

# DESIGN STORAGE RING AND BOOSTER RING POWER SUPPLY CABLING IN TAIWAN PHOTON SOURCE

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## Abstract

For this paper is studies the storage ring and booster ring power supply cabling design, Papers can be divided into cabling design, control and instrument area construction (CIA), and testing; design including estimated cable length and arrangement, the CIA construction part site of the cable erection and overcome barriers of space; detection section is high resistance meter and insulation testing [1]. Circumference of booster ring is 496.8 meter and storage ring is 518.4 meter, TPS (Taiwan Photon Source) beam current is 500mA at 3GeV. Booster Ring dipole into BD and BH series 54 magnets, cable size is 250 mm<sup>2</sup> and total length of 5000m [2]. Booster Ring and storage ring quadrupole 150 magnets and cable size 250 mm<sup>2</sup>, total length of 17000m. Storing Ring dipole 48 magnets cable size 325 mm<sup>2</sup>, total length of 6000m. On the positive and negative voltage cables will produce magnetic interference effects generated through cabling overlapped technology eliminates magnetic interference [3]. Finally, using a high-impedance machine to detect cabling insulation effect. TPS power supply to the energy transfer is to ensure safe and correct magnet.

## INTRODUCTION

“Taiwan Photon Source interdisciplinary laboratory facilities construction plan” to be executed in National Synchrotron Radiation Research Center. Subsystems must begin to build the system in the unfinished building structure; the degree of complexity is really unimaginable. Needed a software system can provide substantial help in a limited space, so that all of the equipment, planning to do effectively. National Synchrotron Radiation Research Center has embarked on a way to build 3D graphics module, virtual all parts through one to one 3D module, ensure that the planning can be more complete. Spatial planning magnet arrangement and cabling is a major work of this plan in the power supply group. The construction site using a 3D simulation module, early start magnet arrangement design and planning in civil engineering structures has not been completed, such as: cable length, procurement budget ..... Cabling works of various space-related configuration parameters refer to the values obtained in the 3D virtual environment module, essentially greatly enhance the efficiency of the design. 3D software will make the arrangement of the power supply to the magnet parts and models, including: Magnet coding, magnet placement, interference region. Model

contains booster ring area, storage ring area, linac to Booster ring (LTB) and booster to storage ring (BTS) area; clearly show the main structure through 3D simulation software.

## CONTROL AND INSTRUMENT AREA

CIA is located in the inner circle adjacent to TPS tunnel. DC power supplies of magnets and ID controller are placed on the 1<sup>st</sup> floor. Figure 1 has shown cable tray design in CIA to tunnel magnets side. Colour tray is design by power supply group. It can separate to left and right hand side, power supply machine placed in CIA 1F and cable will through trench into the tunnel area of storing ring tray connect to magnets. Figure 2 has shown power rack and magnet placed on CIA cable tray, CIA place on 6 power rack that are 4 QF-SF rack and 2 corrector rack. Each side QF-SF rack will supplies energy to each 5 quadrupole magnets and 4 sextupole magnets.

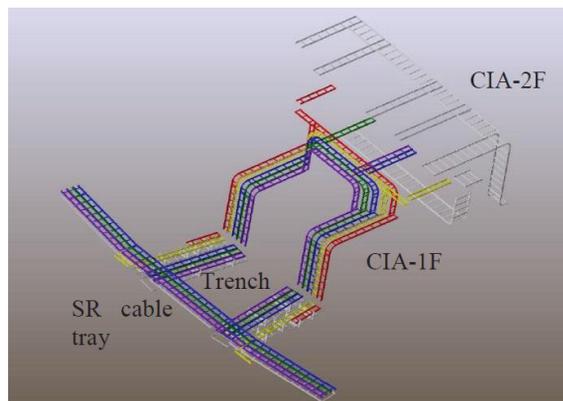


Figure 1: CIA power supply cable tray.

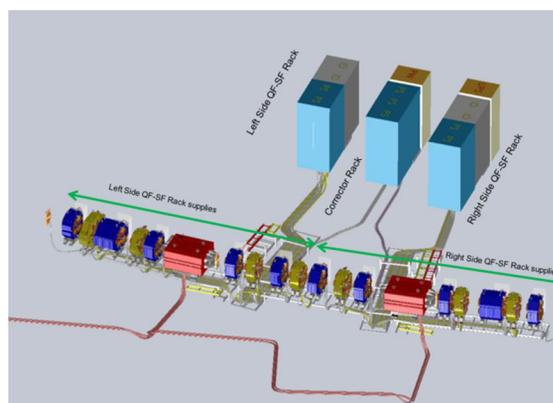


Figure 2: Power Rack and magnet simulation on CIA and Storing ring cable tray.

