CHALMERS

Performance evaluation of amorphous hexa-core for distribution transformers

Bachelor's Thesis in the Bachelor's programme Electric Power Engineering

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Department of Materials and Manufacturing Technology
Division of High Voltage Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
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ABSTRACT

Core losses and magnetization characteristics measured for two 15 kVA transformers with the hexa-cores made of amorphous alloy 2605HB1M from Metglas and 0.18 mm thick grain oriented silicone steel from Krupp are studied. The results of the no-load, short circuit and magnetization tests performed in the frequency range 50 – 400 Hz are presented. The results of the measurements show that the amorphous core provided significantly lower losses than the grain oriented one. However, it has a lower saturation point. General observations made during testing are also discussed.

Key words: Hexa-core, power loss, no-load test, amorphous material, grain oriented material

UTVÄRDERING AV AMORF- OCH MAGNETISK ORIENTERAD HEXA-CORE FÖR TRANSFORMATORER

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SAMMANFATTNING

Järnförluster och magnetiseringskarakteristik som uppmätts för två 15 kVA transformatorer med hexa-core kärnor gjorda av en amorf legering 2605HB1M från Metglas och ett 0,18 mm tjockt magnetiskt orienterat stål från Krupp har studerats. Resultaten av tomgångs-, kortslutnings- och magnetiseringstestet utförda i frekvensområdet 50-400 Hz presenteras. Mätningarnas resultat visar att den amorfa kärnan gav upphov till betydligt lägre förluster än kärnan av magnetiskt stål. Dock så har den amorfa kärnan en lägre satureringspunkt. Allmänna observationer gjorda under testernas gång diskuteras också.

Nyckelord: Hexa-core, effektförluster, tomgångstest, amorft material, magnetiskt orienterat stål

Contents

Preface

In this study, an amorphous and a grain oriented hexa-core transformer of similar size and ratings have been evaluated. The tests have been carried out from April 2012 to May 2012 at the Division of High Voltage Engineering, Chalmers University of Technology, Sweden. This project has been carried out with Assoc. Prof. Yuriy Serdyuk as a supervisor.

We would like to thank Johan Ahlström for helping us with our measuring equipment, Magnus Ellsen for useful tips about our software, Aleksander Bartnicki for helping us with the necessary generator setups and, of course, Yuriy for his support and interest in our work.

Göteborg May 2012

Josefin Almén & Måns Breitholtz

1 Introduction and Background

Transformers are an important part of the electrical grid and they often represent a large investment for power companies. To be economically efficient, transformers should be designed to provide as low power loss as possible. This is especially true for the distribution level where they operate in stand-by mode during significant time and losses in the magnetic core represent an essential part of the total loss. Traditionally, conventional E-shaped cores are used for these transformers. Over the past decades however, a new type of cores from the company Hexaformer AB has entered the market. Such cores have hexagon shaped legs and provide symmetrical magnetic flux paths and have proven to show several advantages over traditional ones, such as lower losses, lower noise, smaller volume etc. [1]. These features make hexa-transformers attractive as components of power electronic devices e.g. DC-DC converters. Aiming at further improving of the hexa-core design and exploring new applications for the hexa-core technology, prototype cores made from newly developed amorphous magnetic material 2605HB1M from Metglas and new thin (0.18 mm) grain oriented steel from Krupp have been developed by Hexaformer AB and have been transferred to the High Voltage Engineering group at Chalmers for testing. The purpose of this study is to evaluate the performance of the transformers built with such cores focusing on behaviour of core loss at frequencies in the range from 50 Hz and up to 400 Hz.

2 What is a transformer?

The transformer is a crucial component in the electrical system. Its main task is to transform voltage from one level to the other and to do this with low losses. On its way from generation sites to consumers, the voltage is transformed up or down several times. Particularly when power is to be transported over long distances, it is most advantageous to use a high voltage level. When the generated power reaches its destination, it is transformed down again for distribution to the customers. The transformer can also be viewed as a device to connect circuits without them having any galvanic contact [2].

2.1 Working principle

The function of a transformer is based on the principles of magnetic induction stating that if a changing current flows through a coil, a magnetic flux is induced. Since the flux travels poorly through air, a magnetic core can be used to lead the flux. Thus, when a voltage u1 (Figure 2.1) is applied to the primary winding with N1 turns wound around an iron core, the current in the winding will create a magnetic flux in the core. This flux will in turn travel through the iron and reach the secondary winding. According to the law of induction, this winding will try to oppose the change in the flux by inducing a voltage u2. The voltage u2 will have the same shape as u1, but it will be either higher or lower depending of the ration of the numbers of turns in the windings. If we consider the transformer to be ideal (e.g. lossless), the power input at the primary winding is equal to the output power at the secondary [2].

2.2 Losses in a transformer

For a real transformer, the power losses have to be considered. It cannot be viewed as ideal, which means that one should take into account the reluctance in the iron core and the resistances of the windings. These parameters give rise to losses which consists of loss due to the leakage flux, iron losses and losses in the windings. The aim of any transformer design is to keep these losses as low as possible.

In Figure 2.2 below, the losses are represented in an equivalent circuit of a transformer. In the diagram, the R_1 and R_2 represent the resistances of the windings which cause voltage drops. In ideal calculations these resistances are neglected. In an ideal core, it is assumed that the current needed to create the flux is zero. However when the reluctance is considered, there must be a small current in order to induce the

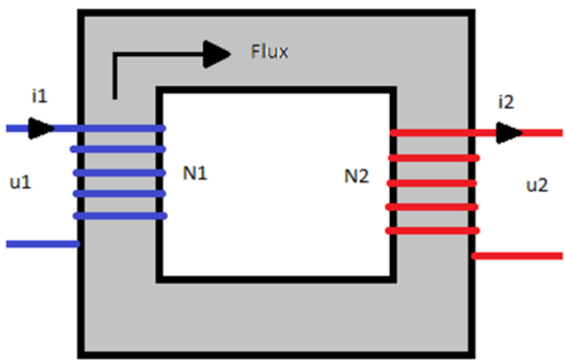

Figure 2.1 A schematic picture of a transformer.

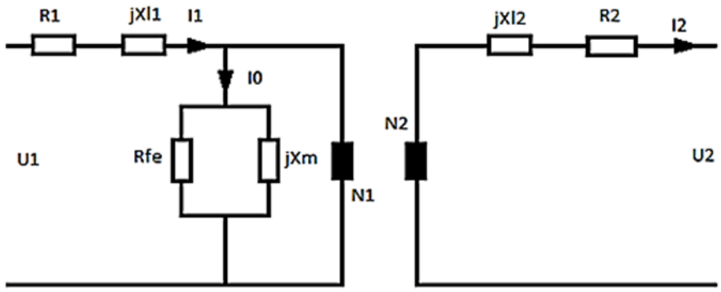

Figure 2.2 A full equivalent circuit of a transformer.

flux. The magnetization circuit is depicted as the magnetizing inductance X_m and the resistance R_{fe} representing losses in the iron core due to circular (eddy) currents. The terms jXl1 and jXl2 indicate the part of the flux that leaks out of the core and, therefore, will not reach the secondary winding. The winding resistance and the leakage inductance of both sides are often combined and placed together on either transformer side as R_k and jX_k.

In a transformer, the no-load loss (aslo called core loss) represents a large part of the total losses over the transformers life time. It is, therefore, important to perfect the core both regarding the shape and material in order to minimize them [2].

2.3 The Hexa-core

The fact that the conventional E-core is not optimal from the point of view of power loss has been known since the end of the nineteenth century. A symmetrical flux path where all the phase winding would lie within equal distance from each other (Figure) was found to be a superior way to build a core. But even though this was known and a symmetrical core was even developed [1], it was far too costly and complicated to manufacture. Since then, the E-shape has been considered as a good enough solution.

The hexa-core goes back to the original idea about a symmetrical structure. Nowadays, new technology allows the manufacturer to wind long metal ribbons in a specific way to create a triangle like placing of the transformer legs (see Figure 2.3). The legs themselves obtain a hexagon cross section and, inherently, such a core is called hexa-core. This type of cores have proven to have several advantages such as lower losses, less vibrations, less noise, being smaller in size and weight and having a more robust construction [1]. Also, manufacturing process can be atomized in a large extent.

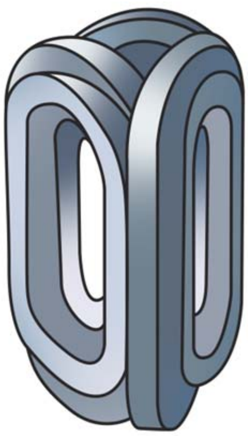

Figure 2.3 A hexa-core.

3 Materials for transformer cores

3.1 Grain oriented steel

Grain oriented (silicone) steel is also known as electrical steel. This material is commonly used for manufacturing transformer cores and also for rotors and stators of electrical motors. Grain oriented steel is made to meet specific magnetic requirements, such as high permeability and low core losses. The steel usually contains up to 3% of silicone, which provides higher electric resistivity for the material. This in turn hinders the eddy currents in the core [4]. The magnetic components are usually assembled from sheets of the steel with the thickness of 0.23 mm.

3.2 Amorphous materials

Amorphous magnetic materials are non-crystalline and do not have magnetic domains. They are made by rapidly cooling the melted metal, thus making it solidify in an irregular pattern (Figure 3.1). This fast cooling is achieved by pouring the metal on a spinning wheel which creates cascades of thin (tens of micrometres) ribbons of metal. The metal solidifies so quickly that it does not have time to form a crystalline structure. These ribbons are then wound into a transformer core. Advantages of this material as a core material include low coercivity, which means lower hysteresis losses, and high electrical resistance, which reduces eddy currents in the core. However, this material is also somewhat brittle and expensive to manufacture [3].

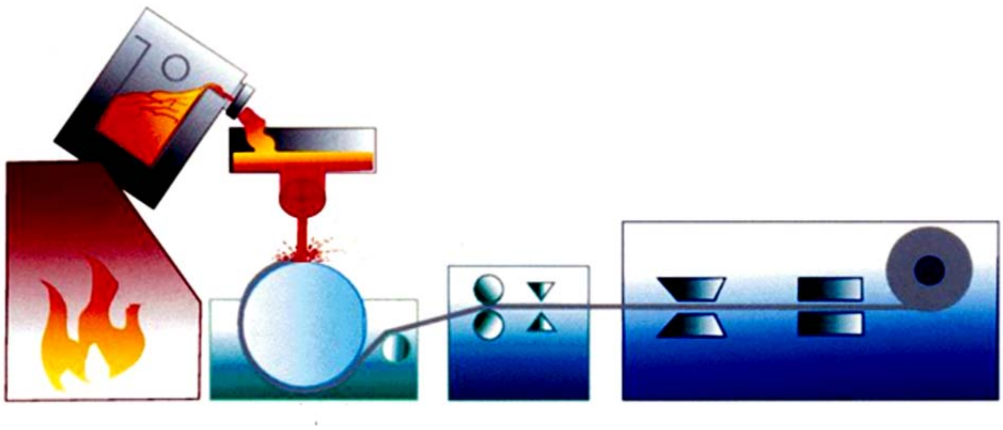

Figure 3.1 Production process of amorphous metals [5].

4 Test setups and procedure

4.1 The test transformers

The transformers are shown in Figure 4.3 and their characteristics are presented in Table 4.1. Note that the transformer with the grain oriented core has a copper band for grounding while the amorphous transformer does not. Both transformers were designed to operate at a magnetic flux density of 1T.

The testing of the transformers involved a three phase short circuit test, a three phase no load test and a magnetization test, which is a no load test on a single phase only. The tests are all meant to be performed at different voltage/current and frequency levels up to their nominal values. Because of this, a grid connected power source could not be used. Instead, a setup of generators were used which could provide different frequency ranges, see Figure 4.1. The basic procedure for all the three tests is illustrated in Figure 4.2.

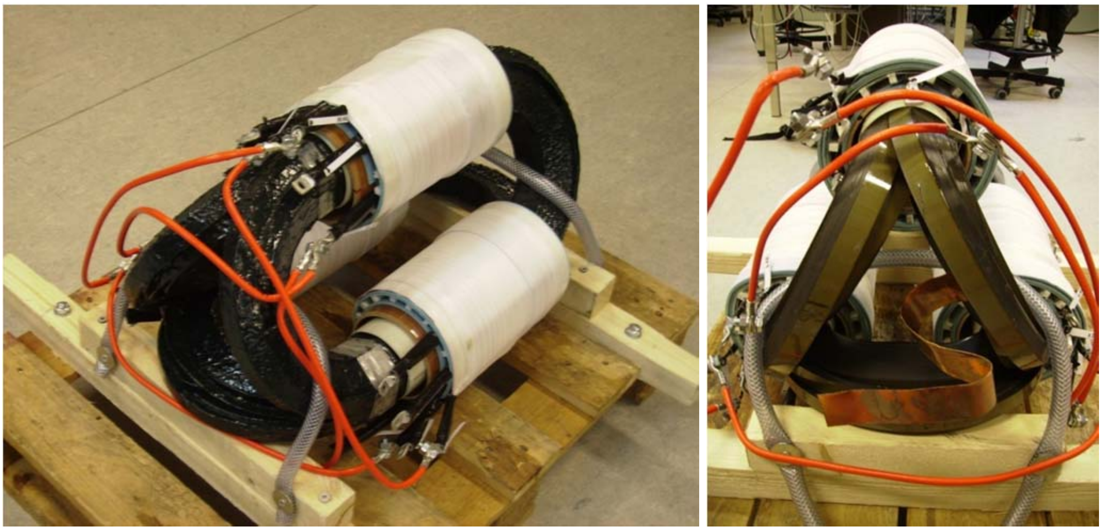

Figure 4.3 The amorphous (left) and grain oriented (right) hexa-core transformers

Table 4.1 Properties the test transformers.

	Amorphous	Grain oriented
Weight	55 kg	49 kg
Coupling	Dy	Dyn
Operating frequency	400 Hz	400 Hz
Rated Power	15 kVA	15 kVA
Voltage level	400 V	400 V
Current level	21,7 A	21,7 A
Number of turns Y	33	33
Number of turns D	57	57
Core material	Metglas 2605HB1M	Silicone steel, 0.18mm
Core leg cross section	3991 mm2	3991 mm2
Core length (one loop)	1,4 m	1,2 m
Winding material	Copper	Copper

Figure 4.1   A photo of the generators used

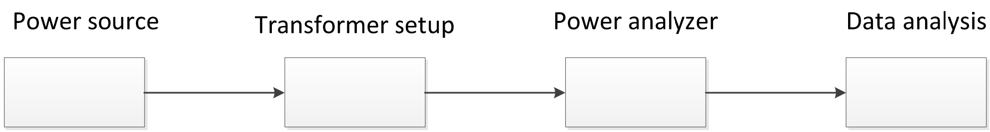

Figure 4.2   Schematics of the test setup.

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4.2 Instruments and software

In the experiments, a Norma 3-phase power analyser D6100 has been used to measure the voltage, the current and the phase angle, see Figure 4.5. A LabView program was designed to automatically obtain the results of the measurements, to sort them and to store in a text file. A simple flow chart of the LabView program is shown in Figure 4.6. Further, a Matlab program was written to calculate other parameters from the

Figure 4.5   The power analyser (right) and generator control (left).

