A Three-dimensional Magnetic Field Mapping System for Deflection Yoke of Cathode-Ray Tube

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Abstract

In this paper, we introduce an efficient three-dimensional magnetic field mapping system for a Deflection Yoke (DY) in Cathode-Ray Tube (CRT). A three-axis Hall probe mounted in a small cylindrical bar and three stepping motors placed in a non-magnetic frame are utilized for the mapping. Prior to the mapping starts, the inner contour of DY is measured by a laser sensor to make a look-up table for inner shape of DY. Three-axis magnetic fields are then digitized by a three-dimensional Hall probe. The results of the mapping can be transformed to various output formats such as multipole harmonics of magnetic fields. Field shape in one, two and three-dimensional spaces can also be displayed. In this paper, we present the features of this mapping device and show some analysis results.

1. Introduction

A DY in CRT is a magnetic device which deflects electron beams to a desired point on the screen. A DY consists of vertical and horizontal coils and a ferrite core, and/or convergence coils. CRTs are required to have a wider flat screen, and a thinner depth to make them competitive with other display devices such as LCD or PDP etc.. In order to meet these requirements in CRT, a large deflection angle is an indispensable feature keeping convergence and distortion error under the certain level. This makes the DY complicated and subsequently it takes a long time to develop. To overcome all these conditions need intensive works such as simulation on beam optics, precise magnetic field measurement, analysis, fabrication, and experiment. Various techniques to reduce the mis-convergence, distortion, etc. have been developed to improve the DY quality [1-2]. Some sensors to measure the field of DY were applied such as a rotating coil [3], flip coil [4] and Hall sensor. The Hall sensor has been widely used in magnetic field measurement because of its easiness in use as well as its high accuracy.

We have developed a three-dimensional Hall probe mapping system for DY. In this paper we describe the system configuration and the methods of protecting Hall probe in abnormal situation. The methods to measure the inner contour for both round and rectangular DY type using the laser sensor are explained also. The mapping process and various output forms to analyze the field are shown.

2. Measurement system

The measurement system consists of four stepping motors, PLC, gauss meter, computer, laser sensor and mechanical frame for supporting motors and platform mechanism for placement of the DY. The block diagram of the field mapping system is shown in Fig. 1.

