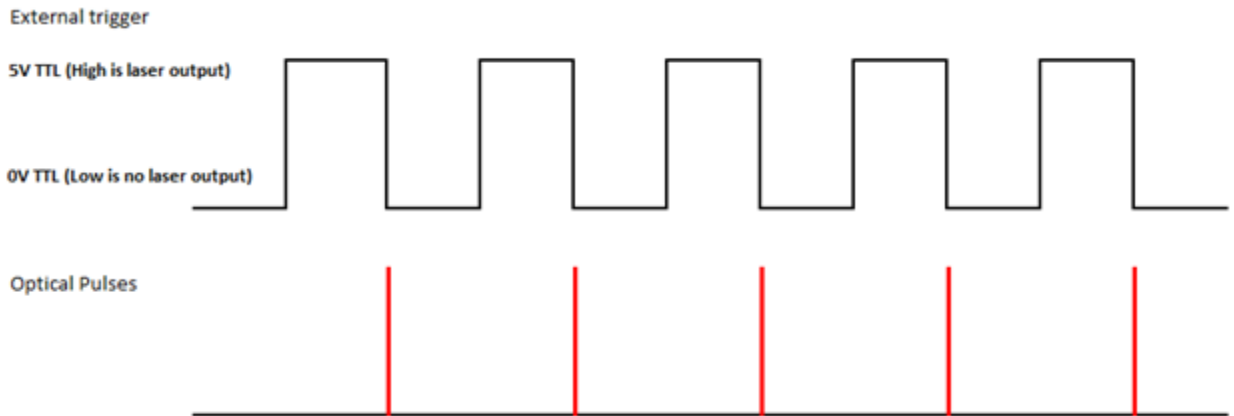


Figure 18: Example of the Fast Response Mode of First Pulse Suppression.

### Slow Response First Pulse Suppression – FPS = 4

In Slow response mode, there is delay from the falling edge of the trigger signal of 500µs to the optical pulse. This delay in the optical pulse is the time necessary to suppress the First Pulse. In Slow Response mode, the amount of First Pulse Suppression cannot be adjusted. See Figure 23 for an example of this feature.

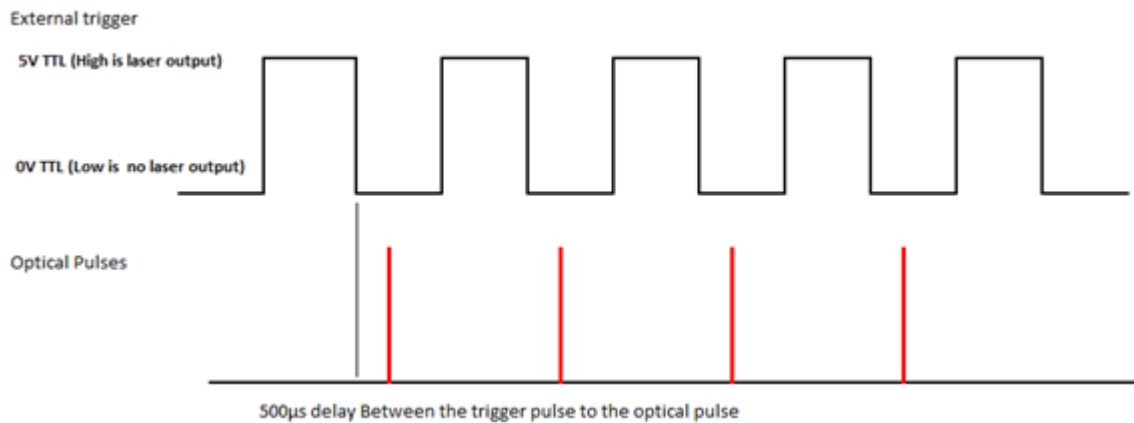


Figure 19: Example of the Slow Response First Pulse Suppression.

### 6.3 Dynamic Pulse Energy Controlled by Duty Control

Duty control is used to adjust the output power of a laser by varying the DUTY cycle time of an External Trigger signal.  $DUTY\ Cycle = \frac{Time\ at\ TTL-High}{Period\ of\ TTL}$

For example, if a laser is running at 10 KHz, the period is 100us with 2 us TTL-High and 98 us TTL-Low, the DUTY will be 2%, and the laser will be at full power. If the duty changed from 2% to 100% then the laser output will drop to minimal power.

The chart below shows the change in output power vs the DUTY cycle. The values are approximate.