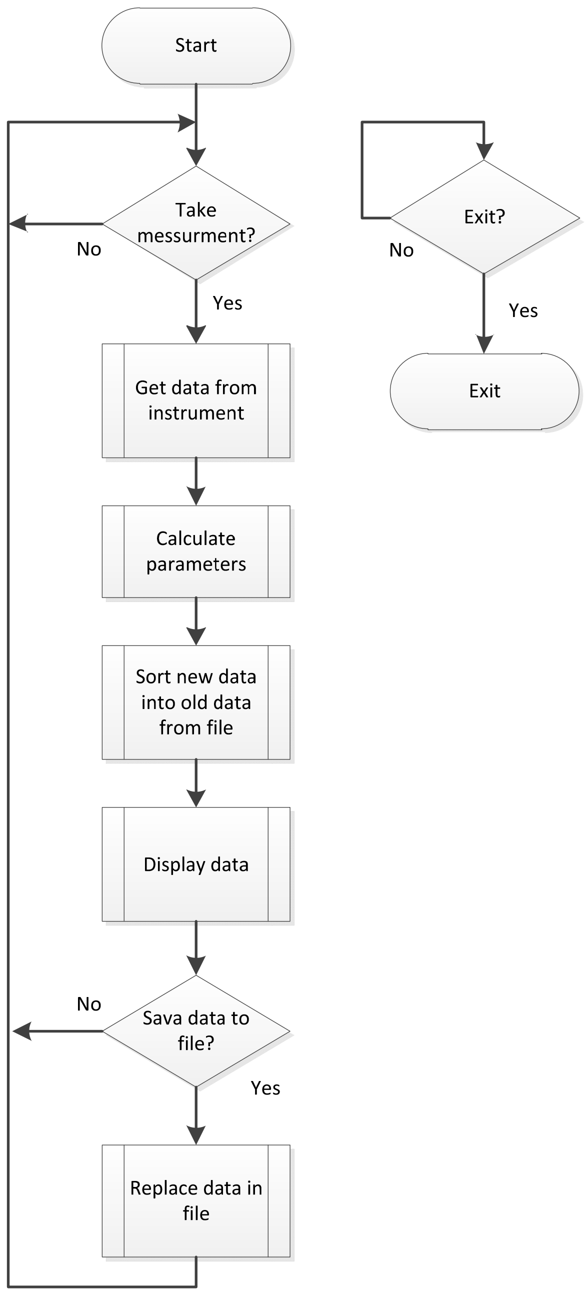


Figure 4.6 Flowchart of the LabView program.

measured data and to represent the data in a graphic form. The LabView and Matlab programs can be found in the appendix.

4.3 No-load test

4.3.1 The Purpose

The purpose of the no-load test is to evaluate the core parameters and to determine the losses caused by the core properties. In a transformer, the no load losses is a large part of the total losses. The sought parameters in this test are those of the magnetizing branch (X_m , R_{fe}) in the diagram in Figure 2.2.

4.3.2 Power source

This test was needed to be conducted at several different voltage and frequency levels to cover the transformers operational range. To achieve this, different external power generators were used in different setups that provided the required range of the parameters.

4.3.3 Transformer setup

The no-load test is often performed on the low voltage side for safety reasons. It is always safer to avoid conducting measurements on high voltages if possible. Since the transformation ration for the tested hexa-transformers is 1:1, the test was conducted on the Y-side for the sake of easier calculations. Figure 4.7 shows the setup for these measurements (note that the delta coupled side is left open) and Figure 4.8 shows the actual setup in the laboratory.

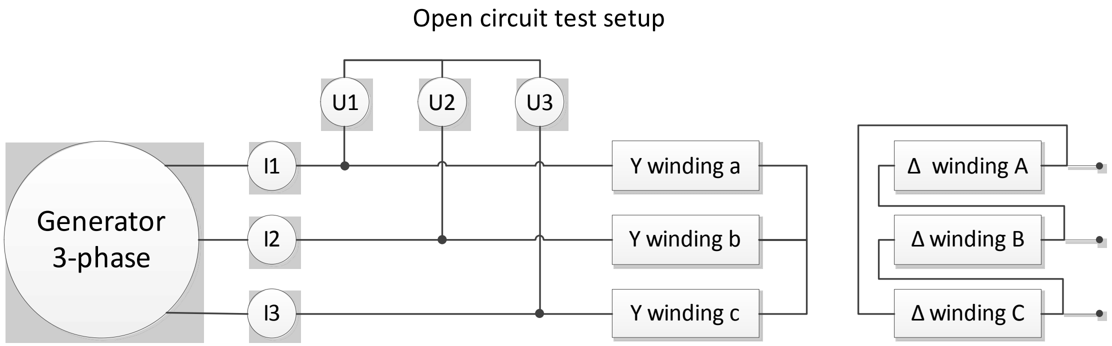


Figure 4.7 Measurement setup for no load test.

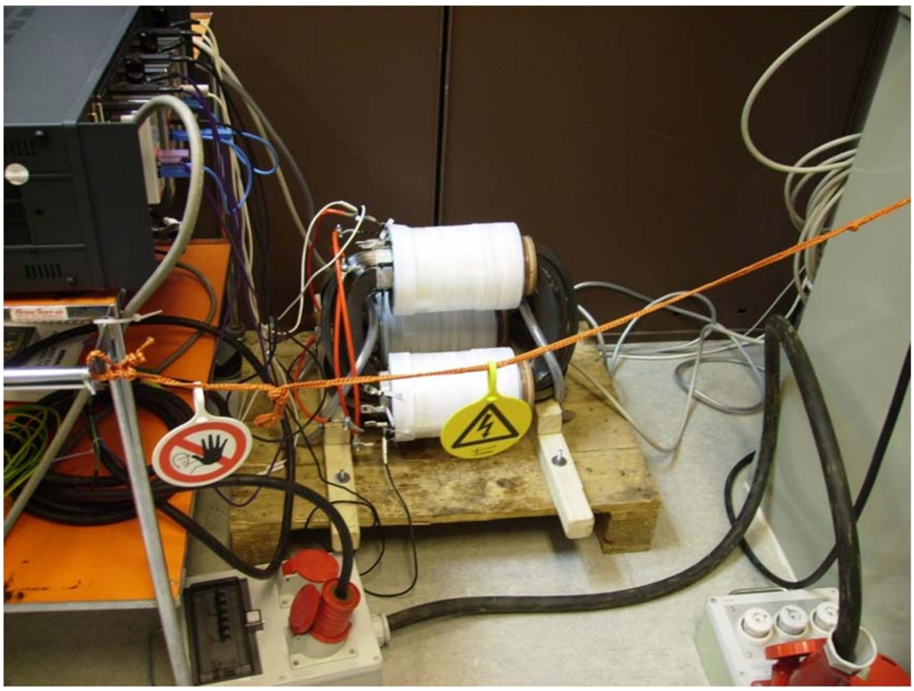


Figure 4.8 No-load test conducted on the grain oriented core.

The voltage was adjusted in steps until the nominal voltage was reached. With the measured values of the voltage, current and power, the parameters jX_m and R_{fe} could be calculated. In this case, the values of jX_k and R_k (see Figure 2.2) were ignored in order to simplify the calculations. This only caused a minor error, since they were much smaller than jX_m anf R_{fe} due to the low currents in this test. The measurements started at 20 V and the voltage increased in steps up to 400 V for the grain oriented transformer and 360 V for the amorphous one. The lower voltage level for the amorphous transformer was a precaution, since it became considerably loud and noisy at higher voltages.

4.4 Short circuit test

4.4.1 The Purpose

From the short circuit test, the losses caused by the winding resistance can be determined. The sought parameters are the winding resistance R_k and the leakage inductance jX_k as depicted in Figure 2.2.

4.4.2 Power source

In this test, the voltage applied to a primary winding should be adjusted until a nominal current is measured in the secondary. This presented some difficulties for this setup. Since the very low resistance in the winding is the only the resistance the current will meet, the voltage needed to reach nominal current is very small. The generators used in the previous tests however, could not supply such low voltages. Instead, the transformers were connected to a lab bench (see Figure 4.9) which provided lower voltage levels. The drawback of this was that the test could only be performed at one frequency level; 50 Hz and only up to 10 A which is a half of the nominal current.

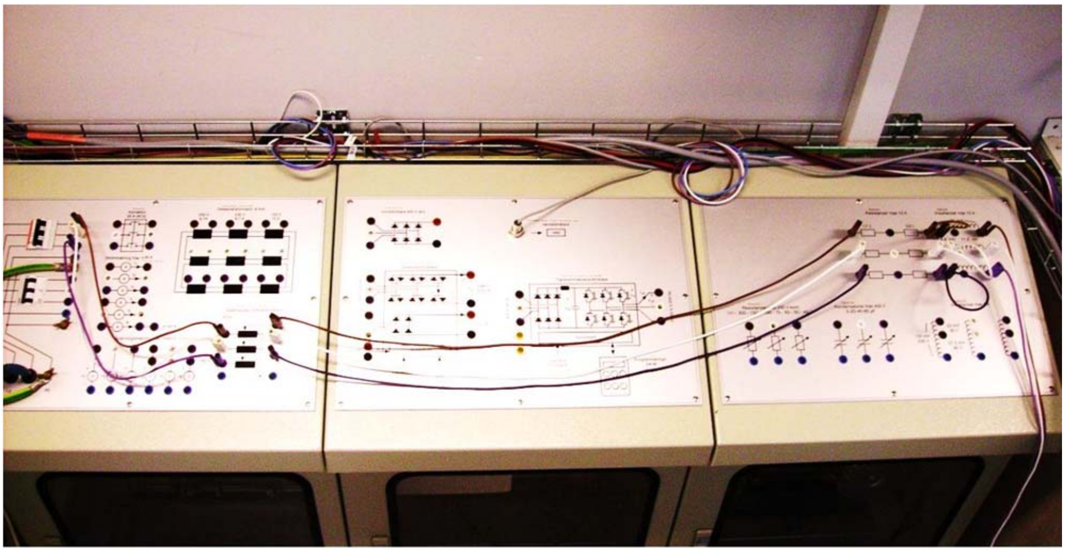


Figure 4.9 The lab bench to which the test transformers were connected.

4.4.3 Transformer setup

For the short circuit test, the Y-coupled side was used again for the measurements as shown in Figure 4.10. Note that the delta coupled side of the transformer is short circuited. Figure 4.11 shows the laboratory setup.

4.5 Magnetization test

4.5.1 The Purpose

To determine the saturation point of the core, a magnetization curve is needed to be obtained.

4.5.2 Power source

Like for the no-load test, the generator setup was used for the magnetization measurements.

4.5.3 Transformer setup

The setup for this test is the same as for the no-load test. The only difference is that the measurements were conducted on one phase only. The reason for this is that the

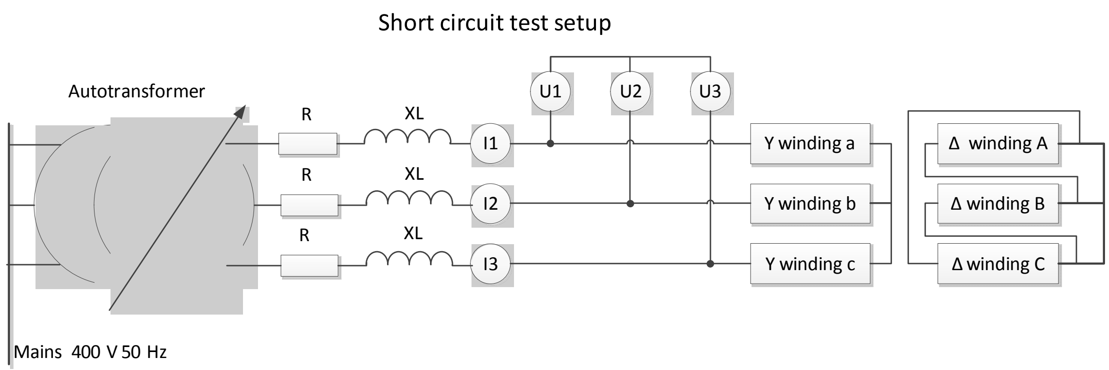


Figure 4.10 Test setup for the short circuit test.

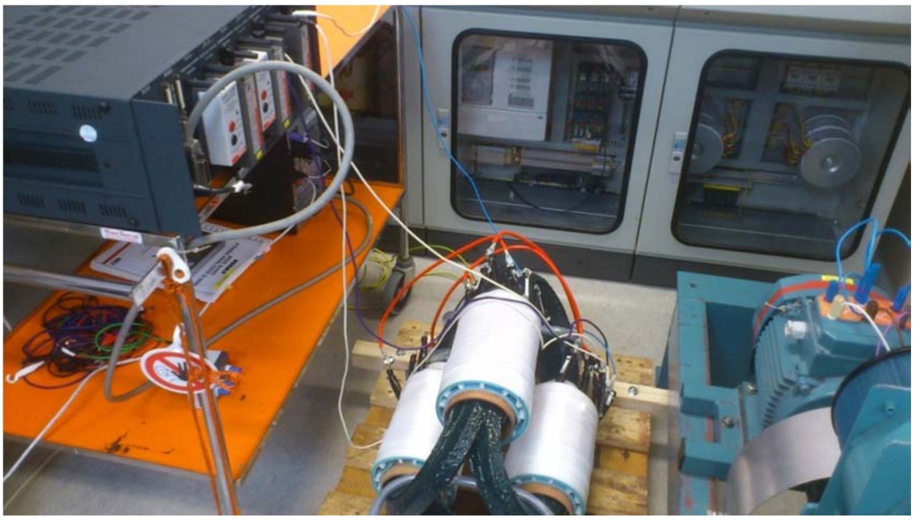


Figure 4.11 Short circuit test conducted on the amorphous core.

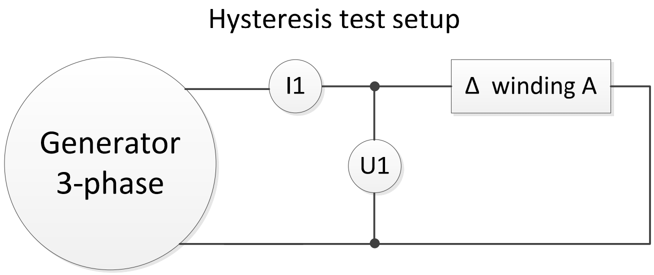


Figure 4.12 Test setup for the magnetization test.

other two phases would have interfered with the flux. Figure 4.12 shows the transformer measurement setup.

5 Results

This chapter presents the results of the measurements. For the sake of comparison, the corresponding graphs for the grain oriented and the amorphous core will be shown together. Since a circumstantial short circuit test could not be conducted, the parameters of the core and the windings will not be displayed. Instead, the losses will be presented directly.

5.1 No-load losses

In Figures 5.1, the no-load losses are presented as a function of the magnetic field density at five different frequencies. As it is seen, the losses become higher at higher frequencies at similar B-field. When compared, one can conclude that the losses in the amorphous core are roughly half of that of the grain oriented at the same flux density (note the different scales on the y-axis).