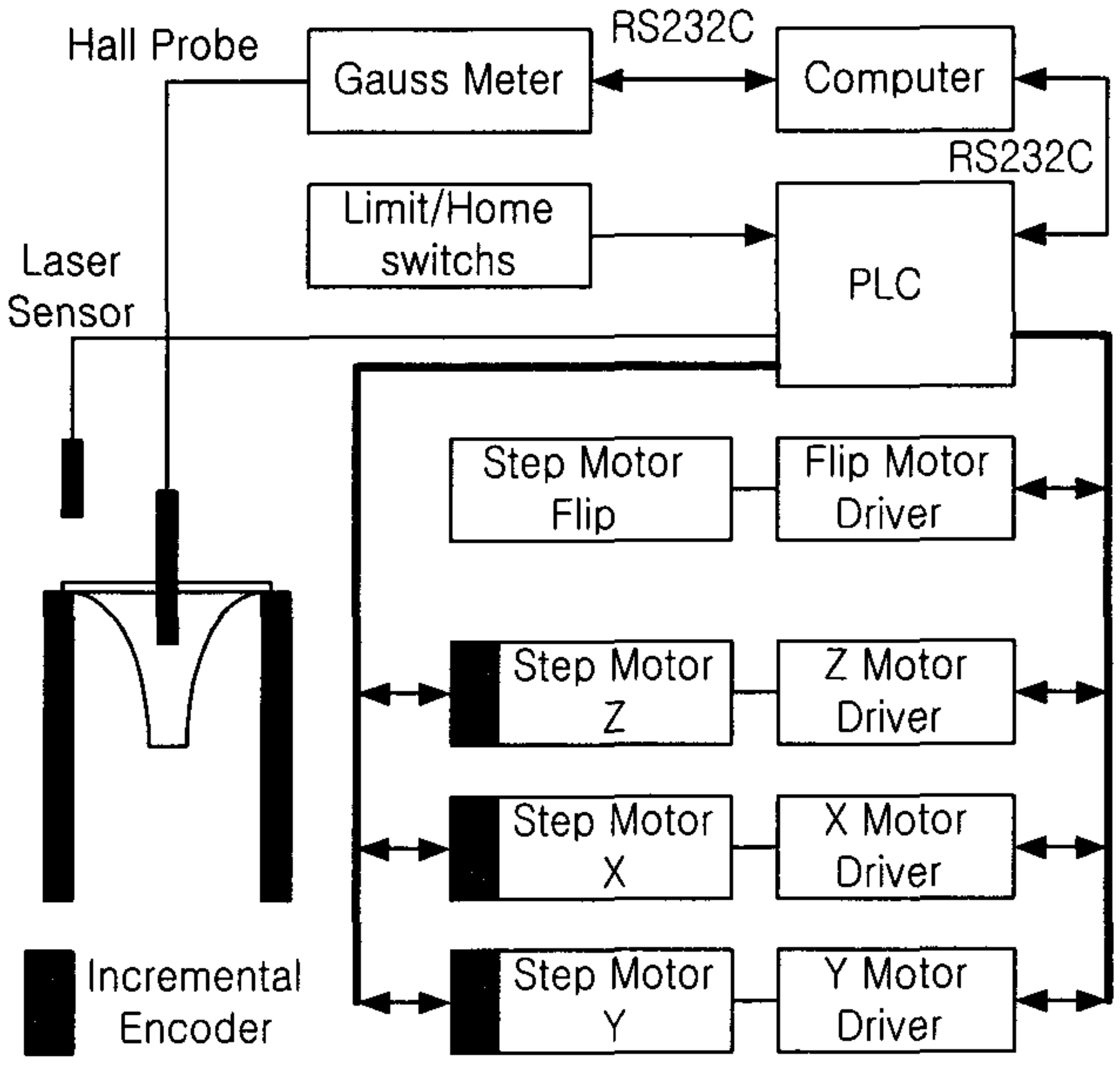

Fig. 1. Block diagram for three-dimensional mapping system.

Three stepping motors are used to carry the Hall probe and the laser sensor to the desired positions in three dimensional space, and the other to flip the laser sensor from 0 to 90 degrees to reduce the measurement error of the laser sensor by aligning the laser beam shape parallel to the inner plane of the DY where the beam shape is similar to a tiny rectangular about 0.5mm × 1mm.

The platform on which the DY was laid has been aligned in both x and y axis using a dial gauge which was temporary placed at the Hall probe position during the alignment. The dial gauge was moved along the x axis and then y axis by driving stepping motors. It was then examined how much discrepancy between platform and motor axis existed. The platform position was adjusted to have a good alignment with each motor axis within 20μm.

Model 7030 gauss meter and Series 7000 three-axis Hall probe of F.W. BELL were used. The gauss meter has an accuracy of ±0.5% in DC mode and temperature stability ±(0.02% of reading ± 1 count) / °C maximum. The normal active area of the Hall sensor is 1.8mm^2.

If an instantaneous AC power failure occurs during the mapping, current position of each axis motor will be lost and physical position of each motor in PLC will be initialized to zero. This is required because when logical positions in computer are different from the actual position of the Hall probe, there might have a probability for the Hall probe to hit the inside surface of the DY so that it gets damaged. In order to protect the Hall probe from that dangerous situation, the PLC is always monitoring the AC power status. If the PLS detects the power failure, the mapping process was halted to inform the computer to know the status of power failure at the PLC.

Different counter values between incremental encoders attached to each x, y, and z axis and pulses which had been fed to stepping motor on each axis were monitored during the entire mapping period to find the discrepancy. If its accumulated value is larger than 1mm, the mapping process is halted automatically, and displayed the status on the monitor screen. The control program is running under Windows 2000 with menu driven method and written in visual C++.

