ISBN: 978-3-95450-223-3 ISSN: 2673-7000 doi:10.18429/JACoW-NAPAC2019-MOPLM23

SENIS HALL PROBE SPEED DEPENDENCE ISSUES*

I. Vasserman†, Argonne National Laboratory, Argonne, IL, USA

Abstract

An extensive test of a Senis 2-axis Hall probe was done at the Advanced Photon Source (APS) using the Undulator A device. Strong dependence of the measurement data on the speed of the sensor is observed. Discussion of the possible reason of such dependence is provided.

TEST RESULTS

We recently found that the LCLS-2 prototype wiggler measurement results collected at the APS and at SLAC are different, and an investigation of this issue was performed. It was found that peak field results are speed dependent. First test of these Hall probes performed at APS did not test this type of errors [1]. To identify the reason for this difference, additional test measurements of the undulator A device using a Senis 131-15 two-axis Hall probe were performed. The first test was done using different scanning speeds (150 mm/s; 50 mm/s) and different step sizes (0.2 mm; 0.1 mm). Results of this test (see Fig. 1) showed strong dependence on the speed and no dependence on the step size.

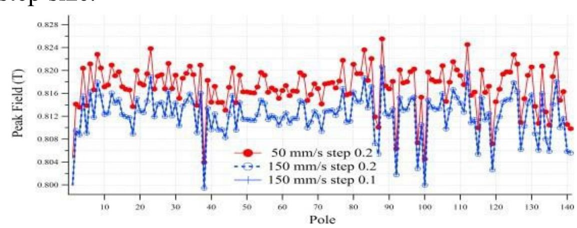

Figure 1: Senis 131-15 Hall probe scan; Una33#2, gap 11.5 mm; scan speed 150 mm/s vs. 50 mm/s.

The scan with the step size of the undulator period (33 mm) was done also to measure only the peak field of one sign (close to -8000 G). The difference is the same as for the measured, real alternating field of the device with a step of 0.1 mm. (see Fig. 2).

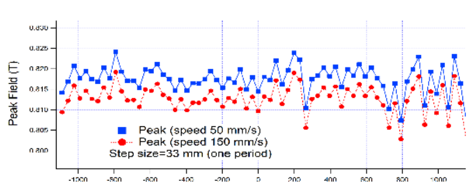

Figure 2: Scan speed 150 mm/sec vs. 50 mm/sec. Step size 33 mm.

Only speed itself is important, not the shape of the field at the measurement point or the frequency of measurements (step size). It seems as if something inside the probe produces a speed dependent signal.

*Work supported by the U.S. Department of Energy, Office of Science, under Contract No. DE- AC02- 06CH11357
† vasserman@aps.anl.gov

It could be wires or some conductive pieces. This is not a critical issue for the APS devices since the results are consistent and reproducible, but awareness of this issue is useful, as it can be important for some applications.

The next step in the test was to cover the entire range of the scanning speed to find where the results are the same as with the conditions during calibration when the Hall probe measures only the stable field (see Fig. 3).

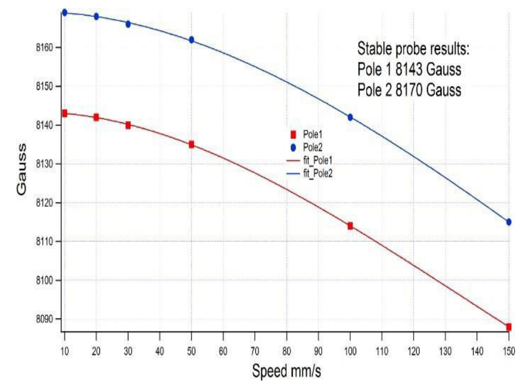

Figure 3: 33-mm-period device; Senis 131-15 Hall probe peak field speed dependence.

As a reference, peak field was measured with the Hall probe in rest over two poles in the middle of the device. One of the possible sources of the error we described earlier is Faraday's law, which states that the electromagnetic force (EMF) through the wire loop is given by the rate of change of the magnetic flux:

$$E = -d\emptyset/dt\,. \tag{1}$$

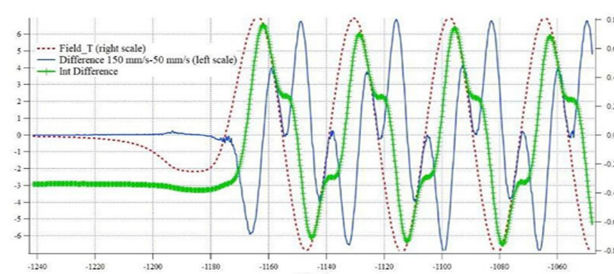

Figure 4: Magnetic field vs Z for 33-mm-period Una#2 device (right scale) and difference of the field measured at scans with speed of 150 mm/s and 50 mm/s (left scale); integrated difference (left scale).