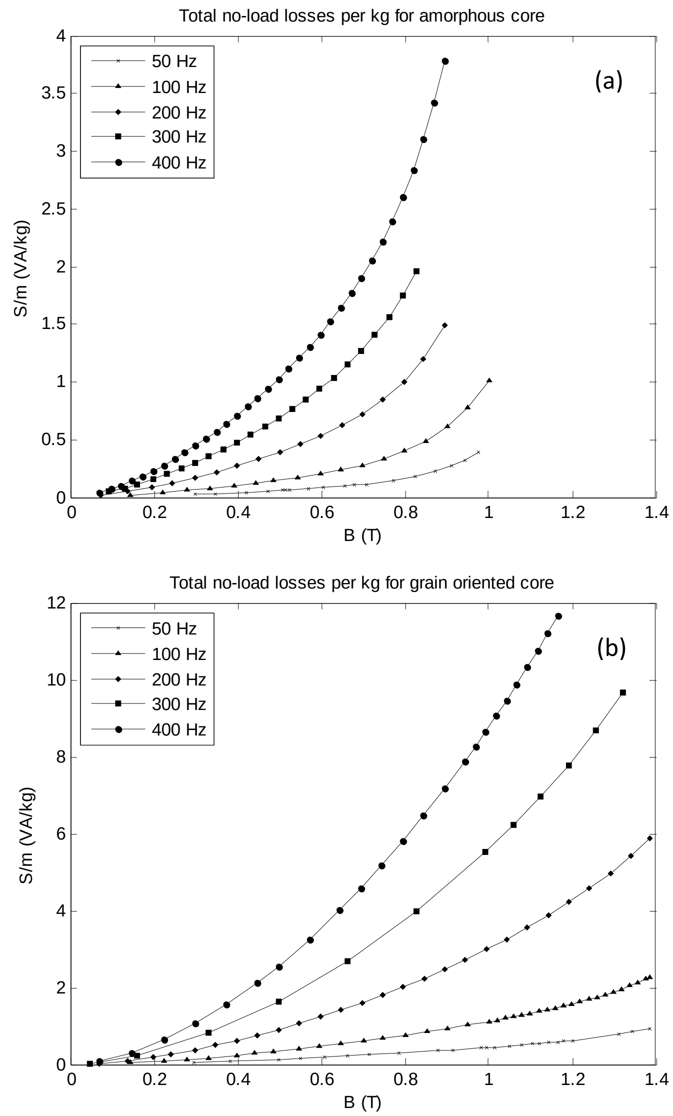
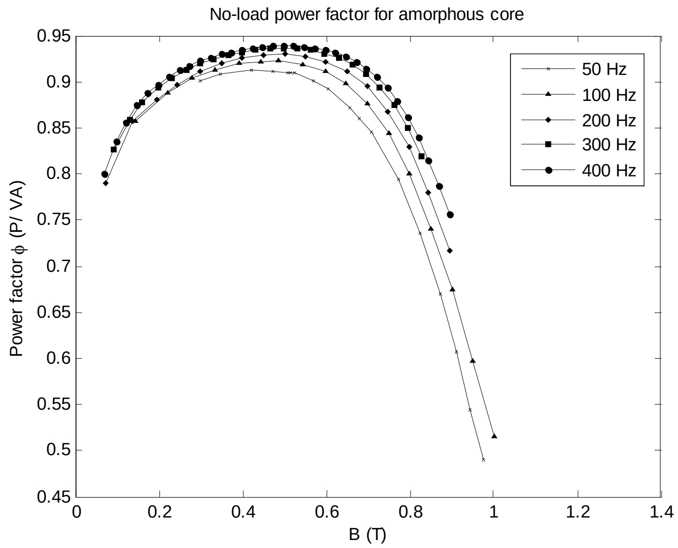
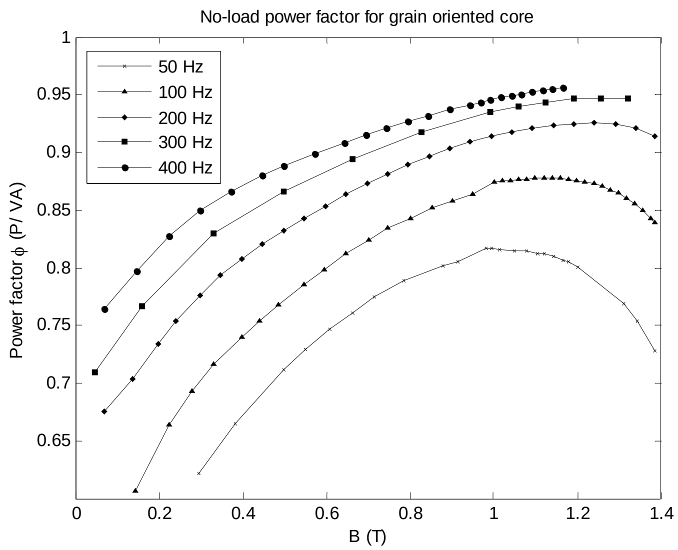


Figure 5.1 No-load losses for the amorphous (a) and grain-oriented (b) cores at different frequencies.

Figure 5.3 shows the power factor (cos Φ) for both transformers as a function of the magnetic field density at different frequencies. From the graphs, it can be found that the maximum power factor grows up to unity at higher frequencies. It can also be seen that the reactive part of the losses increases rapidly at higher flux density for the amorphous transformer. The grain oriented transformer however, does not display such dramatic changes at its operating point (1 T).



(a)



(b)

Figure 5.3 Power factor for the amorphous (a) and the grain oriented (b) cores.

5.2 Core magnetization

In order to analyse

the magnetization of the transformers in terms of the magnetic flux density and magnetic field (so-called B-H curve), these quantities should be deduced from the measured parameters. The procedure was established by considering the following.

The induced voltage in a transformer is a function of the number of turns in the transformer winding N and the varying flux Φ:

$$U_{rms} = \frac{N}{\sqrt{2}} * \frac{d\Phi}{dt} \tag{5.1}$$

The flux itself is harmonic and it can be represented as:

$$\Phi(t) = \Phi_{max} * sin\omega t = A * B_{max} * sin\omega t \tag{5.2}$$

where A is the cross section area of the core and B_{max} is the amplitude of the magnetic flux density. Accounting for the angular frequency $\omega = 2\boldsymbol{\pi}f$ (f is the frequency in Hz), the derivative of the flux in (5.1) is

$$\frac{d\Phi(t)}{dt} = 2\pi f * A * B_{max} * \cos(2\pi f t) = 2\boldsymbol{\pi} f * A * B_{max} \tag{5.3}$$

Finally, by combining equations (5.1) and (5.3), one obtains the induced voltage

$$U_{rms} = \frac{2\boldsymbol{\pi} f * A * B_{max} * N}{\sqrt{2}} = 4{,}44 * f * A * B_{max} * N \tag{5.4}$$

From equation (5.4), the magnetic flux density B_{max} can be calculated for the given frequency f by utilizing the measured magnitudes of U_{rms} and known parameters A and N of the transformer.

To calculate the H-field, equation (5.5) is used:

$$H = \frac{N * I}{l} \tag{5.5}$$

where I is the RMS value of the current and *l* is the equivalent length of the core.

The magnetization curves of the cores are presented in Figures 5.5 and 5.6. It is worth noting that the saturation point is lower for the amorphous core than for the grain oriented one (note that the scales on the B-axis are slightly different in the two graphs). The cores are both meant to be operating around 1 T, which is applicable for the grain oriented. For the amorphous however, it is far too close to the saturation point. On the other hand, the linear part of the amorphous curve occurs at a much lower H-field than for the grain oriented, which means a lower magnetizing current. Note that the values of H are the RMS-values.

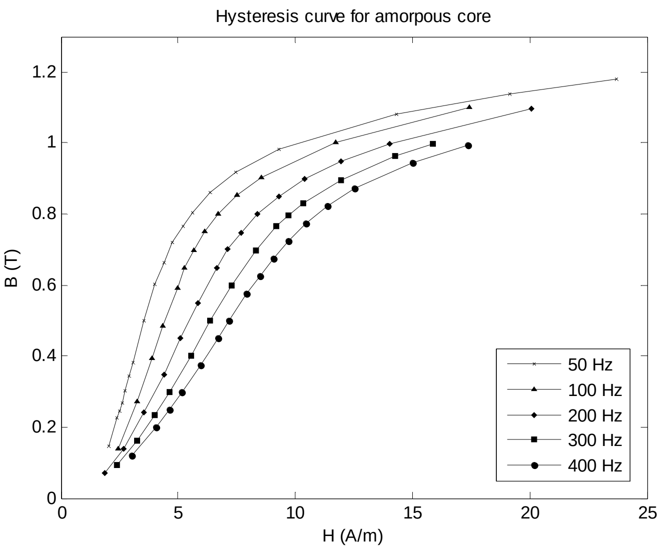


Figure 5.5 Magnetization curves for the amorphous core at different frequencies.

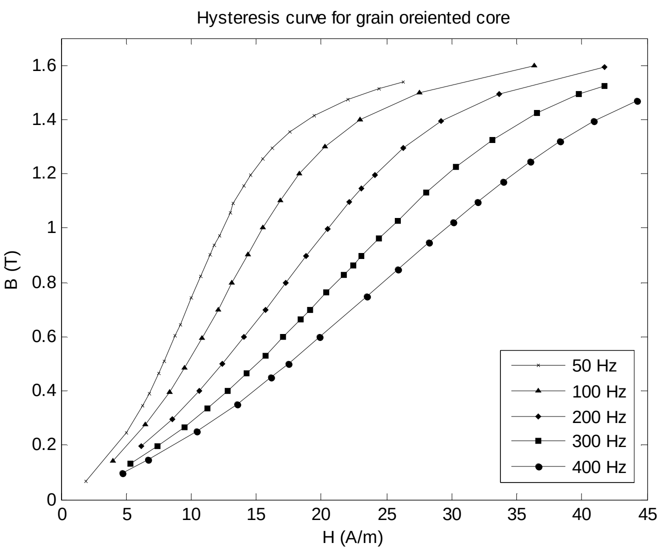


Figure 5.6 Magnetization curves for the grain oriented core at different frequencies.

5.3 Phase core losses

For hexa-transformers, the symmetry of the losses in the core is an inherent property and, therefore, can be used as an indication of e.g. core integrity. Thus, the measurements of the core loss in the grain oriented transformer showed the same level of losses in each phase as seen in Figure 5.7. For the amorphous core, however, considerable differences in the losses in different phases were noted, Figure 5.8. The reasons for that may be some internal damages of the material (e.g. broken strips), which might appear during core production or its thermal treatment due to extremely high brittleness of the amorphous ribbon used.

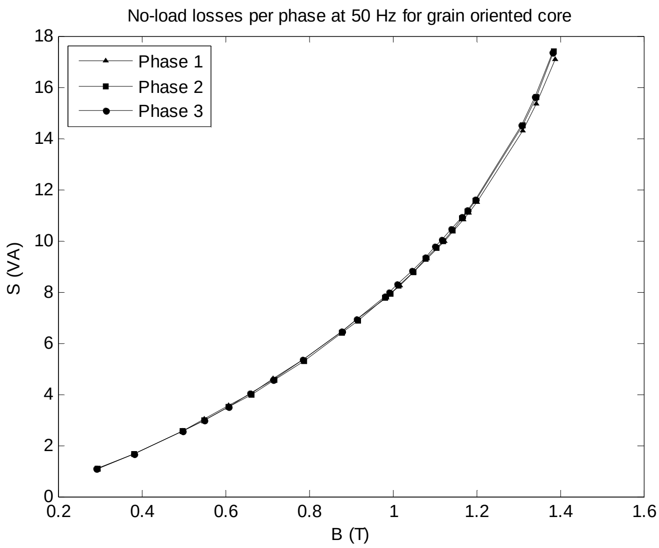


Figure 5.7 Phase no-load losses for the grain oriented core at 50 Hz.

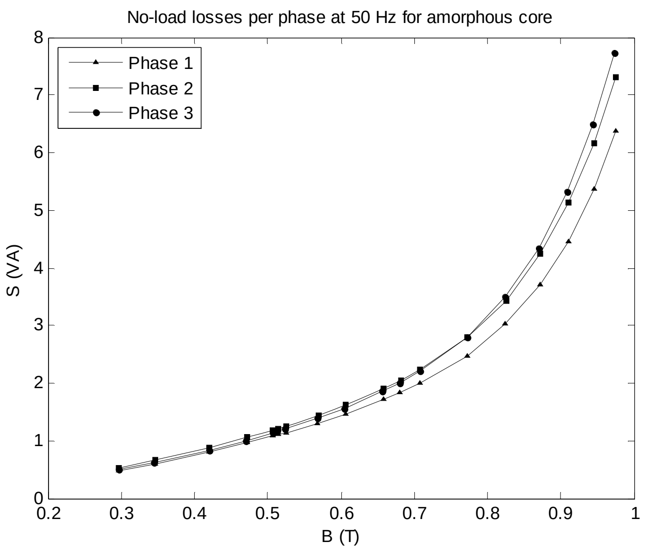


Figure 5.8 Phase no-load losses for the amorphous core at 50 Hz.

5.4 Short circuit test

The short circuit test presented a lot of difficulties. As previously mentioned in section 4.4.2, the generators from the no-load test could not be used since they could not provide a voltage low enough. Instead, a lab setup with an auto transformer connected to the grid was used. This introduced significant limitations in the test since it could only be performed at 50 Hz and only within a limited current range - the highest current level being not even half of the nominal current. It is, therefore, difficult to draw any conclusions from the data that was collected. It is impossible to know exactly how the parameters would change at higher currents. However, from the data points investigated, they seem to be unaffected by changes in the current level. Had the frequency level been variable though, it is safe to say that the variables would have increased. But since the parameters from the short circuit test is related to the windings of the transformer, and this study mainly aims to investigate the core, there was therefore no real need to investigate further. The values obtained for R_k and X_k (see Figure 2.2) at the different current levels are shown in Table 5.1. and Table 5.2.

Table 5.1 The results of the short circuit test for amorphous core at 50 Hz.

	I = 4,511 (A)		I = 6,107 (A)		I = 7,087 (A)	
	Rk (mΩ)	Xk (mΩ)	Rk (mΩ)	Xk (mΩ)	Rk (mΩ)	Xk (mΩ)
Amorphous	39,8	21,6	39,7	21,2	40,1	20,0

Table 5.2 The results of the short circuit test for grain oriented core at 50 Hz.

	I = 4,424 (A)		I = 6,112 (A)		I = 7,901 (A)	
	Rk (mΩ)	Xk (mΩ)	Rk (mΩ)	Xk (mΩ)	Rk (mΩ)	Xk (mΩ)
Grain oriented	40,7	25,4	40,7	25,1	41,0	25,4

6 Discussion and comments

From the presented results, one can conclude that the amorphous material has much lower losses. However, the following observations were made regarding this core.

The amorphous transformer is meant to operate at 1 T. It was discovered though, that this was too close to the saturation point. When testing at the higher voltage and frequency range, the noise and vibrations became so strong that the testing had to be aborted when higher magnetic flux density levels were reached. For the last voltage levels at the higher frequency, ear protection was a necessity. This meant that the core could not be tested for the nominal voltage and frequency. For the grain oriented core however, values above 1 T could be reached without any similar problems. Since one of the purposes of these experiments was to compare two transformer cores at the same nominal values and the amorphous core has a lower saturation level than anticipated, the following calculations were made to avaluate the losses if the cross section area of the amorphous core would be increased in order to handle flux levels corresponding to 400 V test voltage.

If one assumes that the appropriate flux level for the amorphous material is 0.6 T and equation (5.4) is considered, it becomes clear that the cross-section area needs to be increased:

$$A_2 = \frac{1}{0,6} * A_1 = 1,67 * A_1 \tag{6.1}$$

This will cause the total weight and thereby the total no-load losses to increase with the same factor:

$$S_2 = 1,67 * S_1 \tag{6.2}$$

Two things were neglected in this reasoning: the contributing extra copper losses from the longer copper winding needed to have the same number of turns around a thicker core and the fact that the length of the loop will increase when the area increases. Another possible solution instead of increasing the core area would be to increase the number of turns in the winding. The no-load losses would remain roughly unchanged, but the copper losses would increase. Table 6.1 shows the calculated no-load losses for the amorphous core and the measured values of the grain oriented core at nominal voltage and frequency.

