THE CABLE ENGINEERING PROJECT FOR THE TPS POWER SUPPLY

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Abstract

The civil engineering of Taiwan Photon Source will soon be completed. The engineering of the power supply cabling should be done in advance of the schedule for the completion of the civil engineering. Using software (SolidWorks) to build a 3-D model, we obtain detailed cabling information because the model is made to scale 1 to 1. As all components are built into the model of the TPS accelerator, we can build accurately a model of the power supply cabling. For example, we can estimate every length and the total cable length for purchase and budget control. We can evaluate the conditions for every power cable to lay the cable tray from the power supply to the magnets, so we can lay every cable to follow the sequence in the cable tray. We thereby convert the drawing of the two-dimensional construction graph when we design the finished three-dimensional cabling model. The excellent and precise results are proved in this paper.

INTRODUCTION

As the circumference of the TPS accelerator is 518m, the TPS accelerator occupies a huge space; planning the cables from the power supply to the magnets is thus a large engineering project. Because the cable tray is built only at the finish, to measure the cable length is impracticable. NSRRC uses software (SolidWorks) to build all components to be made and to simulate the model of the TPS accelerator [1].

The NSRRC power-supply group uses the model of the TPS accelerator to build the cable from the power supplies to the magnets. We must follow the cable-tray and electricity technique rules to connect the power supply and the magnets. The cable-tray rules include coding, cable layout in the tray and other factors. All power-supply cables must thus follow a sequence, step by step to build the cabling model in three-dimensional space.

We built the cabling model to include the booster ring, storage ring, LTB and BTS sections, for which the cabling involves huge engineering. Much time is taken to design all cables [2-4]. The last cabling is the interlock cable lines, which monitor the temperature and cooling water of the magnets. The corresponding power supply will be stopped if the temperature is too high or if there is insufficient cooling water for the magnets. The last task is to convert the drawing of the two-dimensional construction graph and when we design the finished three- dimensional cabling model. We use the two-dimensional construction graph to implement all cables for the TPS cable engineering.

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BOOSTER RING

The booster ring was designed as a concentric circle with the storage ring of Taiwan Photon Source. The cable tray was designed to be built into the interior wall. We thus lay the cables to follow the cable tray. All magnets of the same family will be connected with a series connection except the correction magnets use an independent power supply.

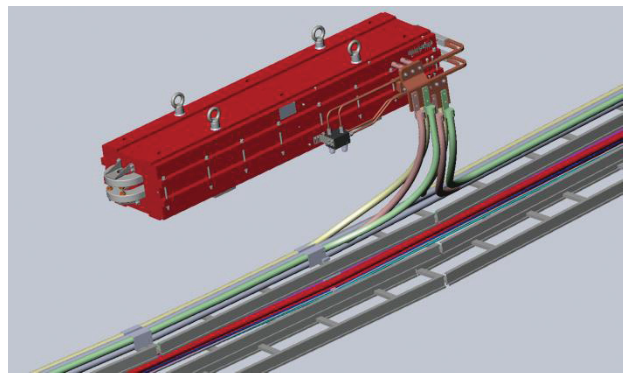

Figure 1: The booster dipole magnets connect with the dipole cable.

The magnets of the booster ring include dipole magnets, quadrupole magnets, sextupole magnets and correction magnets. The booster dipole magnets will be connected with a series connection. As the booster will operate in top-up injection mode at 3 Hz, the booster dipole power supply must be ramped to high voltage; the peak voltage is 1600 V. Figure 1 shows the booster dipole magnets connecting with the dipole cables.