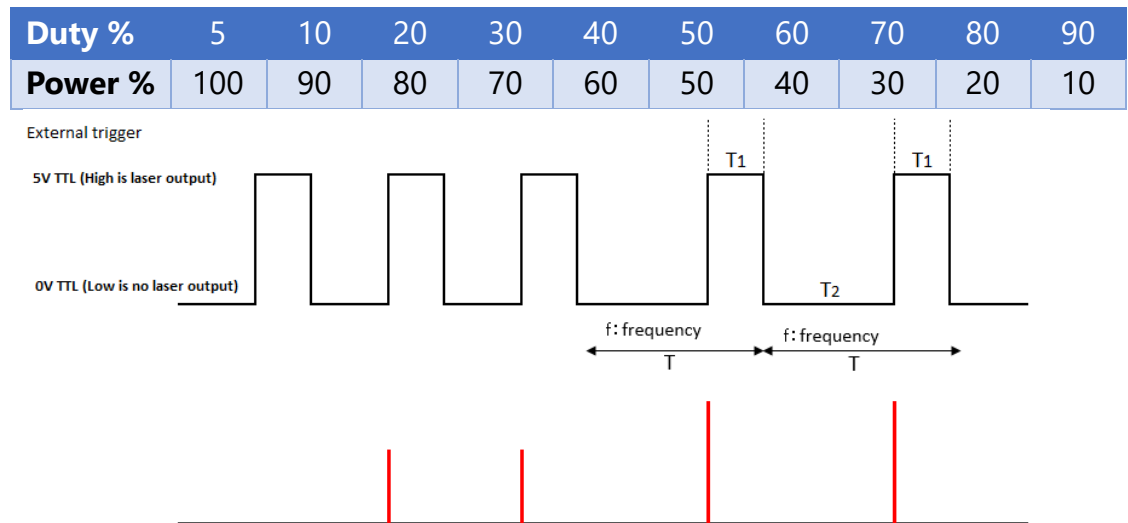


Figure 20: Example of the Dynamic Pulse Energy Controlled by Duty Control

While the system has been optimized for the best performance and stability at the specified current in the test data supplied with the system. Slight changes in diode can be made to adjust the laser power. The output power of the laser can also be changed by adjusting the current level supplied to the diodes. Current adjustment can be set via the GUI or remotely via RS232 commands, but please keep in mind the beam profile and the beam divergence angle can be affected by adjusting the current. This effect will vary from model to model.



## 7. Maintenance



### Warning

Always wear laser safety glasses when operating or working on the **AONano Precision** laser, generates laser radiation in the ultra violet wavelength range (355 nm). The system also generates laser radiation at the fundamental wavelength (1064 nm) as well as the second harmonic (532 nm). Please ensure that proper eye protection is worn at all times when operating or servicing this laser source.

### Wear Laser Safety Glass

To ensure the longest and highest performance out of your new **AONano Precision** laser, Advanced Optowave has developed a periodic maintenance schedule to help achieve this goal. Table 6 shows the maintenance schedule.

Table 6: Maintenance Schedule

FREQUENCY	MAINTENANCE EVENT
<b>Every Month</b>	Generate a maintenance log by pressing the "report" button on the GUI
<b>Every 2 Months</b>	Check the laser output window for damage, replace if damaged.
<b>Every 3 Months</b>	Check the chiller coolant level
<b>Every 12 Months</b>	<ol style="list-style-type: none"> <li>1. Replace the chiller coolant</li> <li>2. Blow-out the chiller's air intake and output cooling channels.</li> <li>3. Blow-out the laser controller's intake and output cooling channels.</li> <li>4. Replace the laser's output window.</li> </ol>

### 7.1 Inspection of Output Window for Damage

The **AONano Precision** laser is equipped with a replaceable output window. This window should be inspected every 2 months depending on the laser usage. **This test requires the user to wear safety laser glasses.** To inspect for damage, please setup a

beam block capable of handling the full output of the laser. The beam should look round and free of scatter. If you see a large amount of scatter around the beam the output window should be replaced.

To replace the output window, execute the following steps

- Shut down the laser using the steps shown in Section 5 Laser Operation, subsection 5.4 – Laser Shut Down Procedure.
- Remove the four screws holding the output window into the laser housing.
- Remove the window from the housing. The output window is a Brewster window. In order to minimize downstream alignment issues, please note the orientation of the window when removing it from the laser housing.
- Insert the new output window into the laser housing – noting to insert the window with the same orientation as the old window. Using the four original screws secure the laser window in the laser head.
- Restart the laser using the steps shown in Section 5 Laser Operation, subsection 5.2.4 – Start Laser Procedure
  - Plug the chiller back into the power source located on the rear panel of the laser controller and turn the power switch on the chiller to the On position.
  - Using the Key Switch on the laser controller turn on the main power and energize the chiller to circulate the new coolant in the system – you may have to add new coolant.
  - Replace the black filler cap.

## 7.2 Updating Monthly Maintenance Log

Every Advanced Optowave GUI is equipped with a maintenance log data capture feature. The purpose of this log is to track the lasers operating parameters over the course of its life. This is an important document to Advanced Optowave's Service Team as it can be used to help diagnostics if a laser issue does occur. This log should be filled out monthly by pressing the Report button on the GUI.