Table 6.1 Comparison between the cores at the same nominal values.

Core type	No-load losses (VA)	Mass (kg)
Grain oriented	476	49
Amorphous 1.67*A	175	92

The second observation regards the phase losses of the amorphous core, which turned out to differ from each other, as seen in Figure 5.8. This indicates that the core might be damaged or otherwise faulty. If this is the case, it might mean that the results discussed in the previous point have been affected negatively and that the amorphous core is indeed able to be operated at its nominal values. The asymmetry of the phases would also account for the high noise level.

7 Conclusions

- The core losses are lower for the amorphous transformer, but one must note that for it to operate at the intended 400 V @ 400 Hz, the core would have to be larger than the grain oriented core.

- The saturation point of the amorphous material turned out to be lower than predicted; saturation starts at about 0.7-0.8 T. A suitable voltage level for the amorphous transformer for its current size is 280 V.

- Based on the consideration of the symmetry of the phase core losses, there is a possibility that the amorphous core have somehow been damaged, either during the manufacturing process or from mechanical stresses during transportation.

- The amorphous transformer was found to be quite noisy that may be related to possible internal damages.

8 References

[1] www.hexaformer.com

[2] Department of Energy and Environment: Compendium for the course Electrical engineering *Electrical Engineering* {Elteknik}, Chalmers University of technology, Göteborg.

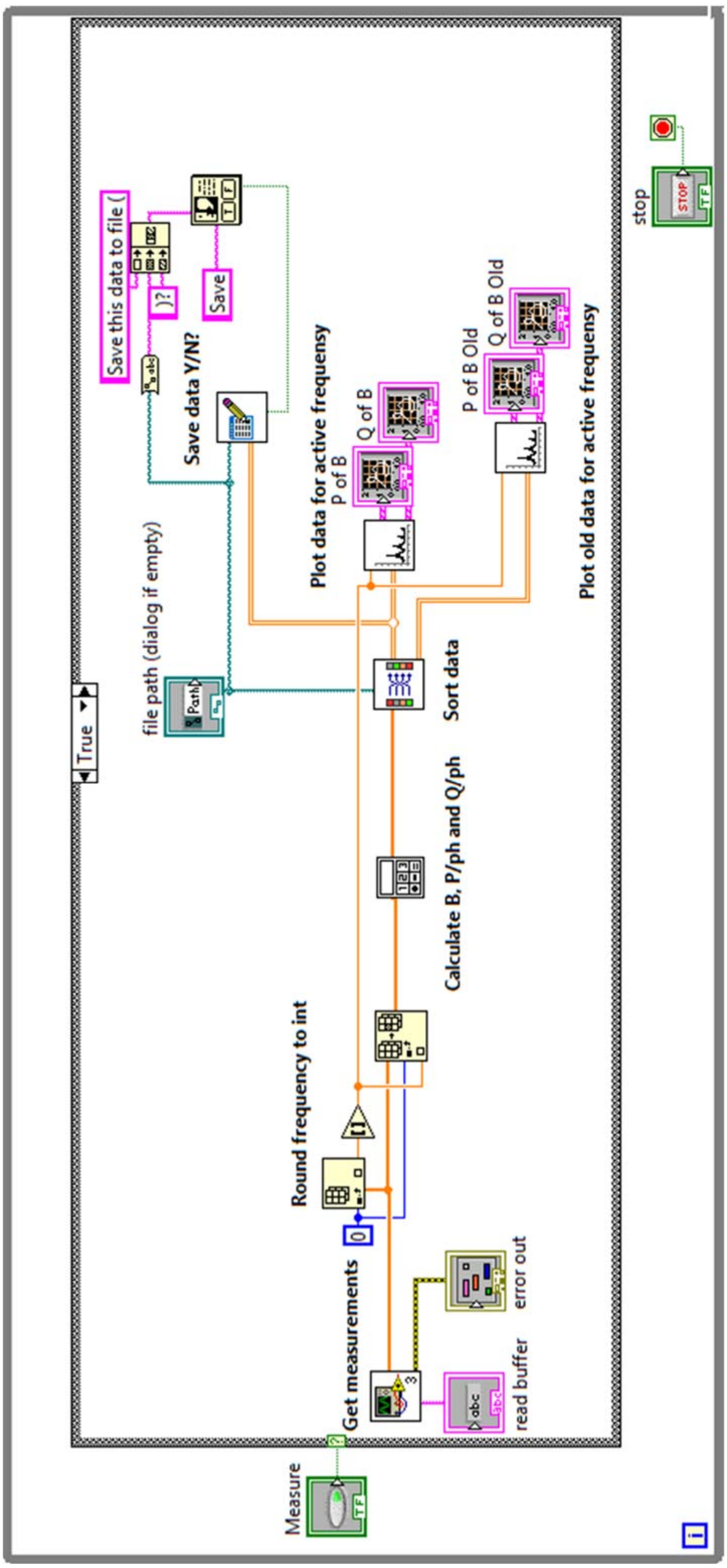
[3] W. NG, H., Hasegawa, R., C.Lee, A., Lowdermilk, L. (1991): Amorphous Alloy Core Distribution Transformer. *Proceedings of the IEEE,* Vol 79, No. 11, pp. 1608-1610

[4] www.wikipedia.org

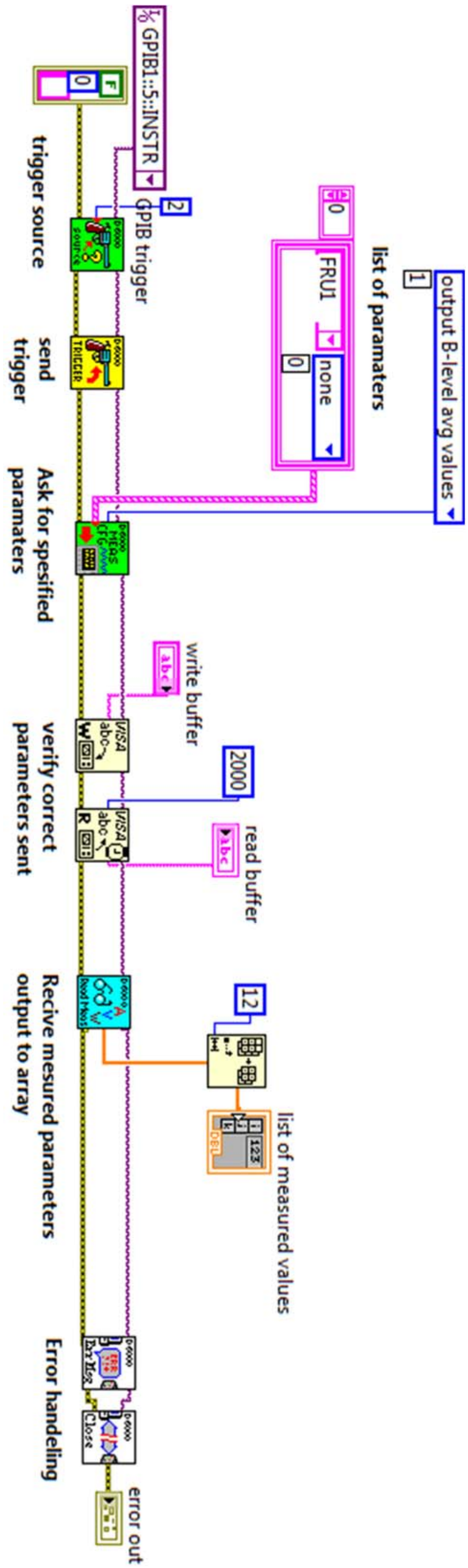
[5] www.brgenergy.com

9 Appendix A

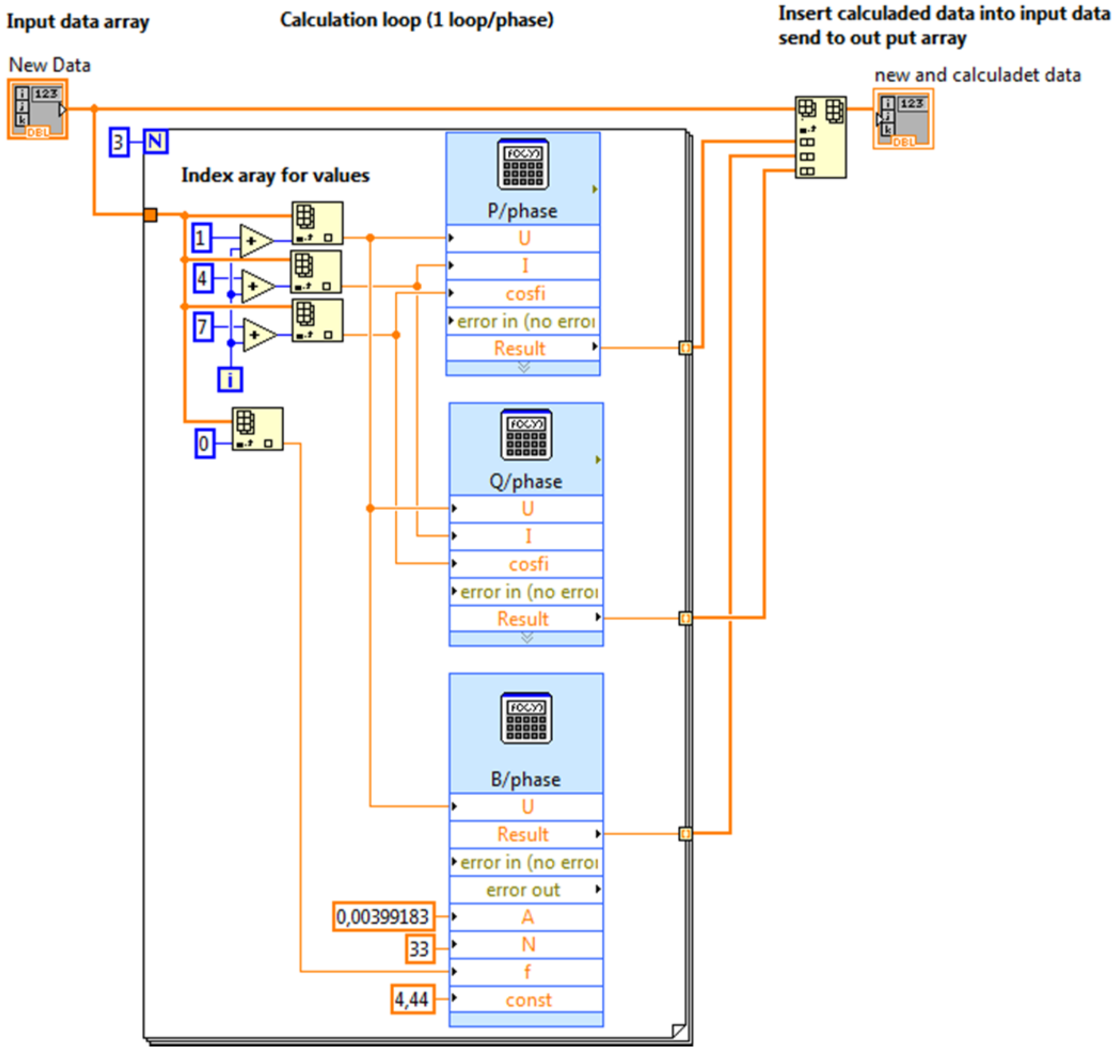
9.1 Labview main program.



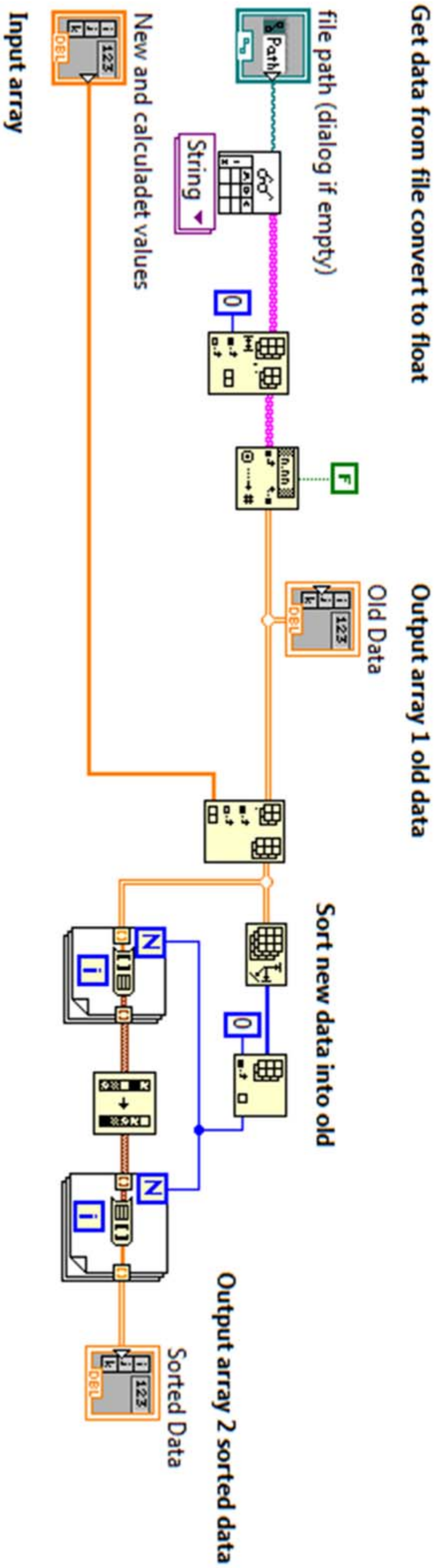
9.2 Labview subVi Get measurements.



