ISBN: 978-3-95450-214-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2021-MOPAB120

UPDATE ON INJECTOR FOR THE NEW SYNCHROTRON LIGHT SOURCE IN THAILAND

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Abstract

Design of the new 3-GeV synchrotron light source in Thailand, Siam Photon Source II (SPS-II), has been updated. The SPS-II accelerator complex consists of a 150-MeV injector linac, a 3-GeV booster synchrotron and a 3-GeV storage ring. The RF system of both storage ring and booster is based on a frequency of 119 MHz. In this paper, design considerations and specifications of the SPS-II injector linac are presented. A study on the injector linac in multi-bunch mode (MBM) and single-bunch mode (SBM) was done to get appropriate parameters for top-up injection and different filling patterns in the storage ring.

INTRODUCTION

Siam Photon Source (SPS) is the first synchrotron light source in Thailand, and the biggest synchrotron facility in South East Asia that has been operating at 1.2 GeV [1]. SPS is a second generation light source consisting of a 40-MeV linac, a full energy booster synchrotron, and a 1.2-GeV storage ring with four Double Bend Achromat (DBA) cells. There are four straight sections in the storage ring and four insertion devices (IDs) were installed. The latest ID installed recently is Superconducting Multipole Wiggler (SMPW) [2].

In order to support the growing user community of synchrotron light in South East Asia, a project to establish a new 3-GeV synchrotron light source, Siam Photon Source II (SPS-II), in Thailand has been started. SPS-II has been designed to produce synchrotron light with higher photon energy, higher brilliance, and have more ID beamlines. A Double Triple Bend Achromat (DTBA) lattice is considered to get low beam emittance and to double the number of straight sections [3]. The SPS-II project was originally planned to use a full energy linac as an injector for injecting beam to the storage ring and driving short-pulse beamlines with a possibility to become a driver for a soft X-ray free electron laser (FEL) in the future [4].

In 2020, a decision to update the SPS-II machine design in several aspects was made relying on conventional technologies. This will reduce the project cost and increase the proportion of components to be developed in Thailand. Main changes of the design are such as an SPS-II injector consisting of a linac and a full energy booster ring [5] and RF system of the storage ring and booster operating at 119 MHz [6]. Layout of the updated SPS-II accelerator complex is shown in Fig. 1.

The SPS-II project plans to use a turn-key linac system with a design and specifications that meet specific requirements of the SPS machine. Requirements, a preliminary design and specifications of the SPS-II linac are covered in this paper.

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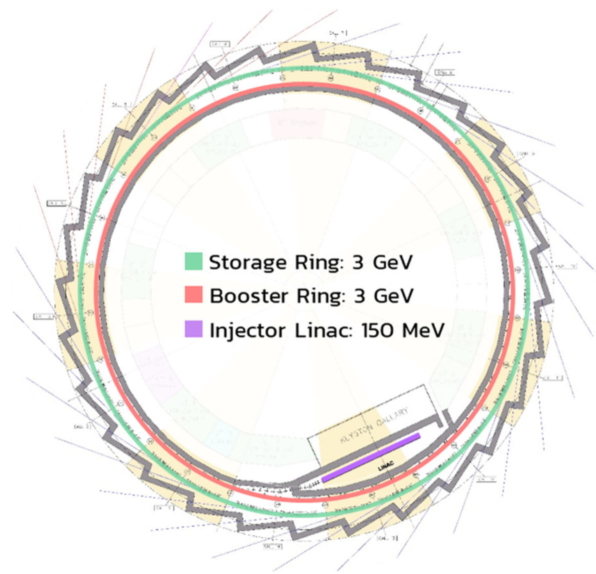

Figure 1: Layout of the SPS-II accelerator.

DESIGN REQUIREMENTS

Top-up Operation

Modern synchrotron light sources are operated in top-up mode to maintain the stored beam current at constant. This results in constant heat load on beamline components and constant photon flux at beamlines. SPS-II is planned to be operated in top-up mode like other modern machines. According to the balance between the machine performance and operating cost, beam current stability of the SPS-II storage ring is expected to be within 1% with the estimated beam lifetime of 4 hours. Requirements for top-up injection to the storage ring are summarized in Table 1. Each top-up injection should be done with one bunch train from the linac. Another factor to be taken into account is transmission efficiency from the linac to the storage ring. At this stage of the SPS-II design, the transmission efficiency of 50% is considered. Thus, the injector linac should produce a bunch train of charge more than 8 nC for compensating the transmission loss.

Filling Pattern

The SPS-II machine should support operations with different filling patterns for future experiments and applications. A uniform fill with single or multiple ion-clearing gaps is for normal user operation, while specialized filling patterns, such as camshaft, should be available for user requests and machine development. In order to fulfil this, the

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linac has to be operated in two modes, multi-bunch mode (MBM) and single-bunch mode (SBM).

