ILSF, A THIRD GENERATION LIGHT SOURCE LABORATORY IN IRAN

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Abstract

The Iranian Light Source Facility (ILSF) project is a first large scale accelerator facility which is currently under planning in Iran. On the basis of the present design, circumference of the 3 GeV storage ring is 297.6 m. Beam current and natural beam emittance are 400 mA and 3.278 nm.rad respectively. The facility will be built on a land of 50 hectares area in the city of Qazvin, located 150 km West of Tehran. The city is surrounded by many universities, research centers and industrial companies. The design and construction of prototype items such as radio frequency solid state amplifier, dipole magnets, highly stable magnet power supplies and girders have already begun. Site selection studies, including geotechnical and seismological measurements are being performed. Conceptual Design Report, CDR, as the first milestone of the project was published in October 2012.

INTRODUCTION

Synchrotron radiation, as a versatile research tool, has experienced an unprecedented expansion. Nowadays, a large and continuously growing community of researchers representing a variety of disciplines depends on light sources as an essential part of their research programs. In spite of innumerable applications of synchrotron radiation, a large portion of the world namely Middle East is unfortunately poor on modern synchrotron light source facility. Following SESAME project which was dedicated by UNESCO to the Middle East countries [1], several countries of the region such as Armenia [2] and Turkey [3] have planned to have their own synchrotron radiation facility. The Iranian Light Source Facility (ILSF) project [4] was initiated in 2003 and formally approved by the Iranian government in 2008 [5-6]. At the end of 2009, Institute for Research in Fundamental Sciences (IPM) was selected to plan, construct, equip, and exploit the facility. The ILSF is conceived as a national synchrotron light source to provide a powerful source of x-ray for the users and cover requirements of the experimental science in several fields. The figure of merit of the ILSF storage ring follows modern synchrotron light sources design trend. To have a competitive leading position in the future, the ILSF is designed to emphasize small emittance electron beam (below than 5 nm.rad), high photon flux density, brightness, stability and reliability.

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STORAGE RING SPECIFICATIONS

As a solution, a four-fold symmetric ring has been designed. The ring consists of 4 super periods and provides 4 long, 16 medium and 12 short straight sections with the length of 7.88 m, 4 m and 2.82 m respectively. Each super period is designed based on three double bend achromat unit cells with two matching sections to optimize the machine functions. The circumference of the storage ring is 297.6 m and the linear lattice functions are well matched to the requirements of a small emittance and small beam size at the radiators. Main specifications of the designed ring and its optical functions in a super period are given in Table 1 and Fig.1.

Table 1: Major Parameters of the Storage Ring Main Lattice Candidate

Parameter	Unit	Value
Energy	GeV	3
Current	mA	400
Circumference	m	297.600
Horizontal emittance	nm.rad	3.278
RF frequency	MHz	500
No. of dipoles	-	32
No. of quadrupoles	-	104
No. of sextupoles	-	128

MAGNETS

Two different types of dipole magnets are used in ILSF ring both with the same field of 1.42T but

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different gradients. Quadrupoles have 9 families with the same cross section but 3 different core lengths and sextupoles have 9 families with the same cross section but 2 different core lengths. For the booster ring the sextupole components is inserted in both dipoles and some of the quadrupoles. [7]

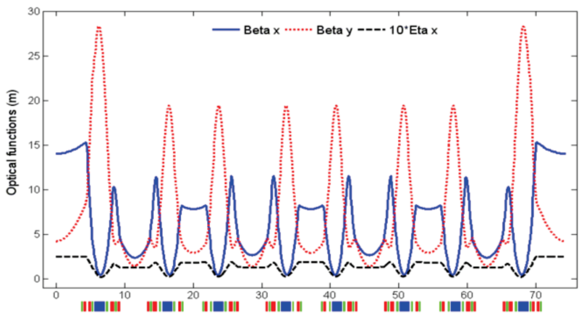

Figure 1: The Optical functions in a super period of ring.

Prototype magnets are being fabricated locally at ILSF; a pure H-type dipole magnet with central field of 0.5T and length of 500mm was designed, fabricated and measured successfully [Fig. 2].A storage ring quadrupole magnet with field gradient of 18 T/m and mechanical length of 233mm is now under fabrication [Fig. 3]. In addition physical and mechanical design of a storage ring C-type dipole magnet with central field of 1.42 T, gradient of 3.837 T/m and mechanical length of 1340mm are completed and fabrication is in progress. [Fig. 3].

RF SYSTEM

To store 400mA stable current at ILSF storage ring, 6 NC HOM-damped cavities are required which will be selected among the so far candidates, ELETTRA, EU, PEP-II and KEK-PF(ASP type). One 7-cell PETRA cavity will provide the acceleration at ILSF booster. Although, 500MHz has been selected as the RF frequency in the CDR, some consideration is also given to the idea employed at MAXIV on using 100MHz RF frequency. At 100MHz advantages are expressed specially in design and fabrication of HOM free cavity.

In order to perform cavity low power measurements and to test LLRF units, an aluminum pillbox cavity is fabricated at ILSF. For cavity field and impedance measurements a bead pull measurement system has been designed and fabricated.