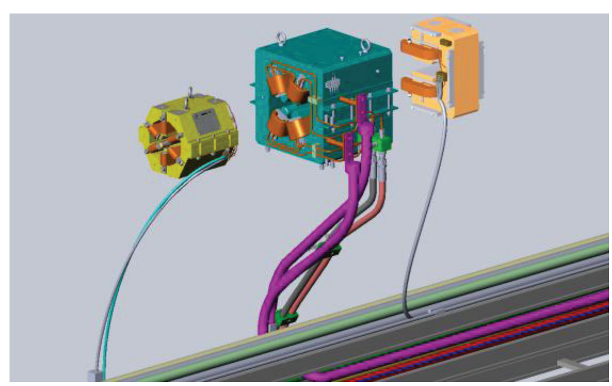

Figure 2: The booster quadrupole, sextupole and corrector magnets connected with cables.

The booster quadrupole magnets belong to four families: Q1, Q2, QM and QF. The same family of quadrupole magnets will be connected with a series connection. We thus use four units of power supplies to deliver the current to the booster quadrupole magnets. The booster sextupole magnets have two families: S1 and S2. As the impedance of the booster sextupole magnets is larger than for the quadrupole magnets, the power supplies deliver to the booster sextupole magnets in only half the circle. We shall connect each family of booster sextupole magnets from areas R1 to R3 with a series connection; the other booster sextupole magnets are from areas R4 to R6, also with a series connection. We thus use four units of power supplies to deliver the current to the booster sextupole magnets. Figure 2 shows the booster quadrupole, sextupole and corrector connector magnets with their cables. Figure 3 shows part of the cabling in the booster ring.

The booster corrector magnets are of two kinds: CH and CV. We use an independent correction power supply to deliver the bipolar current to the magnets. The last issue is the interlock link. We link the interlock signal of the booster dipole, quadrupole and sextupole magnets to PLC, which can stop the corresponding power supply.

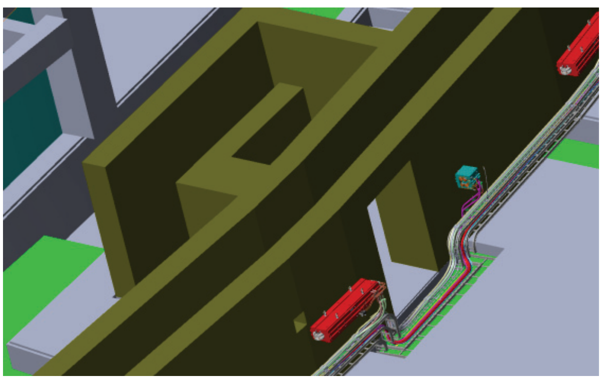

Figure 3: Part of the cabling in the booster ring.

STORAGE RING

The cable tray for the storage ring was designed as a trench connection to the CIA (Control and Instrument Area) room. The storage ring has six areas, R1 to R6. Each area has four CIA rooms, so 24 CIA rooms in the storage ring in total. All magnets use an independent power supply except the dipole magnets of the storage ring. The dipole magnets of the storage ring will be designed with a series connection.

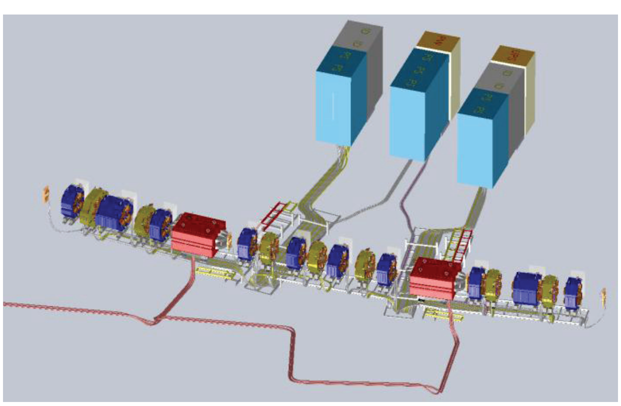

Figure 4: The cabling from the CIA room to the magnets.

As the operating current of the dipole magnet works at 850 A, which is large, we shall use three cables (cross section 325 mm^2) for a parallel connection in the storage ring. A specially designed inserting corrector coil is in each dipole magnet. The corrector is named a trim coil. We link the interlock signal of the storage-ring dipole magnets to the PLC, so that the PLC can stop the dipole power supply if the dipole magnets have an error signal.