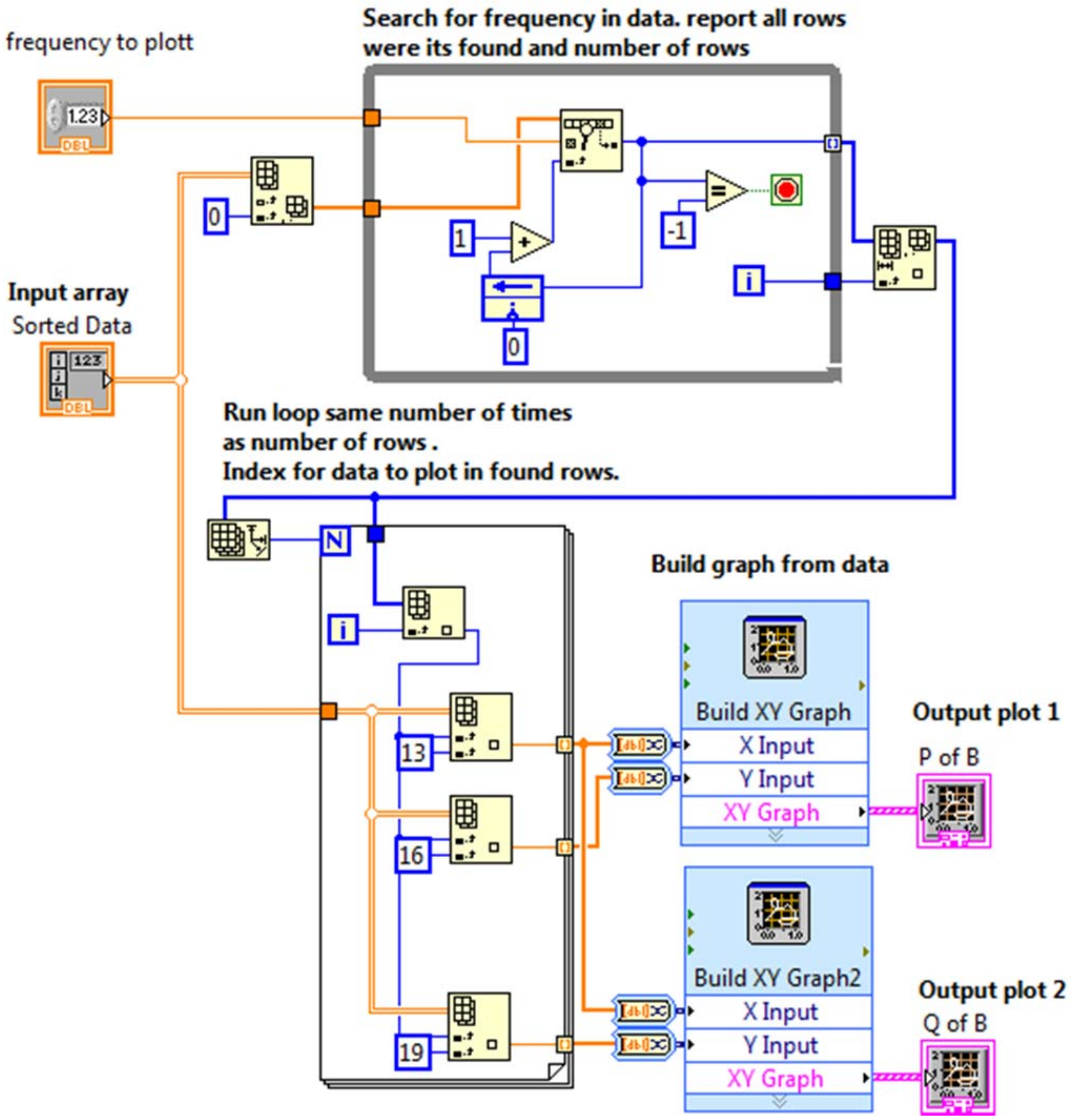
9.3 Labview subVi Calculate parameters.



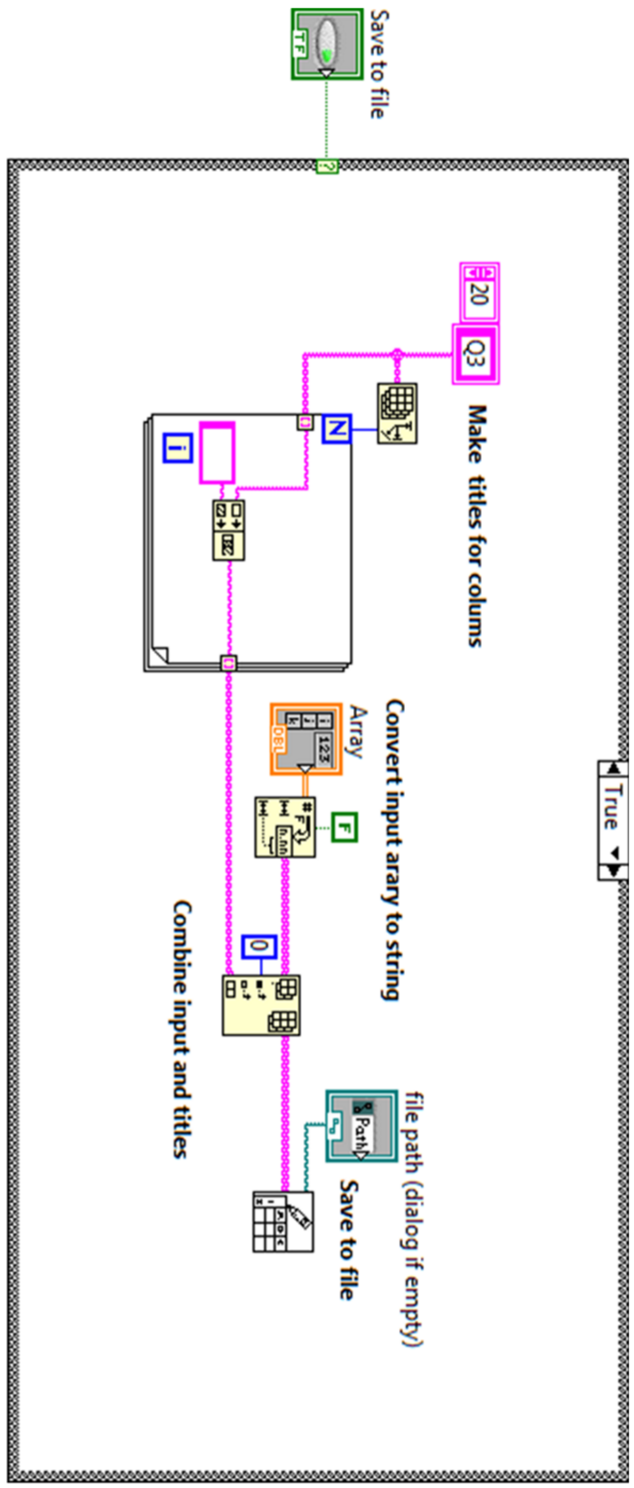
9.4 Labview subVi Sort data.



9.5 Labview subVi Plot data.



9.6 Labview subVi Save to file.



10 Appendix B

10.1 No-load test amorphous core 50 and 100 Hz.

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
50	8,69	8,70	8,70	0,055	0,061	0,057	0,9158	0,9090	0,8773	1,3554	0,6514	0,2971	0,2975	0,2973	0,4408	0,4784	0,4363	0,1934	0,2194	0,2387
50	10,13	10,13	10,10	0,06	0,065	0,062	0,9214	0,9143	0,8860	1,7066	0,7886	0,3465	0,3463	0,3453	0,5565	0,6000	0,5502	0,2348	0,2659	0,2880
50	12,27	12,29	12,28	0,066	0,072	0,068	0,9240	0,9209	0,8909	2,3028	1,0324	0,4197	0,4202	0,4198	0,7451	0,8091	0,7481	0,3083	0,3426	0,3813
50	13,81	13,80	13,77	0,07	0,076	0,073	0,9233	0,9205	0,8900	2,7571	1,2414	0,4721	0,4720	0,4707	0,8923	0,9694	0,8943	0,3712	0,4116	0,4581
50	14,81	14,85	14,80	0,073	0,08	0,077	0,9211	0,9205	0,8879	3,0926	1,4051	0,5065	0,5077	0,5062	0,9960	1,0891	1,0068	0,4209	0,4624	0,5216
50	15,04	15,05	15,00	0,074	0,081	0,078	0,9206	0,9202	0,8876	3,1703	1,4441	0,5144	0,5145	0,5130	1,0220	1,1159	1,0319	0,4336	0,4748	0,5355
50	15,35	15,36	15,31	0,075	0,082	0,078	0,9198	0,9195	0,8863	3,2669	1,4969	0,5249	0,5254	0,5236	1,0518	1,1514	1,0639	0,4487	0,4922	0,5560
50	16,62	16,66	16,60	0,079	0,087	0,084	0,9116	0,9142	0,8762	3,7259	1,7902	0,5683	0,5696	0,5676	1,1924	1,3188	1,2145	0,5377	0,5846	0,6679
50	17,72	17,73	17,70	0,083	0,091	0,088	0,9011	0,9077	0,8654	4,1359	2,0948	0,6058	0,6061	0,6052	1,3187	1,4657	1,3524	0,6345	0,6775	0,7832
50	19,23	19,27	19,20	0,089	0,099	0,097	0,8799	0,8918	0,8399	4,7619	2,6815	0,6574	0,6589	0,6565	1,5038	1,7011	1,5578	0,8121	0,8632	1,0066
50	19,92	19,92	19,88	0,092	0,103	0,101	0,8675	0,8833	0,8279	5,0675	3,0011	0,6811	0,6812	0,6796	1,5948	1,8124	1,6603	0,9144	0,9618	1,1247
50	20,69	20,72	20,68	0,096	0,108	0,106	0,8506	0,8722	0,8099	5,4285	3,4332	0,7075	0,7086	0,7071	1,6965	1,9500	1,7821	1,0489	1,0938	1,2905
50	22,57	22,60	22,56	0,109	0,124	0,124	0,7938	0,8328	0,7508	6,3910	4,8992	0,7719	0,7727	0,7715	1,9586	2,3297	2,1023	1,5006	1,5487	1,8495
50	24,09	24,13	24,07	0,126	0,143	0,145	0,7293	0,7859	0,6880	7,3089	6,7284	0,8239	0,8251	0,8232	2,2053	2,7022	2,4015	2,0688	2,1264	2,5333
50	25,48	25,51	25,43	0,145	0,166	0,171	0,6575	0,7316	0,6154	8,2053	9,0997	0,8713	0,8724	0,8697	2,4344	3,0985	2,6735	2,7894	2,8875	3,4238
50	26,62	26,66	26,57	0,167	0,192	0,2	0,5880	0,6804	0,5461	9,0111	11,8142	0,9103	0,9115	0,9087	2,6186	3,4894	2,9023	3,6025	3,7583	4,4524
50	27,63	27,66	27,62	0,194	0,223	0,235	0,5173	0,6289	0,4807	9,7724	15,0723	0,9449	0,9459	0,9443	2,7720	3,8832	3,1169	4,5855	4,8001	5,6860
50	28,53	28,54	28,47	0,224	0,257	0,272	0,4590	0,5806	0,4258	10,4696	18,6220	0,9755	0,9759	0,9734	2,9264	4,2498	3,2936	5,6645	5,9600	6,9982

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
100	8,48	8,51	8,47	0,048	0,052	0,049	0,8782	0,8629	0,8287	1,0816	0,6496	0,1450	0,1455	0,1448	0,3560	0,3825	0,3433	0,1939	0,2240	0,2319
100	12,82	12,86	12,81	0,059	0,063	0,06	0,9027	0,8936	0,8646	2,0663	1,0730	0,2192	0,2199	0,2189	0,6771	0,7253	0,6643	0,3227	0,3644	0,3861
100	16,39	16,43	16,36	0,066	0,071	0,068	0,9164	0,9110	0,8844	3,0258	1,4277	0,2802	0,2809	0,2798	0,9881	1,0582	0,9798	0,4317	0,4792	0,5170
100	19,50	19,56	19,47	0,072	0,077	0,074	0,9236	0,9199	0,8949	3,9871	1,7790	0,3333	0,3344	0,3329	1,2983	1,3925	1,2964	0,5390	0,5935	0,6466
100	22,99	23,05	22,96	0,079	0,084	0,082	0,9293	0,9271	0,9022	5,1695	2,2027	0,3930	0,3942	0,3925	1,6790	1,8019	1,6881	0,6672	0,7282	0,8071
100	26,00	26,07	25,95	0,085	0,091	0,088	0,9311	0,9293	0,9049	6,3135	2,6480	0,4445	0,4458	0,4437	2,0502	2,2024	2,0619	0,8030	0,8753	0,9700
100	28,37	28,46	28,34	0,089	0,096	0,093	0,9309	0,9308	0,9048	7,2617	3,0362	0,4851	0,4866	0,4845	2,3509	2,5352	2,3765	0,9222	0,9955	1,1188
100	31,83	31,93	31,79	0,096	0,104	0,101	0,9278	0,9287	0,8998	8,7858	3,7621	0,5442	0,5458	0,5435	2,8320	3,0775	2,8777	1,1386	1,2290	1,3952
100	34,93	35,03	34,88	0,103	0,112	0,109	0,9195	0,9234	0,8896	10,2673	4,6352	0,5972	0,5989	0,5964	3,2921	3,6098	3,3670	1,4069	1,5002	1,7287
100	37,76	37,88	37,71	0,109	0,12	0,117	0,9063	0,9137	0,8732	11,7520	5,7446	0,6456	0,6476	0,6448	3,7406	4,1530	3,8597	1,7445	1,8468	2,1540
100	40,81	40,94	40,76	0,118	0,131	0,129	0,8833	0,8980	0,8468	13,4913	7,3973	0,6978	0,6999	0,6969	4,2540	4,8043	4,4353	2,2577	2,3544	2,7866
100	43,83	43,95	43,77	0,129	0,145	0,144	0,8480	0,8722	0,8079	15,4196	9,8118	0,7493	0,7515	0,7483	4,8014	5,5399	5,0777	3,0011	3,1063	3,7042
100	46,73	46,88	46,67	0,144	0,162	0,163	0,7994	0,8376	0,7587	17,5021	13,1423	0,7990	0,8014	0,7980	5,3795	6,3523	5,7717	4,0434	4,1438	4,9562
100	49,74	49,89	49,67	0,166	0,186	0,19	0,7334	0,7885	0,6960	19,9485	18,1029	0,8504	0,8530	0,8493	6,0407	7,3253	6,5829	5,5990	5,7133	6,7910
100	52,62	52,77	52,55	0,195	0,218	0,226	0,6607	0,7307	0,6266	22,6090	24,7884	0,8997	0,9023	0,8985	6,7619	8,4175	7,4283	7,6824	7,8657	9,2392
100	55,54	55,72	55,47	0,234	0,265	0,275	0,5805	0,6638	0,5440	25,6264	34,4052	0,9497	0,9526	0,9485	7,5573	9,7820	8,2840	10,6017	11,0222	12,7772
100	58,47	58,64	58,39	0,289	0,327	0,343	0,4916	0,5937	0,4557	28,8055	47,9441	0,9997	1,0026	0,9983	8,2921	11,3974	9,1138	14,6902	15,4492	17,8008

10.2 No-load test amorphous core 200 and 300 Hz.

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
200	8,40	8,45	8,40	0,042	0,046	0,043	0,8161	0,7947	0,7549	0,8634	0,6718	0,0718	0,0722	0,0718	0,2879	0,3056	0,2700	0,2038	0,2334	0,2346
200	16,19	16,29	16,18	0,059	0,063	0,06	0,8739	0,8642	0,8335	2,5147	1,5076	0,1384	0,1392	0,1383	0,8276	0,8811	0,8051	0,4603	0,5131	0,5338
200	22,80	22,94	22,79	0,07	0,075	0,074	0,8868	0,8920	0,8598	4,3921	2,3716	0,1949	0,1961	0,1948	1,4195	1,5308	1,4403	0,7397	0,7758	0,8553
200	28,50	28,68	28,49	0,079	0,084	0,082	0,9036	0,9068	0,8780	6,2747	3,1006	0,2436	0,2451	0,2435	2,0345	2,1842	2,0558	0,9643	1,0155	1,1208
200	34,69	34,91	34,68	0,088	0,094	0,091	0,9204	0,9181	0,8947	8,6209	3,8927	0,2965	0,2984	0,2965	2,8096	2,9964	2,8145	1,1935	1,2937	1,4053
200	40,75	41,00	40,73	0,096	0,102	0,099	0,9286	0,9261	0,9035	11,1798	4,7715	0,3483	0,3505	0,3482	3,6437	3,8844	3,6506	1,4561	1,5829	1,7320
200	46,60	46,89	46,59	0,104	0,111	0,107	0,9339	0,9318	0,9102	13,8966	5,6801	0,3984	0,4009	0,3983	4,5260	4,8286	4,5454	1,7326	1,8803	2,0686
200	52,54	52,86	52,52	0,112	0,119	0,115	0,9372	0,9351	0,9130	16,9110	6,7465	0,4491	0,4519	0,4490	5,4998	5,8824	5,5284	2,0466	2,2290	2,4707
200	58,42	58,79	58,40	0,119	0,128	0,124	0,9380	0,9363	0,9132	20,1540	7,9918	0,4994	0,5026	0,4993	6,5427	7,0243	6,5923	2,4181	2,6342	2,9414
200	64,04	64,46	64,03	0,127	0,136	0,132	0,9361	0,9353	0,9094	23,5038	9,4785	0,5475	0,5510	0,5473	7,6012	8,2173	7,6803	2,8567	3,1079	3,5117
200	69,87	70,31	69,85	0,135	0,146	0,141	0,9308	0,9315	0,9016	27,2423	11,4537	0,5973	0,6011	0,5971	8,7728	9,5618	8,9053	3,4465	3,7346	4,2716
200	75,70	76,19	75,68	0,144	0,157	0,152	0,9205	0,9242	0,8876	31,3014	14,1305	0,6471	0,6513	0,6470	10,0068	11,0548	10,2367	4,2463	4,5691	5,3136
200	81,35	81,88	81,34	0,153	0,17	0,165	0,9043	0,9122	0,8666	35,5768	17,7099	0,6954	0,7000	0,6954	11,2704	12,6678	11,6384	5,3198	5,6895	6,7001
200	87,36	87,91	87,33	0,166	0,186	0,182	0,8762	0,8919	0,8330	40,5687	23,2052	0,7468	0,7515	0,7466	12,7214	14,5833	13,2681	6,9982	7,3953	8,8142
200	93,08	93,67	93,05	0,183	0,206	0,205	0,8350	0,8626	0,7887	45,8484	30,8152	0,7957	0,8008	0,7955	14,1836	16,6456	15,0228	9,3482	9,7602	11,7097
200	98,63	99,26	98,60	0,205	0,232	0,234	0,7794	0,8228	0,7337	51,6242	41,4226	0,8432	0,8485	0,8429	15,7597	18,9400	16,9282	12,6667	13,0814	15,6772
200	104,49	105,16	104,46	0,239	0,268	0,276	0,7076	0,7687	0,6687	58,5893	57,0767	0,8933	0,8990	0,8930	17,6402	21,6898	19,2586	17,6180	18,0446	21,4132