3. Contour measurement

To get the inner contour of DY for field mapping is one of the necessary procedures to get information on the space to be measured. The Hall probe should be moved inside a DY without touching the DY coil or frame to prevent it from the damage. The laser sensor LM10-250 of NAIS Co. was utilized to measure the inner contour of the DY. The LM10-250 has the measurement range of 250 mm and the linearity error ±0.4% in full scale. The sensor output was averaged to have minimum random fluctuation up to 10 data sets. Its accuracy is always within ±0.1 mm. The laser sensor was installed upside-down on top of the DY. In the case of a round-type DY the laser sensor scans the depth of the DY by moving from the outer radius to the center position by 1mm step. These scan data sets are applied to solve the circular equation to get x and y position values at the given depth along inner surface contour from 0 to 120 mm in 1mm step along the z axis. The measured inner shape of the DY is shown Fig. 2.

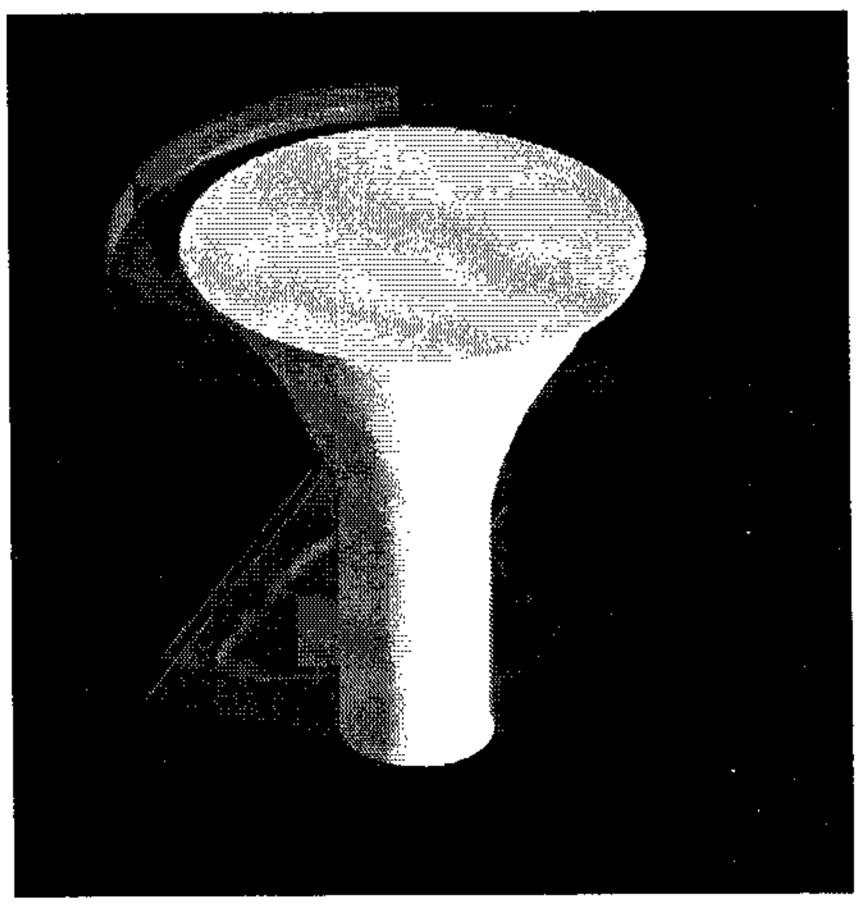

Fig. 2. Inner contour shape measured by laser sensor.

Measuring the inner contour of a rectangular DY is more complicated than a round type DY and we have used a very sophisticated procedure to identify the inner contour of a rectangular DY which will not be described here.

From these steps, the minimum step for mapping was fixed to 1mm in three-dimensional space. The Hall probe size and safety margin to protect the mapping system are taken into account when final table is constructed.

4. Field mapping

A sample DY to be measured was placed on the platform at first. The DY was moved to the exact center position in the x-y plane using four non-magnetic steel rods which can be moved only inward and outward directions and tightly guided by through halls in four support-poles. Four rods were divided into two pairs, one pair was on the x axis to adjust the DY to y direction, and the other was for x direction. The z axis alignment was dependent upon the flange thickness of the horizontal coil. The Hall probe was always moved up or down within 4mm to keep a distance 10mm between the flange plane of the DY and the initial position of the Hall probe.

The gauss meter including the Hall probe must be calibrated to zero gauss using the zero-gauss chamber. The Hall probe was moved to home positions in x, y, and z axis to set all counters, encoders and driver pulses to zero.

