Acceptance Test Procedure (ATP) for QCW Laser: Optical Tests

# Introduction

**Purpose** This document outlines the Acceptance Test Procedure (ATP) for the optical assessment of a Quasi-Continuous Wave (QCW) laser system. The primary focus is to evaluate key optical characteristics such as pulse width, pulse frequency, wavelength, and coherency, ensuring the laser meets specified operational standards.

**Equipment Required**

* **Oscilloscope**: For measuring pulse width and jitter.
* **Frequency Counter**: To determine the pulse frequency.
* **Spectrometer or Wavelength Meter**: For accurate wavelength measurement.
* **Interferometer**: For assessing coherency.
* **Beam Profiler or CCD Camera**: To evaluate beam quality and mode structure.

**General Instructions**

* **Preparation**: Ensure all instruments are calibrated and in good working condition. Set up the test environment to mitigate external factors like vibrations or ambient light that may affect measurements.
* **Safety**: Always adhere to laser safety guidelines. Use appropriate laser safety glasses and ensure no direct eye exposure to the laser beam.
* **Procedure Consistency**: Conduct all tests under similar environmental conditions to ensure consistency in data.
* **Data Recording**: Record all measurements accurately. Multiple readings may be necessary to account for any variability.
* **Analysis**: Compare the measured values against the manufacturer’s specifications. Note any deviations and investigate potential causes.

**Specific Tests**

* **Pulse Width and Jitter**: Use the oscilloscope to measure the duration of the laser pulses and the variability (jitter) in their timing.
* **Pulse Frequency**: Employ a frequency counter to determine the rate at which the laser emits pulses.
* **Wavelength Measurement**: Utilize a spectrometer or wavelength meter to accurately determine the laser's emission wavelength.
* **Coherency Test**: An interferometer can be used to assess the coherency of the laser beam, which is crucial for applications requiring high precision.
* **Beam Quality Assessment**: A beam profiler or CCD camera should be employed to evaluate the spatial quality and mode structure of the laser beam.

**QCW Laser Optical Characteristics**

| **Test Category** | **Measurement Tool** | **Example Value Criteria** | **Units** | **Instructions for the Worker** |
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| **Pulse Width** | **Oscilloscope + Detector** | **Width: 10-20 ns** | **Nanoseconds (ns)** | **Instructions: 1. Connect the laser output to the oscilloscope using a suitable connector. 2. Attach a detector to the laser beam path. 3. Ensure the oscilloscope is set to the appropriate settings: sufficient bandwidth, time scale, and trigger level to capture the laser pulse accurately. 4. Emit multiple laser pulses and record the waveforms on the oscilloscope. 5. Using the detector, measure the pulse width at its full width at half maximum (FWHM) intensity for each pulse. 6. Calculate the average pulse width. 7. Record the result.** |
| **Pulse Frequency** | **Oscilloscope** | **Frequency: 1-10 kHz** | **Kilohertz (kHz)** | **Instructions: 1. Connect the laser output to the oscilloscope. 2. Ensure the oscilloscope is set to the appropriate settings: sufficient bandwidth, time scale, and trigger level to accurately capture the laser pulse. 3. Emit laser pulses for a fixed duration (e.g., 1 second). 4. Use the oscilloscope to measure the time interval between consecutive pulses. 5. Calculate the pulse frequency. 6. Record the result.** |
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| **Wavelength** | **Spectrometer/Wavelength Meter** | **Wavelength: 1064 ± 5 nm (example for Nd:YAG)** | **Nanometers (nm)** | **Instructions: 1. Direct the laser beam into the spectrometer or wavelength meter using appropriate optics. 2. Allow the instrument to stabilize. 3. Read and record the laser's emission wavelength. 4. Verify the stability of the wavelength measurement over time.** |
| **Coherency** | **Interferometer** | **Coherence Length: > 10 m** | **Meters (m)** | **Instructions: 1. Set up the interferometer to split and recombine the laser beam. 2. Ensure precise alignment of optical components. 3. Observe the interference pattern and note its characteristics. 4. Assess the coherency by observing the phase stability of the laser beam over time and distance. 5. Verify if the coherence length meets the specified criteria.** |
| **Beam Profile** | **Beam Profiler/CCD Camera + MATLAB** | **M^2 < 1.2** | **N/A** | **Instructions: 1. Position the beam profiler or CCD camera at an appropriate distance from the laser output. 2. Capture the spatial intensity distribution of the laser beam. 3. Use MATLAB (provided code below) to analyze the beam profile, including shape, width, and uniformity. 4. Record the M^2 value and assess if it meets the specified criteria.** |
| **Beam Divergence** | **Beam Profiler/Goniometer** | **Divergence: < 1.5 mrad** | **Milliradians (mrad)** | **Instructions: 1. Measure the beam diameter at multiple points along the beam path using a suitable detector. 2. Calculate the divergence angle by analyzing the change in beam diameter over distance. 3. Verify if the divergence angle meets the specified criteria. 4. Ensure that measurements are taken along a straight line.** |
| **Polarization** | **Polarization Analyzer** | **Polarization Ratio: > 90%** | **Percentage (%)** | **Instructions: 1. Introduce the laser beam into a polarization analyzer. 2. Observe and record the polarization ratio, which represents the percentage of laser power in a specific polarization state. 3. Ensure the polarization ratio meets the specified criteria.** |