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
300	16,28	16,25	16,07	0,053	0,055	0,053	0,8440	0,8252	0,8080	2,1465	1,4643	0,0928	0,0926	0,0916	0,7227	0,7400	0,6843	0,4593	0,5065	0,4989
300	22,88	22,88	22,71	0,064	0,066	0,064	0,8707	0,8592	0,8454	3,8026	2,2704	0,1304	0,1304	0,1294	1,2652	1,3031	1,2344	0,7146	0,7759	0,7800
300	34,69	34,62	34,37	0,081	0,083	0,082	0,9015	0,8939	0,8837	7,5670	3,8109	0,1977	0,1973	0,1959	2,5174	2,5780	2,4757	1,2086	1,2932	1,3112
300	40,79	40,79	40,43	0,088	0,091	0,09	0,9115	0,9056	0,8953	9,8961	4,6727	0,2325	0,2324	0,2304	3,2796	3,3759	3,2400	1,4797	1,5810	1,6116
300	46,75	46,69	46,33	0,096	0,099	0,097	0,9191	0,9144	0,9049	12,3973	5,5435	0,2664	0,2661	0,2641	4,1078	4,2183	4,0710	1,7608	1,8673	1,9153
300	52,65	52,55	52,07	0,103	0,106	0,104	0,9256	0,9209	0,9116	15,0619	6,4409	0,3000	0,2995	0,2968	4,9995	5,1294	4,9364	2,0447	2,1709	2,2267
300	64,46	64,33	63,82	0,116	0,12	0,118	0,9345	0,9304	0,9218	21,0830	8,3982	0,3674	0,3666	0,3637	6,9823	7,1709	6,9294	2,6589	2,8245	2,9146
300	70,18	70,08	69,43	0,122	0,126	0,124	0,9375	0,9336	0,9246	24,2753	9,4392	0,4000	0,3994	0,3957	8,0403	8,2701	7,9665	2,9835	3,1736	3,2826
300	76,04	75,91	75,30	0,129	0,133	0,131	0,9397	0,9360	0,9270	27,7698	10,5924	0,4334	0,4326	0,4291	9,1816	9,4503	9,1373	3,3426	3,5528	3,6967
300	81,81	81,77	81,02	0,135	0,14	0,137	0,9413	0,9376	0,9276	31,3973	11,8448	0,4662	0,4660	0,4617	10,3728	10,7181	10,3116	3,7204	3,9750	4,1514
300	87,70	87,55	86,84	0,141	0,147	0,144	0,9415	0,9383	0,9282	35,2839	13,2551	0,4998	0,4990	0,4949	11,6508	12,0344	11,5992	4,1696	4,4364	4,6493
300	99,29	99,18	98,26	0,154	0,161	0,157	0,9401	0,9369	0,9247	43,6093	16,6721	0,5659	0,5652	0,5600	14,3563	14,9515	14,3012	5,2052	5,5779	5,8887
300	105,13	104,97	104,02	0,161	0,168	0,165	0,9369	0,9345	0,9203	48,1287	18,9095	0,5992	0,5982	0,5928	15,8186	16,5188	15,7951	5,9024	6,2932	6,7151
300	110,99	110,80	109,85	0,168	0,177	0,173	0,9319	0,9309	0,9138	52,9439	21,6275	0,6325	0,6315	0,6261	17,3342	18,2254	17,3863	6,7495	7,1516	7,7270
300	116,67	116,55	115,57	0,175	0,186	0,182	0,9247	0,9256	0,9041	57,9511	24,9636	0,6649	0,6642	0,6587	18,8578	20,0441	19,0483	7,7650	8,1958	9,0022
300	122,61	122,40	121,34	0,183	0,196	0,193	0,9139	0,9175	0,8917	63,3640	29,2321	0,6988	0,6976	0,6915	20,5403	21,9880	20,8279	9,1212	9,5338	10,5732
300	134,25	134,02	132,89	0,203	0,22	0,219	0,8792	0,8920	0,8522	75,1620	41,5901	0,7651	0,7638	0,7574	24,0087	26,3467	24,8029	13,0086	13,3546	15,2248
300	140,09	139,88	138,64	0,217	0,236	0,236	0,8526	0,8724	0,8241	81,6910	50,5651	0,7984	0,7972	0,7901	25,8814	28,7988	26,9993	15,8660	16,1370	18,5552
300	145,75	145,63	144,34	0,233	0,255	0,257	0,8188	0,8482	0,7899	88,5650	61,8924	0,8307	0,8300	0,8226	27,7471	31,4732	29,3459	19,4530	19,6554	22,7853

10.3 No-load test amorphous core 400 Hz.

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
400	16,24	16,24	16,06	0,048	0,051	0,048	0,8195	0,7980	0,7823	1,9069	1,4291	0,0694	0,0694	0,0687	0,6426	0,6555	0,6082	0,4494	0,4951	0,4842
400	22,89	22,89	22,64	0,059	0,061	0,059	0,8505	0,8345	0,8216	3,4195	2,2470	0,0978	0,0978	0,0968	1,1464	1,1725	1,1013	0,7091	0,7743	0,7640
400	28,31	28,31	28,01	0,067	0,069	0,067	0,8683	0,8558	0,8441	4,8997	2,9560	0,1210	0,1210	0,1197	1,6370	1,6764	1,5862	0,9351	1,0132	1,0077
400	34,67	34,67	34,30	0,075	0,078	0,076	0,8842	0,8742	0,8641	6,9060	3,8341	0,1482	0,1482	0,1466	2,3023	2,3550	2,2469	1,2164	1,3080	1,3087
400	40,89	40,89	40,46	0,083	0,086	0,084	0,8960	0,8872	0,8783	9,1148	4,7381	0,1748	0,1748	0,1729	3,0371	3,1055	2,9742	1,5056	1,6146	1,6190
400	46,79	46,79	46,29	0,09	0,093	0,091	0,9050	0,8975	0,8890	11,4266	5,6217	0,2000	0,2000	0,1979	3,8026	3,8888	3,7329	1,7877	1,9105	1,9224
400	52,66	52,66	52,10	0,097	0,099	0,098	0,9124	0,9061	0,8978	13,9377	6,5303	0,2251	0,2251	0,2227	4,6367	4,7428	4,5608	2,0801	2,2145	2,2368
400	58,55	58,55	57,93	0,103	0,106	0,104	0,9187	0,9131	0,9049	16,6493	7,4727	0,2503	0,2503	0,2476	5,5352	5,6620	5,4569	2,3799	2,5275	2,5674
400	64,38	64,37	63,69	0,109	0,112	0,11	0,9237	0,9187	0,9108	19,5048	8,4372	0,2752	0,2752	0,2722	6,4758	6,6292	6,3986	2,6856	2,8508	2,9003
400	70,27	70,26	69,52	0,115	0,118	0,116	0,9282	0,9234	0,9158	22,5856	9,4472	0,3004	0,3003	0,2972	7,4946	7,6750	7,4105	3,0035	3,1907	3,2506
400	76,08	76,07	75,27	0,121	0,124	0,122	0,9320	0,9275	0,9196	25,7923	10,4797	0,3252	0,3252	0,3217	8,5581	8,7701	8,4654	3,3291	3,5345	3,6165
400	81,87	81,87	81,00	0,126	0,13	0,128	0,9351	0,9305	0,9228	29,1635	11,5663	0,3499	0,3499	0,3462	9,6771	9,9110	9,5749	3,6664	3,9015	3,9981
400	87,78	87,78	86,85	0,132	0,136	0,134	0,9376	0,9332	0,9255	32,7633	12,7213	0,3752	0,3752	0,3712	10,8641	11,1405	10,7630	4,0284	4,2904	4,4041
400	93,51	93,50	92,51	0,137	0,142	0,139	0,9401	0,9357	0,9279	36,4188	13,8510	0,3997	0,3997	0,3954	12,0702	12,3886	11,9577	4,3758	4,6700	4,8042
400	99,44	99,44	98,38	0,143	0,148	0,145	0,9420	0,9375	0,9296	40,3928	15,1339	0,4250	0,4250	0,4205	13,3852	13,7504	13,2510	4,7707	5,1049	5,2558
400	105,24	105,24	104,12	0,148	0,153	0,15	0,9434	0,9390	0,9308	44,4257	16,4418	0,4498	0,4498	0,4450	14,7138	15,1294	14,5755	5,1726	5,5412	5,7253
400	110,93	110,92	109,75	0,153	0,159	0,156	0,9445	0,9398	0,9314	48,5651	17,8412	0,4742	0,4741	0,4691	16,0714	16,5538	15,9259	5,5925	6,0189	6,2245
400	116,91	116,90	115,66	0,159	0,165	0,162	0,9449	0,9404	0,9315	53,0842	19,4313	0,4997	0,4997	0,4944	17,5761	18,1052	17,4109	6,0872	6,5496	6,7972
400	122,60	122,59	121,29	0,164	0,171	0,167	0,9450	0,9403	0,9310	57,5544	21,0974	0,5240	0,5240	0,5184	19,0343	19,6547	18,8698	6,5911	7,1113	7,3963
400	128,60	128,59	127,23	0,17	0,177	0,173	0,9443	0,9399	0,9297	62,5062	23,0719	0,5497	0,5496	0,5438	20,6445	21,3807	20,4879	7,1937	7,7663	8,1143
400	134,34	134,33	132,91	0,176	0,183	0,179	0,9430	0,9387	0,9275	67,3880	25,2154	0,5742	0,5742	0,5681	22,2332	23,0890	22,0783	7,8451	8,4766	8,8987
400	140,18	140,18	138,69	0,181	0,19	0,186	0,9408	0,9371	0,9246	72,6010	27,6927	0,5992	0,5992	0,5928	23,9105	24,9054	23,7872	8,6133	9,2800	9,8004
400	146,01	146,00	144,45	0,187	0,197	0,192	0,9379	0,9347	0,9203	78,0100	30,5462	0,6241	0,6241	0,6174	25,6360	26,8291	25,5627	9,4811	10,2026	10,8696
400	151,79	151,78	150,17	0,193	0,204	0,199	0,9339	0,9314	0,9148	83,6050	33,8442	0,6488	0,6488	0,6419	27,4012	28,8256	27,3923	10,4914	11,2633	12,0954
400	157,62	157,62	155,94	0,2	0,212	0,207	0,9282	0,9271	0,9074	89,4970	37,8063	0,6737	0,6737	0,6665	29,2166	30,9498	29,3203	11,7122	12,5139	13,5759
400	163,41	163,40	161,67	0,207	0,22	0,216	0,9211	0,9214	0,8987	95,6420	42,4411	0,6985	0,6984	0,6910	31,1127	33,1681	31,3684	13,1483	13,9881	15,3085
400	169,26	169,25	167,46	0,214	0,23	0,225	0,9119	0,9146	0,8872	102,1080	48,0216	0,7235	0,7234	0,7158	33,0607	35,5570	33,4860	14,8813	15,7195	17,4187
400	175,16	175,15	173,29	0,223	0,24	0,237	0,8997	0,9055	0,8727	108,9610	54,8919	0,7487	0,7487	0,7407	35,0958	38,0967	35,7641	17,0271	17,8496	20,0135
400	180,89	180,87	178,96	0,232	0,252	0,249	0,8848	0,8945	0,8561	115,9080	62,8835	0,7732	0,7731	0,7649	37,1179	40,6887	38,1024	19,5430	20,3387	23,0024
400	186,77	186,75	184,77	0,243	0,265	0,263	0,8661	0,8807	0,8355	123,4110	72,7900	0,7983	0,7982	0,7898	39,2754	43,5175	40,6166	22,6686	23,4088	26,7117
400	192,57	192,55	190,51	0,255	0,279	0,28	0,8430	0,8640	0,8119	131,1720	84,6240	0,8231	0,8230	0,8143	41,4618	46,4669	43,2467	26,4542	27,0746	31,0974
400	198,43	198,41	196,31	0,271	0,296	0,299	0,8151	0,8438	0,7846	139,4790	99,0810	0,8482	0,8481	0,8391	43,7515	49,6251	46,1001	31,0941	31,5566	36,4280
400	204,15	204,14	201,97	0,288	0,316	0,322	0,7834	0,8208	0,7553	148,1080	115,9950	0,8726	0,8726	0,8633	46,0940	52,8969	49,1067	36,5653	36,8149	42,6071
400	209,95	209,93	207,71	0,31	0,338	0,349	0,7472	0,7942	0,7232	157,3710	136,3970	0,8974	0,8973	0,8878	48,5997	56,3867	52,3796	43,2273	43,1428	50,0227