Mesh size (i.e., mapping interval) for each axis on both outside and inside of the DY could be given separately to reduce the mapping time. With a given mesh size for each axis, a look-up table containing all the positions to get the magnetic field value was constructed. The range of z axis was limited from –50mm to 120mm. The mapping system can also measure the magnetic field in a localized region only.

The x and y axis fields were measured at the same position. This can be done by first measuring the y field and shifting the probe by 1.1mm which is the distance between the two probes. The measured field shape at 20mm in depth is shown in Fig. 3.

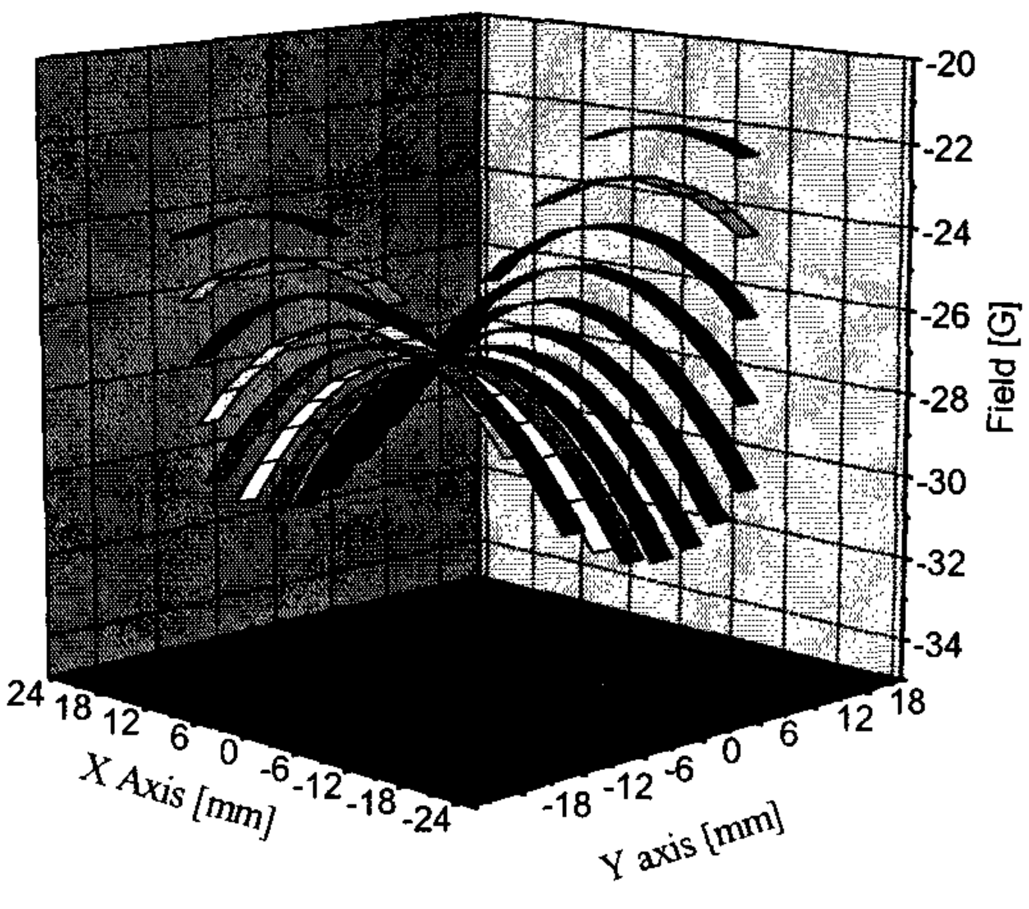

Fig. 3. Measured horizontal magnetic field at 20mm in z axis

The fundamental, third, fifth and seventh harmonic components of the horizontal fields at the center position along the z axis are shown in Fig. 4. The multipole components were obtained by utilizing a polynomial fitting program. In Fig. 5, the vectorial form transformed from measured data is shown.