We can see from Fig. 4 that the difference between results is close to 0 in the regions with no longitudinal gradient, and it becomes strong in the regions with such a gradient. From Eq. (1) we can write the expression for the flux going through the wire loop as:

$$\emptyset = -\int E * dt + C \tag{2}$$

Therefore, if the difference in the scan results is due to the wire loop, the integral of this difference is proportional

North American Particle Acc. Conf. NAPAC2019, Lansing, MI, USA JACoW Publishing
ISBN: 978-3-95450-223-3 ISSN: 2673-7000 doi:10.18429/JACoW-NAPAC2019-MOPLM23

to the magnetic field if the EMF factor is the only source. The comparison between red and green curves shows that this assumption is correct in the first order of approximation for this type of de- vice. A possible explanation of other parameters affecting the results is discussed below. Performance of the devices with a large area of flat field is almost not affected by such an error.

The difference between the scans with speeds of 150 mm/s and 50 mm/s is shown above in Fig. 4 is not possible to explain using only an Eq. (1). The most probable explanation in this case will be effect of a capacitor, which stores an electric charge at the first stage of the scan, and dis charge it at the next stage. The combination of the inductance and capacity of the Hall probe system is the most probable reason for the picture we see in Fig. 4. One more test was done with a previous design of the Senis 2-axis Hall probe 067-11. This probe also has speed dependence issues, though at lower levels of distortion (see Fig. 5).

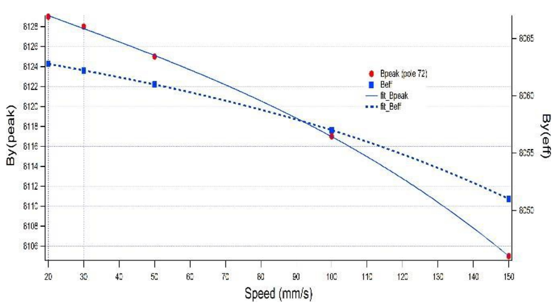

Figure 5: Una33#2 device, Senis 067-11 Hall probe; peak field and effective field speed dependence.

Test measurements for devices with no side access were done using APS 23 mm period undulator. A 3-D Hall probe 419-18 with long signal cable was in- stalled in a copper tube. The results of these measurements shown in Fig. 6 are related to the case when a full length-cable is located inside the undulator.

In this case a strong noise with a period of the device can be seen. This noise is due to coupling between wire loops in the cable with magnetic flux from the device and depends strongly on the speed of the scan.

No noise from the cable can be seen at the end of the scan, when cable is outside the device.

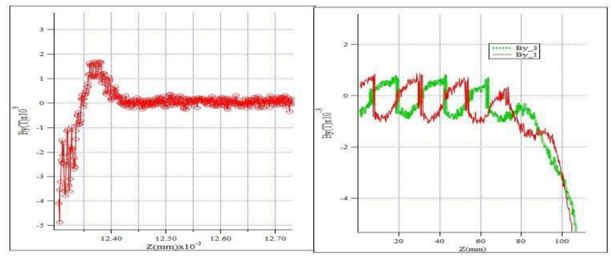

Figure 6: No side access scan with signal able inside undulator. Right: cable inside the device; left: cable outside the device.

CONCLUSION

According to the results of the Senis Hall probe test, speed dependence is associated with longitudinal field change. Therefore, it is most critical for devices with high fields and small periods. The recently received new Senis Hall probe 570-18 does not have this issue. The difference between the new probe and the old probes is a 2x larger bandwidth of the signal and a much shorter signal cable from the transducer to the DMM.

REFERENCES

[1] I.B. Vasserman, N.O. Strelnikov, J.Z. Xu, "Some aspects of achieving an ultimate accuracy during insertion device magnetic measurements by a Hall probe," *Rev. Sci. Instrum.*, vol. 84, p. 025004, Feb. 2013. doi:10.1063/1.4790422