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UTILITY DESIGN OF THE 3 GeV ELECTRON STORGE RING FOR SIAM PHOTON SOURCE II

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Abstract

The Siam Photon Source II (SPS-II) project is a new synchrotron light source in Thailand. The lattice of the 3 GeV electron storage ring is designed with 14 Double Triple Bend Achromat (DTBA) cells and has a total circumference of 327.6 meters. Utility systems are essential for maintaining the stability and reliability of the electron beam. The design includes key components such as the electrical and grounding systems, the deionized water system, the air conditioning system, and the compressed air system. These systems support critical subsystems, including magnets and power supplies, RF cavities and power supplies, vacuum chambers, and insertion devices. This paper focuses on considerations for the stability of the electrical power and grounding systems, as well as the temperature control of the deionized water and air conditioning systems. The electrical power and cooling loads have been estimated based on the requirements of each accelerator subsystem.

INTRODUCTION

The Siam Photon Source II (SPS-II) project in Thailand is a fourth-generation synchrotron light source located in Southeast Asia. The utility systems designed for the accelerator complex are critical to ensuring the functionality, stability, and efficiency of the accelerator machines, as well as maintaining electron beam stability and producing high-quality synchrotron light in the storage ring.

The utility systems comprise a deionized water (DIW) and air conditioning (AC) system for dissipating heat generated by the accelerator machines; a stable voltage supply system for reliable electrical power distribution; a low-impedance grounding system to address safety issues, establish a proper electrical reference level, and reduce electrical noise and electromagnetic interference; and a compressed air system to support pneumatic actuators. An overview of the SPS-II buildings is shown in Fig. 1 [1-7].

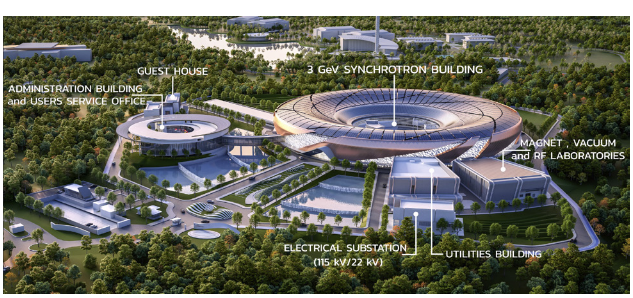

Figure 1: Overview of the SPS-II facilities.

OVERVIEW OF THE SPS-II

The main components of the SPS-II accelerator complex include a 150 MeV injector linear accelerator, a 3 GeV booster synchrotron with a circumference of 306 m, and a 3 GeV electron storage ring with a circumference of 327.6 m. The electron storage ring consists of 14 DTBA cells, which form 14 long and 14 short straight sections, operates at an RF frequency of 499.654 MHz, and has a maximum stored beam current of 300 mA. The first phase of construction also includes seven beamlines. An overview of the SPS-II accelerator complex is shown in Fig. 2 and the diagram of the overall layout of the SPS-II synchrotron radiation facility—which includes components such as the accelerator complex, radiation shielding wall, machine instrument area, control instrument area, beamlines, and laboratories around the experimental hall—is presented in Fig. 3.

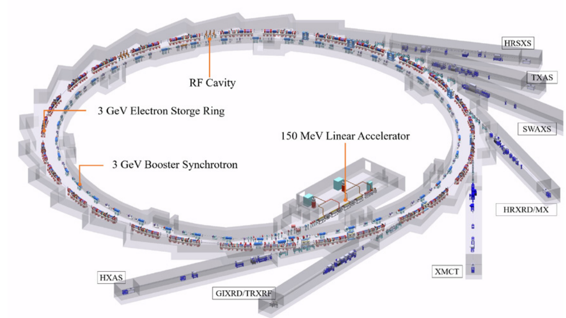

Figure 2: Overview of the SPS-II accelebrator complex.

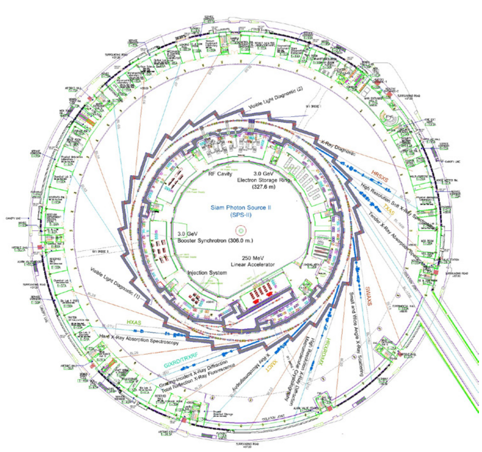

Figure 3: Overall layout of the SPS-II synchrotron radiation facility.