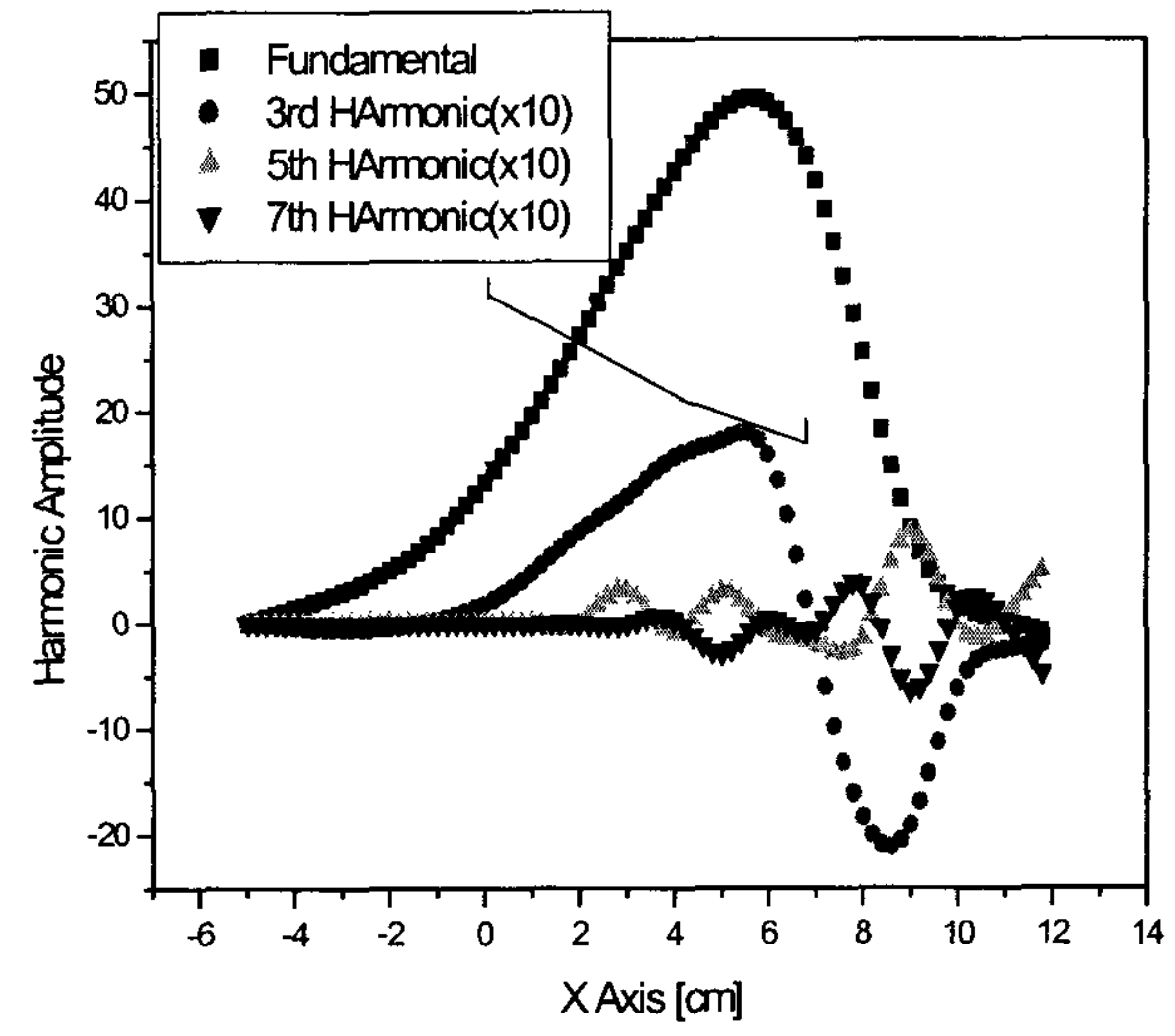

Fig. 4. Fundamental, third, fifth and seventh harmonic components of the horizontal field.