The storage-ring quadrupole and sextupole magnets use cables (cross section 250 mm^2) to connect to an independent power supply. The power supplies for the quadrupole and sextupole magnets are put in the CIA room, which is provided with stable air conditioning that decreases the output current variation of the storage-ring power supply due to temperature drift; the current will flutter less than 10 ppm. A stable temperature is important for the power supply in the CIA room. Figure 4 shows the cabling from the CIA room to the magnets.

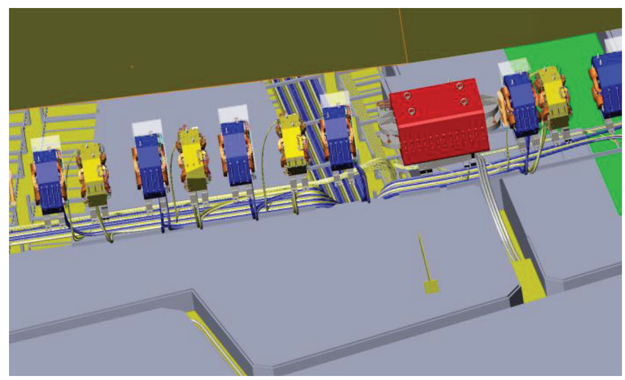

Figure 5: Part of the cabling for the storage ring, view A.

The interlock cable has a direct link to the corresponding power supply, which will be stopped if the temperature is too high or if there is insufficient cooling water for the magnets. A special design for the storage ring sextupole magnets has corrector coils inserted in the magnet. The corrector coils of each sextuple magnet have purpose correctors of three kinds -- CH, CV, SQ. The storage-ring corrector magnets have rapid corrector and general corrector magnets with the correction power-supply setup in the CIA room. Figures 5 and 6 show a part of the cabling for the storage ring in views A and B.

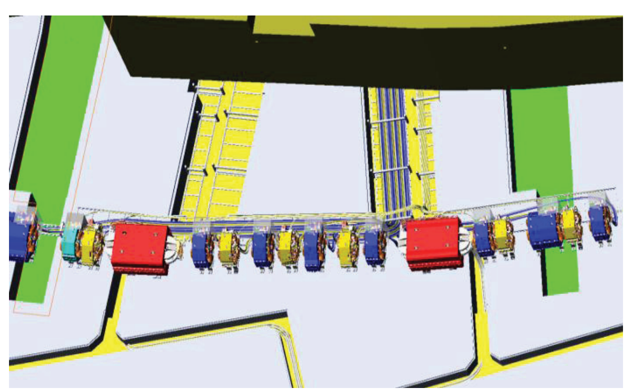

Figure 6: Part of cabling for the storage ring, view B.

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As CIA-23 and CIA-24 are built on the second floor, the cabling is not like that in the other CIA areas. Figure 7 shows part of the cabling of CIA-24.

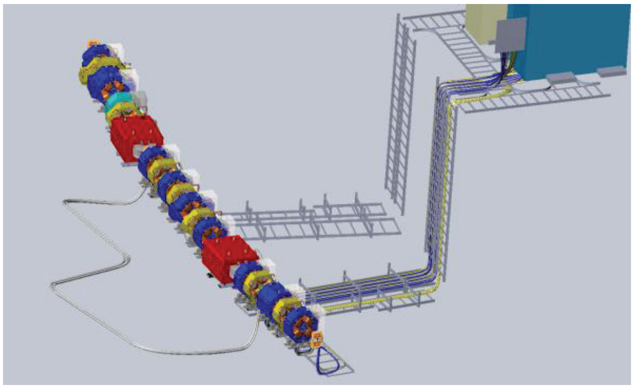

Figure 7: Part of the cabling of CIA-24.

LTB BTS SECTION

The LTB section means the LINAC to booster area. The LTB section has dipole magnet, quadrupole magnets and corrector magnets. We lay the cable in the storage-ring cable tray and trench into CIA-24. The LTB section has particles as a source current to transfer to the booster. The section has more corrector magnets to correct the beam current for stable transfer to the booster in the vacuum cavity.