For the LLRF system, self-excited loop architecture has been used. A semi-digital LLRF system is developed as a prototype. It is tested using the simple aluminum cavity, and some promising results are obtained. The work is progressing to complete the software development, finalize the test and operation routine of the LLRF system and upgrade it to a fully digital system using FPGAs.

Based on the successful experience in SOLEIL and LNLS and also existence of local expertise, ILSF RF group has started R&D on design and fabrication of solid state amplifiers as the RF power amplifier. Three amplifier modules based on three LDMOS power transistors were designed and tested. Output power of 700W and 660W for amplifier modules based on MRFE6VP61K25HR6 and BLF578 transistors were achieved respectively. Furthermore, in order to build up 4KW RF power, a 8:1 radial power combiner is designed for eight amplifier modules at 500MHz.

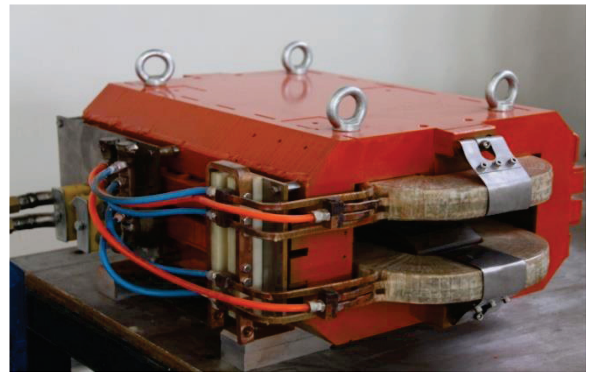

Figure 2: ILSF H-type dipole magnet.

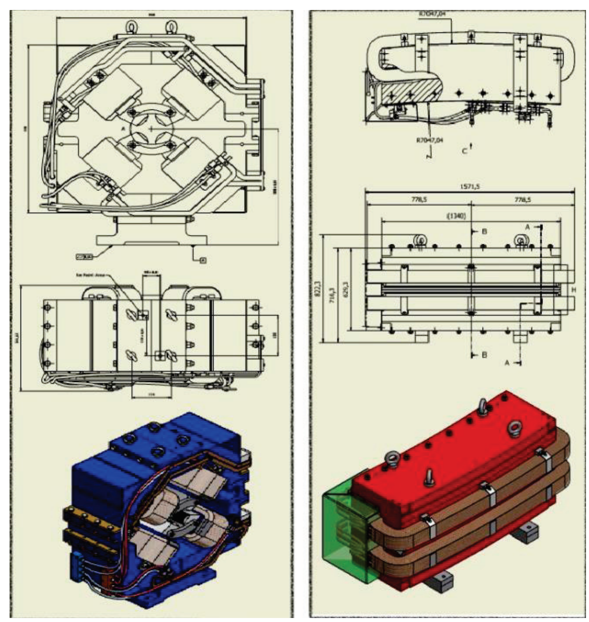

Figure 3: Under construction ILSF storage ring quadrupole magnet (left) and C-type dipole magnet (right).

PRE-INJECTOR

For the pre-injector system, an S band, thermionic cathode, side coupling, 1.5 cell RF gun is designed at ILSF. An alpha magnet is also designed to longitudinally compress the output bunches of this RF gun. These bunches will then be injected into a sequence of three S band, 3.4 m long, travelling wave, linear accelerator sections operating at ~17 MV/m in $2\pi/3$ mode. After accelerating in such a sequence, the electron beam will attain the energy of 150 MeV and the normalized emittance of 6 mm-mrad, ready to be injected into the booster ring.

POWER SUPPLY

The ILSF storage ring will be equipped with 32 dipole magnets of two different types. Two single converters feed the two series-connected strings of dipole magnets. The power converters for powering bending magnets consist of 4 paralleled series modules. Each module will be a non-isolated step down 4-phase synchronous buck converter (Table 2).

Each of 104 quadrupole magnets will be connected to a separate independent power supply with highly stable and low-ripple current. This arrangement is very advantageous for beam-based alignment.

A total number of 128 Sextupole magnets, grouped into 9 families, will be required for the ISLF storage ring lattice. All magnets from each family will be connected in series and will use one power supply.

Table 2: List of Main Power Supplies in ILSF Storage Ring

Storage Ring P.S.	Dipole	Quadrupole	Sextupole
Maximum output current	529A dc	190 A dc	127 A dc
Output voltage	588V dc	24 V dc	192 V dc
overall stability	±10 ppm	±10 ppm	±10 ppm
No. of Power Supplies	2	104	9

After successful design and construction of a prototype power supply for quadrupole magnets (2400W and 40ppm stability) at the R&D laboratory, the next prototype power supply will be a ramping power supply suitable for booster of ILSF, it consists of two main sections: a 8KHz switch-mode regulator (based on IGBT) followed by a 12-pulse thyristor rectifier as pre-regulator (Fig. 4).

Figure 4. Two prototype power supplies of different rating designed and constructed at ILSF R&D lab.

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