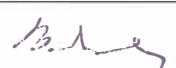


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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints on one 1030 nm oscillator for the ADONIS-FSYNC project. This can lead to the identification of product interfaces with the ELI Beamlines science-based technology and ELI building facility. This RSD also acts as the parent document for the technical requirements that need to be addressed in lower-level design description documents.

1.2. Scope

This RSD contains all of the technical requirements: functional, performance and design, delivery, safety and quality requirements for the following product (tender code: TP22_056): **"Repetition rate lockable femtosecond fiber laser oscillator operating at 1030 nm"** (further referred to as **"Oscillator"**).

The Oscillator is considered to be a part of FSYNC Laser technology and will be placed in the L1 laser hall. The Oscillator including accessories is registered in the CA PBS software under the following PBS code: *RA1.L1.L1_2.OSC.SPAR.1*.

This Oscillator is product **Category B** according to the ELI Beamlines RSD categories. Category B is an Off-the-shelf Product with customization (e.g., product performance) that does not require any design modifications of the product. All verification activities performed by a supplier shall be executed in accordance with the supplier's plan of outgoing inspection and tests. The verification of all specified parameters listed in this RSD shall be undertaken by the supplier before delivery to the ELI Beamlines facility and the Oscillator shall be furnished with a verification protocol (FAT protocol) and a declaration of conformity, to reflect their proper characteristics. Furthermore, the Oscillator will be subject to testing and verification upon delivery and installation at the ELI Beamlines facility by qualified ELI Beamlines personnel. All non-conformances (if any) must be addressed by the supplier in a timely manner.

1.3. Terms, Definitions and Abbreviations

1.3.1. Abbreviations

For the purpose of this document, the following abbreviated terms are applied:

Abbreviation	Meaning
CA	Contracting Authority (Institute of Physics AV ČR, v. v. i.)
ELI	Extreme Light Infrastructure
FAT	Factory Acceptance Test
FWHM	Full Width at Half Maximum
RF	Radio Frequency

Abbreviation	Meaning
RMS	Root Mean Square
RSD	Requirements Specification Document
SDK	Software Development Kit
USB	Universal Serial Bus

1.3.2. Terms and Definitions

The verification of all specified functional and performance requirements listed in this RSD shall be undertaken by the supplier through one or more of the following verification methods:

- 1. Review** - Verification via Review shall consist of using approved records (examples of such approved records are design documents and reports, technical descriptions, engineering drawings, manuals and accompanying operation documentation) or evidence that unambiguously shows that the requirement is met.
- 2. Inspection** - Verification via Inspection shall consist of a visual examination of the manufactured and/or assembled product, i.e. its physical characteristics proving that the specific requirements have been met.
- 3. Test** (including functional demonstration) - Verification via Test shall consist of measuring product performance and functions under realistic operating conditions. When the test objectives include the demonstration of qualitative operational performance (functional demonstration), the execution shall be observed and results recorded.

1.4. References to standards

If this document includes references to standards or standardized/ standardizing technical documents the CA allows/permits also another equivalent solution to be offered.

2. Functional, Performance and Design requirements

REQ-035184/A

The Oscillator shall meet all the general requirements defined in Tables 1 and 3 below.

REQ-035185/A

The Oscillator shall be provided with a Remote Control Interface for basic device control and monitoring from the CA's software, without requiring any particular software or drivers to be installed. The physical interface shall be either RS-232, RS-485, Ethernet or USB.

REQ-035186/A

The Oscillator shall be equipped with an interlock input for an external dry contact (closed to enable) which disables laser emission via a reliable mechanism.

REQ-035187/A

Locking electronics are not requested from the Supplier, but fine control of the repetition rate via an externally driven piezo within a limited range, and a method of coarse tuning the repetition rate over a larger range shall be provided (see more details in Table 2).

NOTE 1: The CA will lock the Oscillator to an RF reference at 80 MHz using their own locking electronics.

NOTE 2: The fine and coarse repetition rate control parameters (e.g., sensitivity, range, capacitance, resonance) shall be documented by the Supplier in the product user manual (see REQ-035193/A).

REQ-035188/A

The repetition rate shall be controlled by adjustment of an absolute set point (e.g., temperature, actuator position); the current value of which shall be available to read and set via the Remote Control Interface.

NOTE 1: Other methods of the course repetition rate tuning (e.g., custom hardware interfaces, external motor control) are not acceptable as a means of coarse tuning.

NOTE 2: Relative adjustments (e.g., 'up', 'down' commands) are not acceptable as a means of coarse tuning.

REQ-035189/A

During the course repetition rate tuning, the Oscillator shall continue to simultaneously satisfy all performance requirements defined in Table 1.

