An overview of the magnet measurement development at SRRC

C. S. Hwang, T. C. Fan, F. Y. Lin

SRRC, No. 1 R&D Road IV, Science-Based Industrial Park, Hsinchu 300, Taiwan

Introduction

Several magnet measurement systems were developed at SRRC to characterize the lattice and insertion device magnets. For the lattice magnets, a high-precision harmonic magnetic-field measurement system using a fixed-angle Hall probe method was developed. This system can be used to perform the field measurement and analysis of (1) the point by point field mapping and field integral (2) gradient field (3) static or time-varying field (4) the harmonic field analysis of large curvature bending magnet or combined function dipole magnet (5) the harmonic field analysis of multipole magnets. However, the fixed-angle Hall probe system should be associated with a precise three-orthogonal axes x-y-z table and software algorithm to suit for different kinds of magnets. For example, the elliptical trajectory is built for bending magnet mapping and circular trajectory is for the field mapping of the multipole magnets. The Hall probe of this system also need be calibrated. The field strength, the angle and the position of the Hall probe should be calibrated carefully. The measurement data of fixed-angle Hall probe system can be analyzed by the non-linear 2-D least square fitting to obtain the harmonic field components. However, the Hall probe needs to be rotated 90^o to obtain the skew dipole component. The overall system accuracy is better than 0.01%.

In addition, a simple rotating coil system [2] and a stretch wire systems [3] with self-centering position were used to measure and analyze the quadrupole and sextupole magnets. These two systems can be double-checking with the Hall probe system by each other's. Although the traditional rotating coil system is precise measurement for the lattice multipole magnets, the mechanical construction will be complex much more than the stretch wire system and the fixed-angle Hall probes system. The alignment error of the simple rotating coil system with self -centering position is very difficult to control within 0.1 mm. The alignment of the shaft coupling between the rotator and the rotor encoder of the rotating coil system should be aligned very carefully. Otherwise, the misalignment will create a systematic error on each harmonic component. Although, the mechanical structure of the stretch wire system is much simpler than the rotating coil system, it cannot fit for the long multipole magnets due to the coil sag. The better length of the coil is maintained within 1 m long. The accuracy of most the harmonic components are about 0.01%. However, the system accuracy still has the potential to keep all the harmonic components better than 0.01%.

For the insertion device magnets, a three-orthogonal axes Hall probe [4]on the fly mapping method is developed to characterize the electron trajectory and spectrum performance, especially for the elliptically polarized undulator and the adjustable phase undulator (APU). However, the magnetic field and the relative position of the three-orthogonal Hall probes should be calibrated and adjusted carefully. In addition, the planar-Hall effect induced the field error should be reduced by the exact choice of the Hall probe material and the exact installation. Meanwhile, the three Hall probes should be put into a standard magnet to calibrate the three orthogonal surfaces and a precise sin wave field is used to calibrate the relative position among the three probs. The long term stability and precision of the first and second field integral is about ±20 G-cm and ±500 G-cm^2, respectively.

For the first and second field integral measurement and analysis of the insertion device magnets, the stretch wire system is a good choice for the fast speed measurement and high precision. Therefore, this system mainly used for the multipole shimming of the insertion device magnets. The mechanical precision of stretch wire system is not so critical. However, the integral signal process from the integrator should be filtered and compensated to enhance the system precision and accuracy. The coil sag should keep as small as possible to reduce the systematic error. The precision of the first and second field integral is about ±1.5 G-cm and ±70 G- cm^2, respectively.

For the magnet block sorting, there is a highly automatic measurement system for the measurement of three-orthogonal magnetic dipole moments of the permanent magnet block [5]. The magnet block was installed on the block holder which was mounted on the rotation mechanism. The rotation mechanism can rotate to 360^o, 180^o, and 90^o along the three axis, respectively, to obtain the three components of magnet dipole moments. The magnetization direction of the easy-axis can be found by means of the mathematic analysis. The measurement speed of this system is 90s/block. The only criticism item of this system is the long time stability. This is due to the drive train system is consists of the time belt. Therefore, before the first run, the system should be pre-run to keep reliable tension strength of the time belt to keep a good performance. The long-term precision is the order of 0.04% for the easy-axis component and 0.02^o for the minor components.

Finally, a pulse-wire system [6],[7] is being developed for the measurement of the point field, first and second field integral of the mini-pole undulator. The main error source of pulse-wire system is the rigidity and the inhomogeneous mass distribution on wire of the Be-Cu wire that will distort the magnetic field wave front. Although, the impurity wire problem can be solved replacing the thin wire by the thick wire. A stronger rigidity will be created and then make a strong dispersion frequency which will change the phase of the acoustic wave front on the field measurement process. Therefore, a Fast Fourier Transform (FFT) and the reverse of FFT can perform the trace-back of the distortion signal to solve the thick wire problem. After the trace-back, the exact phase can be recovered to replace the original distortion signal. This algorithm has improved the first field integral and the results are much close to the result of the Hall probe measurement. The second field integral will advance to be investigated to understand the error source. However, the precision of the second field integral can maintain within 1 μm.

Reference

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