### BOOSTER RING CABLING AREA

Booster ring magnet can be divided into 6 section (BR1~BR6), each section has 9 dipole magnet, 14 quadrupole magnet and 4 sextupole magnets. (1) Dipole magnets connected is series type, booster power supply output high level part of the positive polarity, output low level part of the polarity is negative. Dipole magnet is connected to a number of the first is magnet code number R1B7, dipole magnet connected to the number of the last is magnet code number R1B6, by R1B6 back to power supply low level output terminal. Each booster ring dipole magnets are connected to 6 cables (three positive and three negative, 250mm<sup>2</sup>) and 4 core interlock signal line (thermal protection and cooling water protection) transmitted to CIA. (2) Quadrupole magnets can be divided into Q1, Q2, QM, QF four types are connected in series, each BR area 14 quadrupole magnets has two cable (250mm<sup>2</sup>) connectors and 4 core interlock signal line (thermal protection and water protection) transmitted CIA. (3) Booster ring sextupole magnets divided into two types, type A is BR1 → BR3 booster ring surrounded by a half circle; type B is BR4 → BR6 booster ring surrounded by a half circle that is connected series type. Each BR area 4 sextupole magnets for two cable (5.5mm<sup>2</sup>) connectors and 4 core interlock signal line (thermal protection and cooling water protection) transmitted to CIA. (4) Booster ring corrector magnets divided into CH (10 pcs.) and CV (6 pcs.) two kinds of type (H: horizontal arranged, V: vertically arranged), each BR area has 16 corrector magnets for two cable (5.5mm<sup>2</sup>) connector. Figure 3 has shown booster ring cable layout, 6 BR DPS cable (250mm<sup>2</sup> in diameter and 1600V) and 8 BR CPS cable (5.5mm<sup>2</sup> in diameter and 600V) place on first tray, BR DPS cabling arrangement utilizing stacked exclusive polarity way and cable loop of circle to eliminates magnetic interference. 8 BR QPS cable (250mm<sup>2</sup> in diameter and 600V) and 4 BR SPS cable (5.5mm<sup>2</sup> in diameters and 600V) place on second tray. Cable tray is 200mm in width and 60mm in height with cover on it.

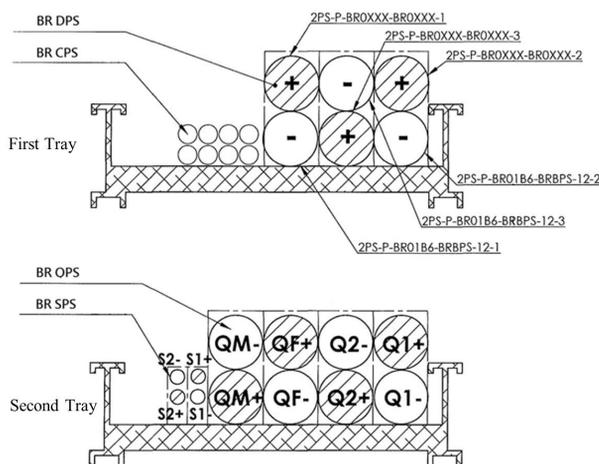


Figure 3: Booster ring cable layout.

### STORING RING CABLING AREA

Storing ring magnet can be divided into 24 section (SR1~SR24), each section has 2 dipole magnets, 10 quadrupole magnets and 7 sextupole magnets. Dipole magnets connected is series type; each storing ring dipole magnets are connected to 6 cables overlapped (325mm<sup>2</sup> in diameter and 1000V) and attached a Trim core magnet controlled by the correction magnet power supply. Each section have 10 quadrupole magnets and 7 sextupole magnets connected one to one type 2 cables (250mm<sup>2</sup> in diameter; 600V). SR DPS, QPS and SPS have 4 core interlock signal line (thermal protection and cooling water protection) transmitted to CIA. CSV.CSQ.CSQ (5.5mm<sup>2</sup>\*2C in diameter; 600V) correction magnet coils will be attached to each sextupole magnet controlled by the correction magnet power supply. Each SR area has 4 pair fast corrector vertical (FCV) and fast corrector horizontal (FCH) magnet coil connected to 2 cables (5.5mm<sup>2</sup>\*2C in diameter; 600V). Figure 4(a)-(d) has shown storing ring DPS, QPS, SPS and CPS simulation cable layout. Table 1 is shown booster and storage ring cable length. This cabling project estimate to total length of the cable is 51,000 meter.