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ELECTRICAL POWER SYSTEM

The electrical power system for SPS-II ensures stability, safety, reliable electric energy, and good power quality with minimal harmonic distortion. The main substation is supplied by the Provincial Electrical Authority (PEA) at a rated voltage of 115 kV and includes three 22 kV feeders that distribute power to the accelerator and beamline systems, utility systems, and office areas, as illustrated in Fig. 4.

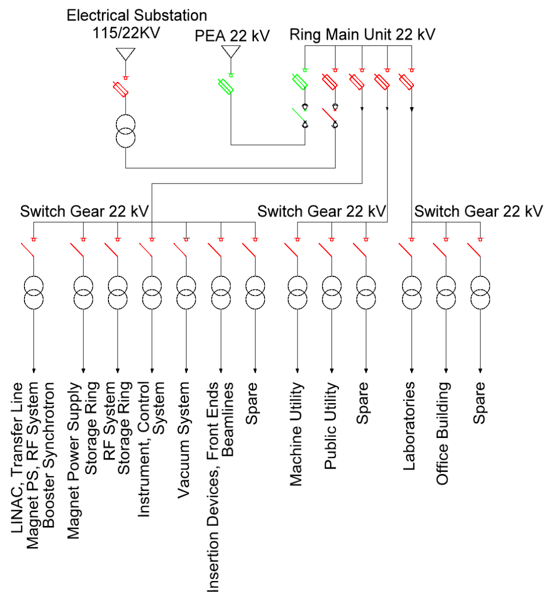

Figure 4: Single-line Diagram of the Electrical Power System.

The power demand of the SPS-II facilities is shown in Table 1.

Table 1: Power Demand of the SPS-II Facilities

Subsystem	Power Demand (kW)
3 GeV Synchrotron Building	5,700
Utilities Building	4,600
Magnet, Vacuum, RF Laboratory	1,100
Administration Building	500
Guest house Buildings	550
Electrical Substation	85

To maintain a stable voltage supply system and ensure reliable electrical power distribution, a comprehensive protection and monitoring system is required. The emergency power system, including diesel generators and uninterruptible power supplies (UPS), supports critical loads during power outages. A low-impedance grounding system is essential for safety, establishing a consistent electrical reference level, and reducing electrical noise and electromagnetic interference (EMI). The grounding impedance must be less than 0.20 Ω.

COOLING WATER SYSTEM

The cooling water system is essential for maintaining electron beam stability and ensuring high-quality synchrotron light production. The deionized water (DIW) system is divided into four subsystems: DIW-1 for cooling magnets and power supplies in the storage ring, DIW-2 for cooling aluminium chamber in the storage ring, DIW-3 for cooling linac, booster synchrotron, transfer line, insertion devices, front ends and beamlines, and DIW-4 for cooling RF cavity and power supplies in the storage ring.as shown in Table 2.

Table 2: Specifications of the Cooling Water System

Subsystem	Temperature (°C)	Pressure (kg/cm^2)	Cooling capacity (L/min)
DIW system-1	25±0.1	6.5-7.5±0.1	3,300
DIW system-2	25±0.1	6.5-7.5±0.1	700
DIW system-3	25±0.1	6.5-7.5±0.1	3,350
DIW system-4	25±0.1	6.5-7.5±0.1	3,400
Chilled Water	7-12±0.2	3.5±0.2	1,600RT
Hot water	45-50±0.3	2.5±0.2	212 kW
Cooling tower water	28-32±0.5	3.0±0.2	1,600RT

The diagram of the cooling water system (DIW-1) is shown in Fig. 5. Precise temperature control is maintained during the heat exchange processes at heat exchangers HE-1 and HE-2, with the temperature regulated at 25°C ±0.1°C and pressure maintained within the range of 6.5–7.5 ±0.1 kg/cm^2. The second stage of heat exchange occurs in the chiller (CH-1) in conjunction with the cooling tower (CT-1). The deionized water treatment system utilizes reverse osmosis (RO), an ion-exchange system, dissolved oxygen membranes, and ultraviolet (UV) sterilization to maintain high water quality, preventing corrosion and contamination. The cooling water system is designed to ensure long-term reliability, maintaining water resistivity at greater than 10 MΩ·cm.