Table 1: Requirements for Injection to SPS-II Storage Ring

Parameter	Value
Stored beam current	400 mA
Circumference	327.502 m
Revolution period	1.09 µs
RF frequency	119 MHz
Circulating charge	436 nC
Total number of buckets	130
Number of filled buckets	~104
Beam lifetime	240 min
Stability of beam current	1%
Interval between injections	144 s
Current variation between injections	4 mA
Charge variation between injections	4.36 nC
Repetition rate	2 Hz

INJECTOR LINAC CONFIGURATION

Recent synchrotron light sources, TPS [7] and Sirius [8], use a 150-MeV linac in the injection system. SPS-II will also use a 150-MeV linac to generate a 150-MeV beam for injecting into the booster. A configuration of an injector linac has to correspond to RF system of the storage ring and booster. Majority of modern storage rings use RF system based on a frequency of 500 MHz. An injector linac of these storage rings utilizes an electron gun with modulation at 500 MHz to produce a chopped beam at the gun level and a 500-MHz subharmonic prebunher (SHB) for compressing bunch length to match the 500-MHz buckets. However, the same configuration of the linac is not suitable for the SPS-II project due to the 119-MHz RF system. Furthermore, it may be impractical to use a 119-MHz SHB since a diameter of a 119-MHz SHB should be 4 times larger than a diameter of a 500-MHz SHB. Preliminary configuration of the SPS-II injector linac consists of three main parts as follows:

Electron Gun

A thermionic triode gun with gun high voltage of 100 kV is considered. The 119-MHz voltage modulation at the gird level requires for MBM to generate a bunch train with 1-ns bunches. In SBM, a single bunch of 1 ns or less is expected.

Bunching Section

A bunching section is used for making appropriate bunched beams. The bunching section of the SPS-II injector linac consists of a standing-wave (SW) SHB operating at 476 MHz and an S-band traveling-wave (TW) buncher operating at 2856 MHz. The SHB will be used for velocity modulation and compress the beam in the following drift. The buncher will simultaneously bunch and accelerate the beam to increase capture efficiency in S-band accelerating structures.

Accelerating Section

Four S-band TW accelerating structures will be used to generate 150-MeV beam. Two RF stations of 50 MW power will provide RF power to S-band components. The RF power from the first station will be distributed to buncher and two S-band structures. The second station will support the last two S-band structures.

Other components, for example, focusing magnets (solenoids and quadrupoles), beam instrumentation and diagnostics, and control system, will be appropriately designed and considered in details later. The proposed configuration of the SPS-II injector linac is shown in Fig. 2.

INJECTOR LINAC SPECIFICATIONS

From the design requirements and the proposed configuration of the SPS-II injector linac, preliminary specifications of the linac are summarized in Table 2. Small beam emittance and low energy spread are expected for high injection efficiency to the booster. The bunch duration of 150-600 ns in MBM will allow flexible injection to the storage ring for different operation modes. Repetition rate of 2 Hz will be used in normal operation.

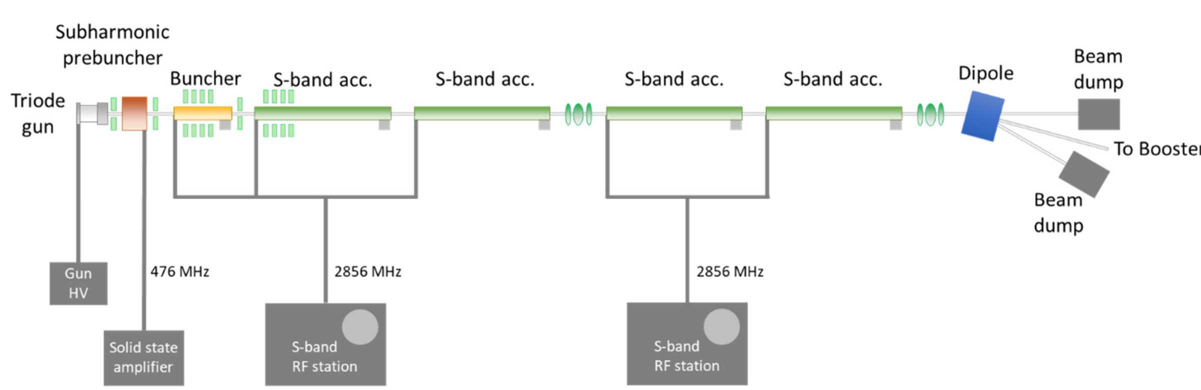

Figure 2: Configuration of the SPS-II injector linac.

ISBN: 978-3-95450-214-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2021-MOPAB120

Table 2: Beam Parameters of SPS-II Injector Linac

Parameter	Value
Energy (MeV)	≥ 150
Normalized emittance (mm·mrad)	≤ 50
Energy spread (%)	≤ 0.5
Pulse-to-pulse energy variation (%)	≤ 0.25
Pulse-to-pulse jitter (ps)	≤ 100
Bunch charge (nC)	MBM: ≤ 15 SBM: ≤ 5
Bunch duration (ns)	MBM: 150-600 SBM: ≤ 2
Repetition rate (Hz)	1-5 (adjustable)

Specifications of components in the injector linac will correspond to the expected linac beam parameters. Recently, physics design of an electron gun design for SPS-II has been started based on parameters listed in Table 3.

Table 3: Parameters of SPS-II Electron Gun

Parameter	Value
Cathode type	EIMAC Y646B
Cathode area	0.5 cm^2
Current density	2 A/cm^2
Cathode current	≥ 1 A
Grid pulser repetition rate	119 MHz

SCHEDULE OF SPS-II INJECTOR LINAC

Physics design and beam dynamics study of the SPS-II 150-MeV injector linac will be completed in 2021. The procurement process should start in 2022 with construction duration about two years. At first, the linac will be installed and tested at a pilot plant for the SPS-II project at SLRI and then it will be moved to an actual site for SPS-II later. Installation and commissioning of the linac should be completed in the SPS-II accelerator building within 2026.

ACKNOWLEDGEMENTS

The authors would like to thank W. Fang and Prof. Z. Zhao, University of Chinese Academy of Sciences, Shanghai Advanced Research Institute (SARI) and Shanghai Synchrotron Radiation Facility (SSRF) for helpful support and suggestions for SPS-II project.

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