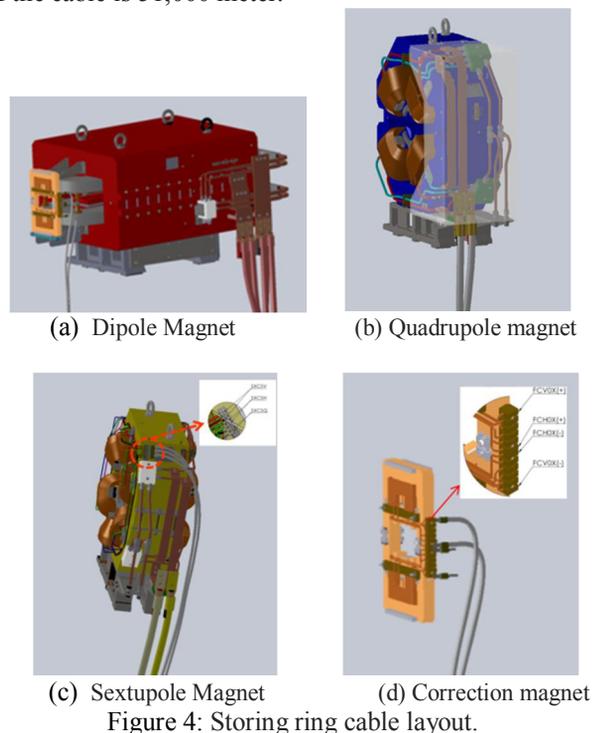


Table 1: Storage Ring Quadrupole and Sextupole Magnets

Cable Diameter (mm <sup>2</sup> )	Voltage (V)	Length (m)	Power supply
325	1,000	6,000	SR DPS
250	600	17,000	SR QPS & SPS BR QPS
250	1600	5,000	BR DPS
14	600	3,000	BR SPS
5.5*2C	600	12,000	CPS
2*4C	600	8,000	Interlock signal

## INSTALLATION AND TESTING TUNNEL MAGNET CABLING

Booster ring and storage ring magnet installation project within half year to be installed. Line to line polarity testing, insulation testing, valve and temperature testing after construction of civil engineering are completed. (1) Line to line polarity testing are power supply supplies a low current value to correspond magnet to check magnetic field will be correct. Co-work to subsystems-magnet group measurement magnetic field by gauss meter, gauss meter are measurement instruments used for two general purposes: to measure the magnetization of a magnetic material like a ferromagnetic or to measure the strength and the direction of the magnetic field at a point in space. (2) Insulation testing is used to high impedance machine to detect cabling insulation effect, testing the integrity of insulation cable requires measuring its resistance to current flow across it. A high level of resistance means that very little current is escaping through the insulation. Conversely, a low level of resistance indicates a significant amount of current may be leaking through and along the insulation. (3) valve and temperature testing, power supply APG terminal has safety interlock pin, this function users to control the power supply's ON/OFF through the APG and system status, it has high speed time accuracy under 100ms will be trigger. For valve protection is detect magnet pipes water pressure, trigger will be start at water pressure under  $7\text{kgw/cm}^2$ , transmit the trigger signal to the APG interlock safety and turn off power supply to avoid magnet burn out. Temperature protection is detecting magnet coil temperature; trigger will be start at coil higher  $50^\circ\text{C}$  degree turn off power supply. The status of storage ring and booster ring is shown in Fig.5 (a) and (b).



(a) Status of storage Ring



(b) Status of booster ring

Figure 5: The status of storage ring and booster ring.

## CONCLUSION

TPS cabling project is a majority for power supply group that are working planning at civil construction work unfinished. Must be executed schedule to set 3D environment; magnet space configuration design, cable length, cable path direction, cable tray space planning, power supply and placing of the magnets is used to high efficiency in a limited space. Total cable length estimate use by 3D software, the exact value of the assessment can be more precise, to reduce unnecessary expenditure and manpower. Coverts 3D simulation model diagram into a 2D construction diagram that can be used as a blueprint and engineering design diagram at future project.

## REFERENCE

- [1] Chroma Ltd Mar 2008 *Programmable DC Power Supply 62000P Series Operation & Programming Manual* version 12.
- [2] Yung-Hui Liu, June-Rong Chen, "TPS STORAGE AND BOOSTER RING CABLE TRAY INSTALLATION STATUS AND CIA DESIGN ARRANGEMENT," 5<sup>th</sup> International Particle Accelerator Conference (IPAC), pp3748-3750, Dresden, 2014.
- [3] NSRRC staff, "Taiwan Photon Source (TPS) Design Handbook", NSRRC, Taiwan, 2008.