Table 1: The parameters of the Oscillator

Description of parameter	Value	Verification details
Pulse energy	> 1 nJ in the whole bandwidth, >50 pJ in the 1029-1031 nm spectral range.	Test (FAT protocol)
Repetition rate	80.0 MHz $\pm$ 1 kHz achievable at any ambient temperature within the range of 17 – 23 deg C Absolute frequency measurements shall be made in reference to a GPS-locked 10 MHz source	Test (FAT protocol)
Pulse duration	< 30 ps (stretched) and compressible to < 300 fs	Test (FAT protocol)
Bandwidth (FWHM)	< 30 nm	Test (FAT protocol)
Output power stability	< 0.5 % RMS for one hour (3 s max averaging)	Test (FAT protocol)
Pulse energy stability	< 3 % difference of any pulse energy from the average pulse energy in a random 500 ns interval (minimum of 5 consecutive measurements).	Test (FAT protocol)
Output power drift over 24 hours	< 3 % difference of average output power (3 s max averaging) from the mean value of the oscillator output power over 24 hours within an ambient temperature variation range of $\pm$ 0.5 deg C (Larger temperature variation is allowed for the test).	Test (FAT protocol)
Output fiber specifications	PM980 single mode fiber, FC/APC connectors keyed to slow axis (3 m minimum length)	Inspection
Output isolation (built-in)	> 25 dB	Review of documentation
Timing jitter of oscillator	< 20 fs RMS (1 kHz – 1 MHz) under free running (unlocked) conditions. Phase noise shall be measured using a low-noise photodiode via a phase noise analyser at a filtered harmonic of 80 MHz	to be verified by the CA

Table 2: The parameters of piezo control of repetition rate

Description of parameter	Value
Piezo voltage range	0 - 150 V
Piezo resonance frequency	> 2 kHz
Coarse tuning range	$\pm$ 3 kHz from 80 MHz
Coarse tuning rate	> 1 kHz per minute

Table 3: General requirements

Description of parameter	Value
Electrical power	Single-phase 230 V/50 Hz; IEC (C13) socket or SCHUKO plug
Electrical controller/driver	19-inch standard rack mount dimensions
Control interface	RS-232, RS-485, Ethernet or USB

3. Delivery requirements

REQ-035190/A

The transportation of the Oscillator to the final destination at the ELI Beamlines premises shall be conducted by the Supplier.

REQ-035191/A

The Oscillator and its components shall be delivered in a protective package to prevent damage and contamination. The Oscillator and its components shall be cleaned and packaged in compliance with the cleanliness of class 7 according to ČSN EN ISO 14644 (or equivalent, e.g. EN ISO 14644).

NOTE: If the Supplier cannot fulfill class 7 cleanliness requirements, the Supplier and the CA shall agree on the cleaning methods to be used to achieve the corresponding level of cleanliness.

4. Safety Requirements

REQ-035192/A

The Supplier shall supply a Declaration of Conformity (DoC) for each product type. The DoC shall declare compliance in part with:

- Act No. 118/2016 Coll., as amended (2014/35/EU);
- Act No. 117/2016 Coll., as amended (2014/30/EU);
- the other relevant EU/EC regulation and ISO standards.

Compliance with these obligations shall be demonstrated by the (EU/EC) DoC and the CE/CCZ marking.

5. Quality requirements

5.1. General quality requirements

REQ-035193/A

The Supplier shall provide the Product User Manual (Instructions for use) as part of the delivered Product. The Product User Manual shall include the instructions and descriptions regarding the following:

- transport, handling and storage;
- installation and cleaning;
- user manual for the software, SDKs and/or communication protocol;
- safe operation and maintenance procedures.

NOTE: The content of the Product User Manual shall be agreed upon with the CA.

REQ-035194/A

The Supplier shall provide a declaration of conformity with technical requirements defined by the product RSD and ensure completeness of the Oscillator.

REQ-035195/A

The Supplier shall provide verification protocols (FAT protocols) outlining the results of tests executed for the Oscillator before its delivery at ELI Beamlines premises to confirm specification conformity (see REQ-035189/A). Verification of parameters shall be performed according to Table 1 (see chapter 2).

NOTE: The content of the verification protocols shall be agreed upon with the CA.

REQ-035196/A

The Supplier shall establish and maintain a nonconformity control system compatible with ČSN EN ISO 9001 (or equivalent, e.g. EN ISO 9001).

5.2. Acceptance

Acceptance will be carried out by the CA upon delivery of the Oscillator not obviously damaged during transport. The basis for acceptance will be verification protocols (FAT protocols) summarizing the overall verification results together with relevant documentation supporting the verification (see REQ-035192/A, REQ-035193/A, REQ-035194/A and REQ-035195/A).

The Acceptance phase shall demonstrate the following:

- The final product has been successfully verified and this process has been documented in an appropriate way through test protocols (see REQ-035195/A);
- All detected nonconformities have been solved following REQ-035196/A;
- The final product is free of fabrication errors and is ready for the intended operational use.

In case of the successful acceptance phase, the CA will provide the Supplier signed acceptance protocol. In case of the unsuccessful acceptance stage, the CA will provide the Supplier Nonconformity Report (NCR) and the process in accordance with REQ-035196/A will be applied.

REQ-035197/A

The acceptance shall be complete when the Oscillator complies with all specifications verified by the Supplier's outgoing check (see REQ-035194/A and REQ-035195/A) and after successful passing acceptance tests performed by the CA.

NOTE 1: Supplier's outgoing check shall be carried out before delivery.

NOTE 2: The final verification will be carried out by the CA after the Oscillator installation at ELI Beamlines premises within 8 weeks upon the issuing of the Handover/takeover protocol.