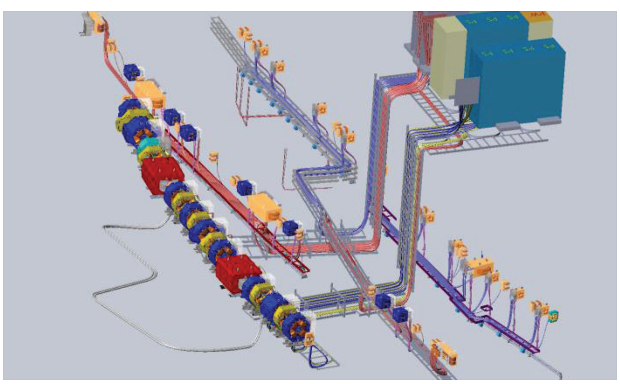

Figure 8: The cabling for the CIA-24 area from view A.

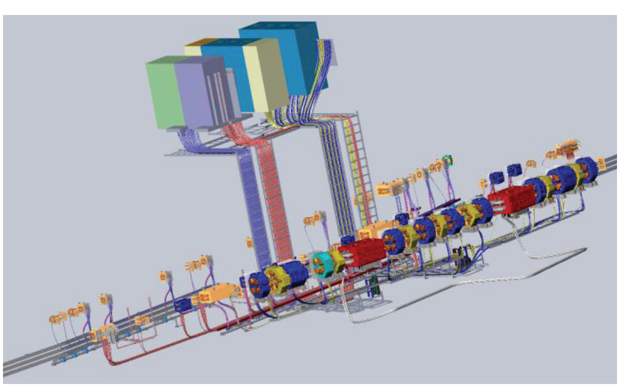

Figure 9: The cabling for the CIA-24 area from view B.

The BTS section means the booster to storage-ring area. The BTS section has dipole magnet, quadrupole magnets and corrector magnets. The BTS first and last devices are DC septums that need three power supplies to operate. The power supplies will be set as master and slave. We lay the cable in the storage-ring cable tray and trench into CIA-24. Figures 8 and 9 show the cabling for CIA-24 area from views A and B, as CIA-24 adds the LTB and BTS two-section power supplies. As the cable engineering is more complicated than in other areas, the CIA-24 requires more space to put the cabinets for the power supplies. The cable trays also need a large space for the power-supply cables for the LTB and BTS sections. The interlock cable is set the same as for the storage ring, that is, to a magnet from the corresponding power supply.

CONCLUSION

We used software (SolidWorks) to build a 3-D cabling model, which includes the booster ring, storage ring, LTB and BTS sections. We can observe the arrangement of all cables that conform to electronic- engineering rules and an optimal arrangement. For example, all cable polarities are opposite, which can diminish the noise [5]. The booster and storage-ring magnets with a series connection to the power supplies must lay return cables to the power supplies, which can decrease the inductance for the power supplies. The output voltage will be decreased when the power supplies are at the ramping time.

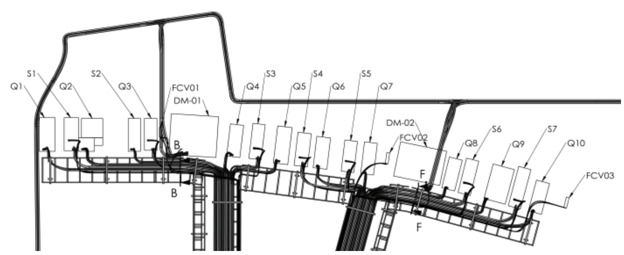

Figure 10: Part of two-dimensional test graphs.

The model can convert a drawing as the two-dimensional construction graph when we design the finished three-dimensional cabling model. We use the two-dimensional construction graph to implement all cables for the TPS cabling engineering. Figure 10 shows part of the two-dimensional test graphs.

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