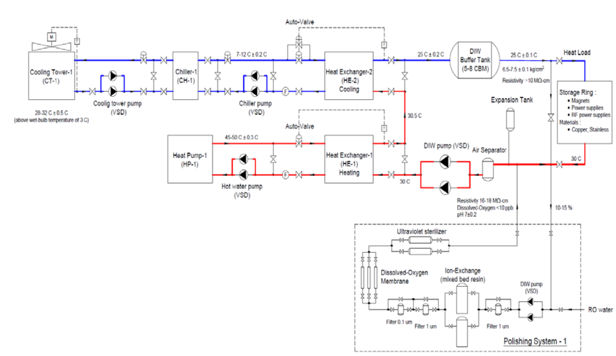

Figure 5: Diagram of de-ionized water system-1.

AIR CONDITIONING SYSTEM

The air conditioning (A/C) system is crucial for maintaining stable environmental conditions essential for the operation of accelerators. Energy-efficient of HVAC technologies help minimize operational costs, and the system

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complies with both comfort and industrial A/C standards. Strict temperature control is applied in critical areas to ensure beam stability and high-quality synchrotron light. Specifically, the temperature criteria inside the booster synchrotron and storage ring tunnel aim for fluctuations of less than ±0.1°C, as shown in Table 3.

Table 3: Specifications of the Air-Cooling System

Area	Temperature (°C)	Relative humidity (%RH)
Linear accelerator tunnel	25±0.1	50±5%
Booster and Storage ring tunnel	25±0.1	50±5%
MIA, CIA	25±0.1	50±5%
Experimental hutch	25±0.1	50±5%
Experimental hall	25±1	55±5%

The air ducts are designed to supply airflow to the booster synchrotron and storage ring tunnel, maintaining a uniform temperature distribution within the range of 25 ± 0.1°C. The system utilizes air handling units (AHUs) and distributes air through ducts routed via the maze, as shown in Fig. 6.

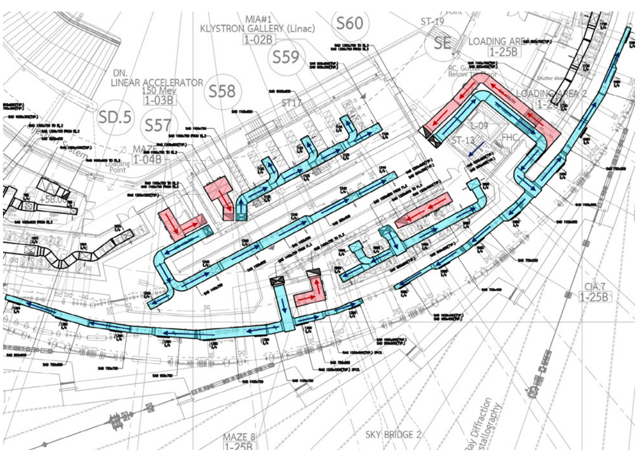

Figure 6: Air supply and return by the air handling unit (AHU) through the maze.

COMPRESSED AIR SYSTEM

The compressed air system is designed for efficient and reliable operation. It consists of two compressors, each equipped with a 1,500–2,000 litre buffer tank and a fine filter with a filtration capability of 0.01 micrometer to ensure high-quality compressed air. The system can generate compressed air at a capacity of 10–12 m^3/min, with air pressure maintained at 6 kg/cm^2. To enhance air quality, the dew point is set at -40°C, and the maximum oil content is limited to 0.1 mg/m^3.

A key feature of the system is the use of variable frequency drives (VFDs) in the compressors, which enable energy-efficient operation by adjusting motor speed according to demand. This enhances both energy savings and overall system sustainability. Additionally, the compressors are equipped with emergency power functionality, ensuring continuous operation during power outages or emergencies.

CONCLUSION

The utility systems of SPS-II are designed to maximize stability, efficiency, and reliability in operation. Core systems—including electrical power, cooling water, air conditioning, and compressed air—are essential for maintaining the functionality of the accelerators and beamlines. Energy-efficient designs help reduce resource consumption and promote long-term sustainability. In addition, precise environmental control ensures electron beam stability and high-quality synchrotron light.

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