10.4 No-load test grain oriented core 50 and 100 Hz.

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
50	8,60	8,60	8,58	0,127	0,125	0,127	0,6160	0,6194	0,6279	2,0231	2,5528	0,2941	0,2939	0,2934	0,6734	0,6665	0,6831	0,8611	0,8448	0,8468
50	11,19	11,22	11,19	0,150	0,148	0,150	0,6604	0,6625	0,6702	3,3291	3,7452	0,3828	0,3835	0,3826	1,1111	1,0974	1,1209	1,2633	1,2408	1,2414
50	14,57	14,60	14,55	0,176	0,173	0,175	0,7083	0,7081	0,7171	5,4354	5,3727	0,4981	0,4993	0,4975	1,8168	1,7911	1,8278	1,8107	1,7858	1,7764
50	16,12	16,12	16,07	0,187	0,184	0,186	0,7270	0,7261	0,7361	6,5589	6,1454	0,5512	0,5511	0,5496	2,1960	2,1578	2,2042	2,0742	2,0434	2,0271
50	17,80	17,83	17,78	0,199	0,196	0,198	0,7446	0,7451	0,7520	7,8915	7,0178	0,6085	0,6096	0,6081	2,6382	2,6051	2,6481	2,3651	2,3316	2,3209
50	19,34	19,36	19,33	0,209	0,206	0,209	0,7581	0,7592	0,7660	9,1886	7,8310	0,6614	0,6619	0,6610	3,0673	3,0332	3,0872	2,6387	2,6004	2,5912
50	20,94	20,96	20,90	0,220	0,217	0,219	0,7728	0,7728	0,7790	10,6345	8,6750	0,7161	0,7168	0,7146	3,5558	3,5136	3,5651	2,9198	2,8853	2,8698
50	23,01	23,04	22,98	0,233	0,231	0,233	0,7863	0,7874	0,7917	12,6400	9,8607	0,7867	0,7878	0,7859	4,2181	4,1849	4,2362	3,3149	3,2764	3,2687
50	25,73	25,74	25,68	0,251	0,249	0,251	0,7992	0,8013	0,8039	15,4676	11,5417	0,8798	0,8802	0,8781	5,1550	5,1317	5,1793	3,8771	3,8313	3,8321
50	26,76	26,80	26,74	0,258	0,256	0,259	0,8036	0,8061	0,8074	16,6624	12,2488	0,9152	0,9164	0,9142	5,5492	5,5346	5,5802	4,1093	4,0631	4,0776
50	28,79	28,72	28,68	0,270	0,270	0,272	0,8137	0,8177	0,8182	19,0393	13,4615	0,9843	0,9820	0,9808	6,3333	6,3283	6,3790	4,5251	4,4556	4,4818
50	30,75	30,69	30,63	0,286	0,286	0,288	0,8126	0,8171	0,8155	21,5079	15,2865	1,0514	1,0493	1,0473	7,1411	7,1687	7,1984	5,1211	5,0569	5,1087
50	31,64	31,60	31,55	0,293	0,294	0,296	0,8120	0,8173	0,8141	22,7165	16,1830	1,0820	1,0806	1,0787	7,5304	7,5831	7,6019	5,4129	5,3465	5,4229
50	33,48	33,40	33,36	0,310	0,311	0,313	0,8076	0,8128	0,8083	25,2651	18,3179	1,1448	1,1422	1,1407	8,3679	8,4495	8,4483	6,1105	6,0549	6,1528
50	35,17	35,09	35,04	0,327	0,330	0,332	0,7995	0,8049	0,7985	27,7958	20,7774	1,2025	1,1998	1,1982	9,1929	9,3201	9,2829	6,9077	6,8704	6,9993
50	38,38	38,33	38,26	0,372	0,378	0,379	0,7692	0,7740	0,7638	33,2859	27,6667	1,3124	1,3106	1,3083	10,9933	11,2225	11,0732	9,1333	9,1798	9,3562
50	39,31	39,26	39,20	0,391	0,397	0,397	0,7540	0,7586	0,7476	35,0639	30,6010	1,3441	1,3423	1,3405	11,5794	11,8340	11,6477	10,0877	10,1644	10,3463
50	40,58	40,50	40,46	0,421	0,429	0,428	0,7296	0,7333	0,7217	37,7086	35,4890	1,3875	1,3849	1,3837	12,4605	12,7406	12,5075	11,6788	11,8137	11,9965

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
100	8,42	8,45	8,42	0,091	0,091	0,092	0,6028	0,6099	0,6068	1,3987	1,8335	0,1440	0,1444	0,1439	0,4618	0,4679	0,4693	0,6114	0,6079	0,6147
100	13,10	13,14	13,09	0,128	0,126	0,128	0,6601	0,6639	0,6675	3,3253	3,7462	0,2240	0,2247	0,2238	1,1055	1,1018	1,1181	1,2578	1,2411	1,2474
100	16,35	16,41	16,33	0,150	0,148	0,150	0,6889	0,6915	0,6970	5,0661	5,2780	0,2795	0,2805	0,2792	1,6872	1,6767	1,7025	1,7750	1,7517	1,7516
100	19,26	19,31	19,24	0,168	0,165	0,167	0,7129	0,7145	0,7216	6,8964	6,7178	0,3293	0,3302	0,3289	2,3015	2,2754	2,3196	2,2642	2,2280	2,2257
100	23,25	23,31	23,21	0,190	0,187	0,190	0,7364	0,7370	0,7442	9,7463	8,8797	0,3974	0,3986	0,3969	3,2575	3,2164	3,2736	2,9927	2,9501	2,9380
100	25,69	25,76	25,65	0,203	0,200	0,202	0,7510	0,7521	0,7588	11,7105	10,2019	0,4392	0,4404	0,4386	3,9126	3,8665	3,9320	3,4396	3,3881	3,3748
100	28,47	28,54	28,42	0,217	0,214	0,216	0,7651	0,7656	0,7723	14,1412	11,8044	0,4867	0,4880	0,4860	4,7260	4,6699	4,7459	3,9774	3,9236	3,9040
100	31,97	32,05	31,93	0,234	0,230	0,233	0,7832	0,7836	0,7895	17,5034	13,7917	0,5466	0,5480	0,5459	5,8487	5,7848	5,8706	4,6432	4,5859	4,5633
100	34,86	34,95	34,81	0,247	0,244	0,246	0,7960	0,7966	0,8018	20,5281	15,4943	0,5960	0,5976	0,5952	6,8596	6,7911	6,8780	5,2155	5,1529	5,1263
100	40,93	41,04	40,87	0,274	0,271	0,274	0,8217	0,8226	0,8262	27,6291	19,0346	0,6998	0,7017	0,6988	9,2222	9,1587	9,2484	6,3954	6,3319	6,3075
100	46,79	46,92	46,73	0,300	0,297	0,300	0,8419	0,8430	0,8447	35,3906	22,5643	0,8001	0,8022	0,7989	11,7989	11,7551	11,8324	7,5632	7,4997	7,4987
100	49,84	49,96	49,77	0,313	0,311	0,313	0,8506	0,8519	0,8527	39,7661	24,4629	0,8521	0,8542	0,8509	13,2506	13,2196	13,2955	8,1920	8,1269	8,1438
100	55,61	55,75	55,53	0,338	0,337	0,340	0,8628	0,8647	0,8635	48,7755	28,4644	0,9508	0,9532	0,9495	16,2183	16,2603	16,2950	9,5028	9,4451	9,5154
100	60,97	60,83	60,66	0,359	0,359	0,362	0,8745	0,8766	0,8759	57,5016	31,7139	1,0424	1,0400	1,0371	19,1405	19,1538	19,2109	10,6177	10,5148	10,5834
100	65,65	65,50	65,31	0,383	0,384	0,386	0,8769	0,8792	0,8769	66,2870	36,1952	1,1224	1,1198	1,1166	22,0297	22,1359	22,1239	12,0766	11,9937	12,1264
100	67,93	67,77	67,58	0,395	0,398	0,400	0,8769	0,8793	0,8763	70,9120	38,7562	1,1614	1,1587	1,1554	23,5527	23,6992	23,6581	12,9114	12,8361	13,0077
100	70,29	70,13	69,94	0,410	0,413	0,414	0,8752	0,8774	0,8740	75,9270	41,9000	1,2018	1,1990	1,1958	25,2090	25,3998	25,3204	13,9365	13,8900	14,0745
100	74,94	74,77	74,57	0,443	0,447	0,448	0,8680	0,8696	0,8657	86,7820	49,6946	1,2813	1,2784	1,2750	28,8099	29,0581	28,9156	16,4812	16,4975	16,7165
100	78,40	78,23	78,02	0,474	0,479	0,479	0,8562	0,8570	0,8533	95,8090	57,9959	1,3404	1,3375	1,3339	31,8310	32,0922	31,8876	19,2077	19,3002	19,4889
100	81,23	81,05	80,83	0,506	0,511	0,510	0,8406	0,8402	0,8373	103,8510	67,2500	1,3888	1,3857	1,3820	34,5509	34,7719	34,5298	22,2629	22,4402	22,5474

10.5 No-load test grain oriented core 200 and 300 Hz.

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
200	8,09	8,07	8,02	0,061	0,061	0,062	0,6731	0,6759	0,6767	0,9995	1,0919	0,0691	0,0690	0,0686	0,3326	0,3325	0,3343	0,3654	0,3626	0,3637
200	16,11	16,08	15,98	0,109	0,108	0,110	0,6998	0,7009	0,7092	3,6921	3,7318	0,1378	0,1374	0,1366	1,2337	1,2159	1,2423	1,2592	1,2374	1,2350
200	23,20	23,15	23,01	0,148	0,145	0,147	0,7303	0,7296	0,7414	7,4550	6,9025	0,1984	0,1979	0,1967	2,4993	2,4475	2,5080	2,3381	2,2939	2,2703
200	28,17	28,10	27,94	0,172	0,168	0,171	0,7501	0,7497	0,7623	10,8017	9,4095	0,2408	0,2403	0,2388	3,6258	3,5437	3,6332	3,1967	3,1285	3,0852
200	34,84	34,76	34,56	0,201	0,197	0,200	0,7734	0,7716	0,7848	16,1057	13,0652	0,2978	0,2971	0,2954	5,4156	5,2781	5,4128	4,4394	4,3515	4,2750
200	40,72	40,62	40,39	0,225	0,220	0,223	0,7901	0,7884	0,8015	21,4858	16,4858	0,3481	0,3473	0,3453	7,2251	7,0400	7,2184	5,6055	5,4926	5,3859
200	46,66	46,55	46,28	0,247	0,242	0,245	0,8047	0,8028	0,8153	27,5659	20,1277	0,3989	0,3979	0,3956	9,2743	9,0359	9,2544	6,8420	6,7112	6,5736
200	58,51	58,37	58,03	0,288	0,283	0,287	0,8296	0,8279	0,8391	41,5997	27,7125	0,5002	0,4990	0,4961	13,9937	13,6575	13,9501	9,4182	9,2518	9,0435
200	64,30	64,14	63,77	0,307	0,302	0,306	0,8406	0,8392	0,8493	49,3986	31,5154	0,5496	0,5483	0,5451	16,6091	16,2340	16,5545	10,7010	10,5217	10,2920
200	70,19	70,02	69,61	0,326	0,321	0,325	0,8512	0,8499	0,8593	57,9918	35,4095	0,6000	0,5986	0,5951	19,4957	19,0779	19,4217	12,0194	11,8307	11,5614
200	76,04	75,86	75,42	0,345	0,339	0,343	0,8614	0,8602	0,8686	67,1910	39,2549	0,6500	0,6485	0,6447	22,5792	22,1273	22,4906	13,3114	13,1191	12,8278
200	81,84	81,65	81,17	0,363	0,357	0,362	0,8711	0,8700	0,8776	77,0000	43,0330	0,6996	0,6980	0,6939	25,8641	25,3816	25,7517	14,5821	14,3829	14,0663
200	87,62	87,41	86,90	0,381	0,375	0,380	0,8800	0,8789	0,8858	87,4010	46,7901	0,7490	0,7472	0,7429	29,3473	28,8409	29,2136	15,8379	15,6506	15,3019
200	93,45	93,23	92,68	0,399	0,394	0,398	0,8882	0,8873	0,8935	98,6040	50,6057	0,7989	0,7970	0,7923	33,1027	32,5587	32,9404	17,1202	16,9257	16,5585
200	105,03	104,78	104,17	0,435	0,431	0,434	0,9022	0,9010	0,9057	122,8210	58,4404	0,8979	0,8957	0,8905	41,1903	40,6441	40,9760	19,6947	19,5646	19,1760
200	110,88	110,62	109,97	0,453	0,449	0,453	0,9083	0,9070	0,9111	136,0950	62,4851	0,9479	0,9457	0,9401	45,6306	45,0891	45,3778	21,0208	20,9362	20,5290
200	116,69	116,41	115,73	0,472	0,469	0,472	0,9134	0,9121	0,9155	150,0180	66,7450	0,9976	0,9952	0,9893	50,2745	49,7538	49,9869	22,4092	22,3658	21,9686
200	122,46	122,17	121,46	0,491	0,488	0,491	0,9179	0,9166	0,9195	164,6560	71,1300	1,0469	1,0444	1,0383	55,1483	54,6699	54,8339	23,8356	23,8441	23,4477
200	128,33	128,03	127,28	0,511	0,509	0,511	0,9215	0,9200	0,9224	180,3700	76,1250	1,0971	1,0945	1,0881	60,3919	59,9546	60,0297	25,4570	25,5386	25,1320
200	134,10	133,78	133,02	0,532	0,530	0,532	0,9241	0,9225	0,9246	196,7670	81,6010	1,1464	1,1436	1,1372	65,8635	65,4447	65,4529	27,2397	27,3857	26,9741
200	139,91	139,58	138,79	0,554	0,553	0,555	0,9257	0,9239	0,9258	214,3260	87,9470	1,1961	1,1932	1,1865	71,7407	71,3280	71,2586	29,3075	29,5368	29,1040
200	151,48	151,13	150,27	0,605	0,604	0,605	0,9254	0,9228	0,9248	253,0680	104,4880	1,2950	1,2920	1,2846	84,7508	84,2614	84,0457	34,7144	35,1857	34,5846
200	157,31	156,95	156,06	0,635	0,634	0,635	0,9218	0,9187	0,9211	274,7970	116,5880	1,3448	1,3417	1,3341	92,0990	91,4767	91,2247	38,7208	39,3194	38,5501
200	162,47	162,10	161,19	0,667	0,665	0,665	0,9158	0,9123	0,9154	295,5750	130,7530	1,3889	1,3857	1,3780	99,1715	98,2954	98,1107	43,4848	44,1319	43,1373

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
300	8,08	8,07	7,95	0,051	0,051	0,051	0,7096	0,7075	0,7105	0,8720	0,8668	0,0460	0,0460	0,0453	0,2929	0,2904	0,2887	0,2908	0,2901	0,2859
300	28,31	28,23	27,98	0,149	0,146	0,148	0,7643	0,7623	0,7737	9,5854	8,0249	0,1614	0,1609	0,1595	3,2266	3,1464	3,2126	2,7223	2,6719	2,6309
300	58,51	58,40	57,94	0,263	0,257	0,261	0,8277	0,8246	0,8370	37,7258	25,3709	0,3334	0,3328	0,3302	12,7155	12,3610	12,6526	8,6226	8,4797	8,2707
300	87,60	87,43	86,70	0,350	0,343	0,348	0,8644	0,8619	0,8717	78,5390	45,3415	0,4992	0,4983	0,4941	26,4645	25,8182	26,2627	15,3942	15,1866	14,7642
300	116,71	116,59	115,58	0,428	0,421	0,427	0,8930	0,8908	0,8984	132,6870	66,4760	0,6651	0,6645	0,6587	44,6281	43,7532	44,3068	22,4912	22,3242	21,6603
300	145,79	145,62	144,37	0,506	0,499	0,504	0,9171	0,9145	0,9206	200,9580	87,1420	0,8309	0,8299	0,8228	67,5906	66,4133	66,9482	29,3723	29,3775	28,3903
300	174,86	174,58	173,10	0,584	0,578	0,582	0,9352	0,9320	0,9372	283,9020	107,8640	0,9966	0,9950	0,9865	95,5541	94,0100	94,3475	36,1699	36,5698	35,1282
300	186,50	186,28	184,62	0,617	0,611	0,614	0,9403	0,9368	0,9416	321,5800	117,1570	1,0629	1,0616	1,0522	108,2042	106,6573	106,7188	39,1543	39,8377	38,1660
300	198,13	197,85	196,10	0,651	0,645	0,647	0,9445	0,9405	0,9453	361,9750	127,1960	1,1292	1,1276	1,1176	121,8768	120,0992	120,0078	42,4018	43,3767	41,4215
300	209,66	209,39	207,58	0,687	0,681	0,682	0,9475	0,9433	0,9479	405,2260	138,4770	1,1949	1,1933	1,1830	136,4362	134,5510	134,2578	46,0388	47,3413	45,1046
300	221,30	220,96	219,08	0,726	0,719	0,720	0,9488	0,9442	0,9490	452,1700	152,8100	1,2612	1,2593	1,2486	152,3703	150,0965	149,7138	50,7426	52,3343	49,7378
300	232,91	232,57	230,58	0,768	0,762	0,762	0,9478	0,9430	0,9479	503,0890	171,9620	1,3274	1,3255	1,3141	169,6017	167,0267	166,4601	57,0657	58,9530	55,9447