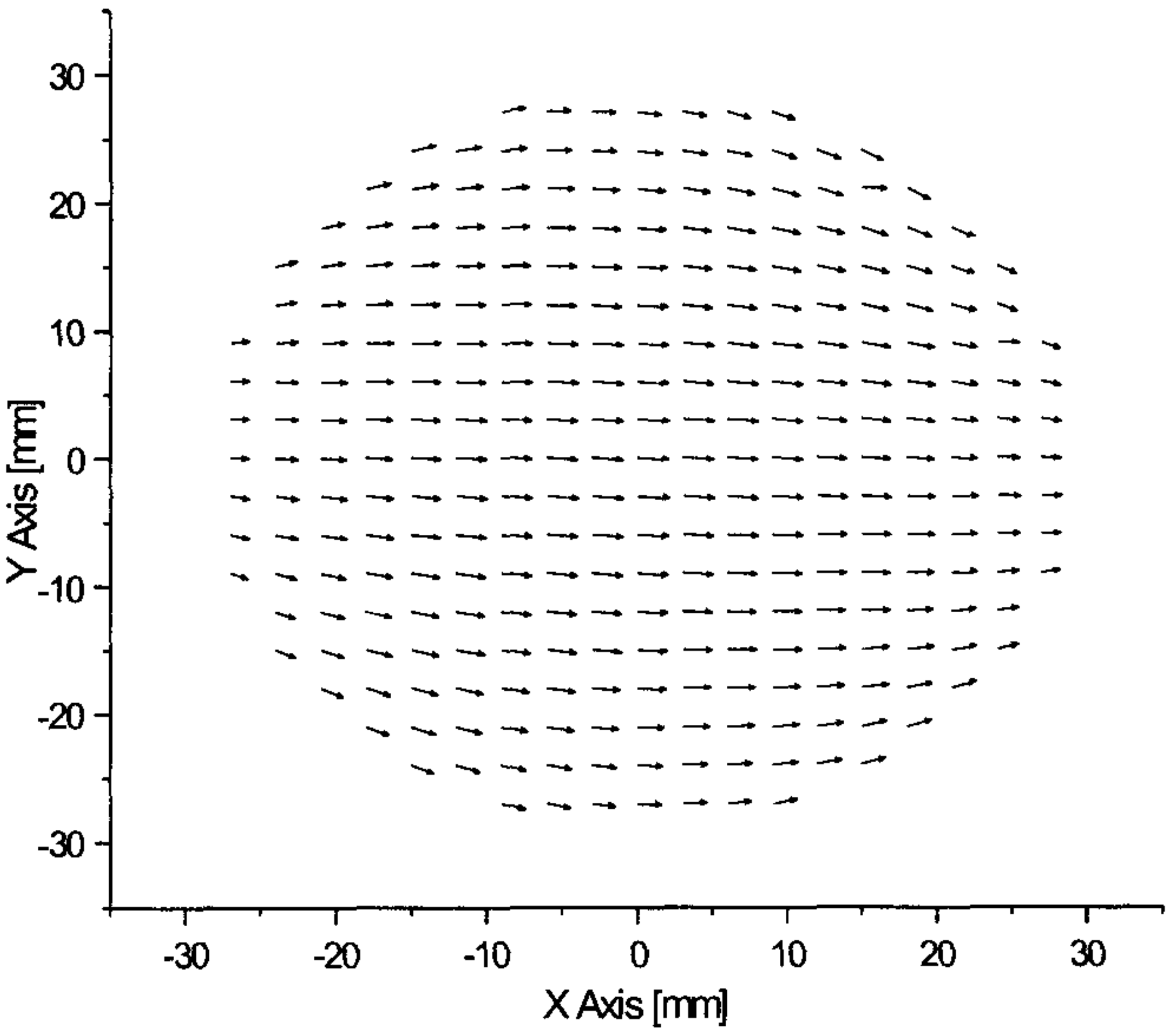

Fig. 5. Measured field data transformed to the vectorial form.

The output data could be easily manipulated to various types and can be used for multipole analysis, trajectory calculation, aberration calculation, etc.

5. Conclusion

Three-dimensional field mapping system using the Hall probe was constructed for the DY. This system has many features: (a) it is very easy to align the DY to the center position; (b) the inner contour of the DY is measured with a laser sensor; (c) it is highly safe in operation by monitoring the AC power status and encoder clocks of each axis; and (d) it is very convenient to use with Windows OS. Both x and y components of magnetic fields were measured at the same position, which reduced the measurement time and made the measurement more precise by eliminating the Hall probe drift with time. The output data could be easily sorted to the other formats for the purpose of modeling, simulation, drawing, and so on. We confirmed that the output data were very helpful in developing a new DY.

6. References

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