10.6 No-load test grain oriented core 400 Hz.

f	U1 rms	U2 rms	U3 rms	I1 rms	I2 rms	I3 rms	λ1	λ2	λ3	P tot	Q tot	B1 top	B2 top	B3 top	P1	P2	P3	Q1	Q2	Q3
400	15,96	16,13	16,01	0,082	0,081	0,082	0,7627	0,7653	0,7641	3,0053	2,5380	0,0682	0,0690	0,0684	0,9993	1,0026	1,0040	0,8475	0,8432	0,8477
400	34,42	34,80	34,52	0,160	0,157	0,159	0,7944	0,7965	0,7990	13,1112	9,9478	0,1471	0,1488	0,1476	4,3666	4,3517	4,3912	3,3384	3,3038	3,3043
400	52,18	52,76	52,33	0,225	0,220	0,224	0,8249	0,8266	0,8305	28,9740	19,6721	0,2230	0,2255	0,2237	9,6632	9,5985	9,7138	6,6219	6,5359	6,5153
400	69,69	70,45	69,89	0,281	0,275	0,279	0,8474	0,8488	0,8528	49,6294	30,8023	0,2979	0,3011	0,2987	16,5654	16,4438	16,6223	10,3785	10,2442	10,1808
400	86,98	87,94	87,23	0,331	0,324	0,329	0,8645	0,8655	0,8692	74,4420	42,9006	0,3718	0,3759	0,3729	24,8521	24,6768	24,9140	14,4484	14,2787	14,1741
400	104,23	105,37	104,53	0,377	0,370	0,375	0,8785	0,8793	0,8825	103,3420	55,7537	0,4455	0,4504	0,4468	34,5105	34,2713	34,5646	18,7692	18,5644	18,4222
400	115,77	117,05	116,11	0,407	0,399	0,404	0,8865	0,8871	0,8899	124,9620	64,7630	0,4948	0,5003	0,4963	41,7178	41,4732	41,7765	21,7789	21,5758	21,4102
400	133,19	134,65	133,57	0,450	0,442	0,448	0,8977	0,8983	0,9007	161,1180	78,5390	0,5693	0,5755	0,5709	53,7823	53,4967	53,8468	26,3920	26,1721	25,9785
400	150,04	151,69	150,47	0,491	0,483	0,489	0,9077	0,9080	0,9102	200,3110	92,0410	0,6413	0,6484	0,6432	66,8434	66,5431	66,9196	30,8990	30,6951	30,4452
400	161,79	163,56	162,25	0,519	0,512	0,517	0,9140	0,9143	0,9163	230,1360	101,5670	0,6915	0,6991	0,6935	76,8098	76,4908	76,8433	34,0870	33,8868	33,5973
400	173,51	175,42	174,01	0,548	0,540	0,545	0,9203	0,9203	0,9221	262,0530	110,9380	0,7416	0,7498	0,7438	87,4847	87,1275	87,4469	37,2021	37,0405	36,6988
400	185,11	187,15	185,64	0,576	0,568	0,573	0,9262	0,9259	0,9277	295,8050	120,0500	0,7912	0,7999	0,7935	98,7674	98,3772	98,6619	40,2179	40,1241	39,7092
400	196,66	198,82	197,22	0,604	0,596	0,601	0,9317	0,9312	0,9329	331,5060	128,9710	0,8406	0,8498	0,8430	110,7100	110,2690	110,5250	43,1522	43,1656	42,6533
400	208,11	210,40	208,70	0,632	0,624	0,628	0,9368	0,9360	0,9378	369,0110	137,7500	0,8895	0,8993	0,8921	123,2694	122,7899	122,9453	46,0441	46,1734	45,5308
400	219,58	221,99	220,20	0,661	0,651	0,656	0,9416	0,9405	0,9423	408,6420	146,3060	0,9386	0,9489	0,9412	136,5796	136,0042	136,0572	48,8553	49,1248	48,3272
400	225,44	227,92	226,08	0,675	0,666	0,670	0,9437	0,9425	0,9443	429,6120	150,8950	0,9636	0,9742	0,9663	143,6240	143,0006	142,9935	50,3520	50,7122	49,8338
400	231,14	233,68	231,79	0,689	0,680	0,683	0,9458	0,9445	0,9463	450,4930	155,0790	0,9880	0,9988	0,9908	150,6237	149,9722	149,9030	51,7186	52,1652	51,1988
400	237,04	239,64	237,71	0,704	0,694	0,698	0,9478	0,9463	0,9483	472,7660	159,6130	1,0132	1,0243	1,0161	158,0922	157,3870	157,2911	53,2052	53,7440	52,6661
400	242,66	245,33	243,35	0,718	0,708	0,711	0,9496	0,9480	0,9500	494,5120	163,9030	1,0372	1,0486	1,0402	165,4262	164,6435	164,4657	54,6057	55,2582	54,0491
400	248,32	251,02	249,01	0,732	0,722	0,725	0,9513	0,9496	0,9516	516,8960	168,3390	1,0614	1,0730	1,0644	172,9349	172,0825	171,8726	56,0621	56,7907	55,4858
400	254,14	256,92	254,87	0,747	0,737	0,740	0,9529	0,9511	0,9532	540,5640	173,0460	1,0863	1,0982	1,0894	180,8917	179,9700	179,7287	57,6056	58,4433	57,0066
400	259,99	262,84	260,73	0,762	0,751	0,754	0,9543	0,9524	0,9545	564,8840	178,0270	1,1113	1,1235	1,1145	189,0596	188,1006	187,7512	59,2028	60,1964	58,6370
400	265,62	268,53	266,38	0,776	0,765	0,768	0,9558	0,9538	0,9559	588,5590	182,4160	1,1354	1,1478	1,1386	197,0345	196,0114	195,5357	60,6157	61,7433	60,0651
400	271,35	274,33	272,13	0,791	0,780	0,783	0,9569	0,9548	0,9569	613,4730	187,7830	1,1598	1,1726	1,1632	205,3807	204,3307	203,7720	62,3551	63,6162	61,8154

10.7 Magnetization test amorphous core.

f	U rms	I rms	B top	H rms
50	7,432	0,0426	0,147132	1,734429
50	11,339	0,0507	0,224479	2,064214
50	12,292	0,0526	0,243345	2,141571
50	13,488	0,0547	0,267022	2,227071
50	15,313	0,0579	0,303152	2,357357
50	17,315	0,0613	0,342786	2,495786
50	19,326	0,0649	0,382597	2,642357
50	25,32	0,0749	0,501261	3,0495
50	30,378	0,0848	0,601394	3,452571
50	33,549	0,0923	0,664171	3,757929
50	36,3	0,1004	0,718632	4,087714
50	38,673	0,1093	0,765611	4,450071
50	40,692	0,1182	0,805581	4,812429
50	43,472	0,1344	0,860617	5,472
50	46,313	0,1573	0,91686	6,404357
50	49,57	0,1961	0,981339	7,984071
50	54,63	0,3012	1,081512	12,26314
50	57,559	0,403	1,139497	16,40786
50	59,64	0,4992	1,180695	20,32457

f	U rms	I rms	B top	H rms
100	14,084	0,0518	0,139411	2,109
100	27,548	0,0691	0,272684	2,813357
100	39,815	0,0824	0,394109	3,354857
100	49,096	0,092	0,485978	3,745714
100	59,89	0,1044	0,592822	4,250571
100	65,32	0,1106	0,646571	4,503
100	70,58	0,1189	0,698637	4,840929
100	75,94	0,1293	0,751693	5,264357
100	80,95	0,1418	0,801285	5,773286
100	86,05	0,1583	0,851767	6,445071
100	91,24	0,1806	0,903141	7,353
100	101,31	0,2471	1,002819	10,0605
100	111,33	0,3674	1,102002	14,95843

f	U rms	I rms	B top	H rms
200	14,132	0,0397	0,069943	1,616357
200	27,731	0,056	0,137248	2,28
200	48,639	0,0751	0,240727	3,057643
200	70,59	0,0926	0,349368	3,770143
200	90,99	0,1079	0,450333	4,393071
200	111,06	0,1232	0,549665	5,016
200	131,16	0,1401	0,649145	5,704071
200	141,37	0,1503	0,699677	6,119357
200	151,3	0,1621	0,748823	6,599786
200	161,29	0,1765	0,798266	7,186071
200	171,48	0,1955	0,848699	7,959643
200	181,37	0,2195	0,897647	8,936786
200	191,28	0,2518	0,946694	10,25186
200	201,44	0,2955	0,996979	12,03107
200	221,61	0,4225	1,096805	17,20179

f	U rms	I rms	B top	H rms
300	27,96	0,0501	0,092254	2,039786
300	48,897	0,0685	0,161336	2,788929
300	70,45	0,0843	0,23245	3,432214
300	90,7	0,0975	0,299265	3,969643
300	121,46	0,1165	0,400758	4,743214
300	151,27	0,1343	0,499116	5,467929
300	181,43	0,1533	0,598629	6,2415
300	211,43	0,175	0,697614	7,125
300	231,67	0,1936	0,764396	7,882286
300	241,58	0,2045	0,797095	8,326071
300	251,51	0,2173	0,829859	8,847214
300	271,68	0,2512	0,89641	10,22743
300	291,75	0,3007	0,962631	12,24279
300	301,89	0,3343	0,996088	13,61079

f	U rms	I rms	B top	H rms
400	48,85	0,0635	0,120886	2,585357
400	80,77	0,0855	0,199876	3,481071
400	101,13	0,0977	0,250259	3,977786
400	120,95	0,109	0,299306	4,437857
400	151,59	0,1254	0,375129	5,105571
400	181,59	0,1408	0,449368	5,732571
400	201,76	0,1512	0,499281	6,156
400	232,02	0,1671	0,574163	6,803357
400	252	0,1783	0,623607	7,259357
400	272,03	0,1904	0,673173	7,752
400	292,19	0,204	0,723062	8,305714
400	312,21	0,22	0,772604	8,957143
400	332,32	0,2393	0,822369	9,742929
400	352,22	0,2635	0,871614	10,72821
400	382,36	0,316	0,946199	12,86571
400	402,38	0,3662	0,995741	14,90957

10.8 Magnetization test grain oriented core.

f	U rms	I rms	B top	H rms
50	3,349	0,0404	0,0663	1,919
50	12,364	0,1057	0,244771	5,02075
50	17,511	0,1323	0,346666	6,28425
50	19,593	0,1419	0,387883	6,74025
50	23,573	0,1587	0,466675	7,53825
50	25,764	0,1675	0,510051	7,95625
50	30,39	0,1847	0,601632	8,77325
50	32,464	0,1923	0,642691	9,13425
50	37,44	0,2104	0,741201	9,994
50	41,504	0,2262	0,821656	10,7445
50	45,466	0,2414	0,900092	11,4665
50	47,45	0,2475	0,939369	11,75625
50	49,087	0,2554	0,971777	12,1315
50	53,443	0,2732	1,058013	12,977
50	55,222	0,2792	1,093232	13,262
50	58,393	0,2949	1,156008	14,00775
50	60,32	0,3076	1,194157	14,611
50	63,42	0,3263	1,255528	15,49925
50	65,347	0,3415	1,293677	16,22125
50	68,3	0,3692	1,352137	17,537
50	71,5	0,41	1,415488	19,475
50	74,47	0,4639	1,474285	22,03525
50	76,53	0,5151	1,515067	24,46725
50	77,76	0,5535	1,539417	26,29125

f	U rms	I rms	B top	H rms
100	14,241	0,083	0,140965	3,9425
100	27,687	0,1373	0,27406	6,52175
100	39,854	0,1756	0,394495	8,341
100	49,04	0,2007	0,485423	9,53325
100	59,854	0,2282	0,592466	10,8395
100	70,45	0,2534	0,697351	12,0365
100	80,6	0,277	0,79782	13,1575
100	91,15	0,3018	0,90225	14,3355
100	101,32	0,3272	1,002918	15,542
100	111,31	0,3543	1,101804	16,82925
100	121,45	0,3863	1,202175	18,34925
100	131,45	0,426	1,30116	20,235
100	141,45	0,4834	1,400145	22,9615
100	151,46	0,5794	1,499229	27,5215
100	161,43	0,7644	1,597918	36,309

f	U rms	I rms	B top	H rms
200	39,773	0,1308	0,196847	6,213
200	60,07	0,1806	0,297302	8,5785
200	80,55	0,2235	0,398663	10,61625
200	100,99	0,2617	0,499826	12,43075
200	121,04	0,2964	0,599058	14,079
200	141,25	0,33	0,699083	15,675
200	161,22	0,3629	0,797919	17,23775
200	181,28	0,3962	0,897202	18,8195
200	201,38	0,4305	0,996682	20,44875
200	221,32	0,4666	1,09537	22,1635
200	231,45	0,4862	1,145506	23,0945
200	241,41	0,5067	1,194801	24,06825
200	261,57	0,5541	1,294578	26,31975
200	281,44	0,615	1,392919	29,2125
200	301,52	0,7082	1,4923	33,6395
200	321,42	0,8783	1,590791	41,71925

f	U rms	I rms	B top	H rms
300	39,931	0,1117	0,131753	5,30575
300	59,797	0,157	0,197301	7,4575
300	80,71	0,1996	0,266303	9,481
300	101,03	0,2367	0,333349	11,24325
300	121,2	0,2703	0,3999	12,83925
300	141,05	0,3012	0,465395	14,307
300	161,05	0,3308	0,531385	15,713
300	181,48	0,3601	0,598794	17,10475
300	201,68	0,3883	0,665444	18,44425
300	211,37	0,4017	0,697417	19,08075
300	231,51	0,4297	0,763869	20,41075
300	251,31	0,4571	0,829199	21,71225
300	261,91	0,4721	0,864174	22,42475
300	271,95	0,4862	0,897301	23,0945
300	291,98	0,5149	0,96339	24,45775
300	311,81	0,5439	1,028819	25,83525
300	341,98	0,5899	1,128365	28,02025
300	371,83	0,6389	1,226855	30,34775
300	401,99	0,6966	1,326368	33,0885
300	431,77	0,7696	1,424628	36,556
300	452,09	0,8381	1,491674	39,80975
300	461,96	0,8796	1,52424	41,781

f	U rms	I rms	B top	H rms
400	39,661	0,0993	0,098146	4,71675
400	59,612	0,1413	0,147518	6,71175
400	101,02	0,2187	0,249987	10,38825
400	141,81	0,2839	0,350927	13,48525
400	181,4	0,3401	0,448898	16,15475
400	201,54	0,367	0,498737	17,4325
400	241,69	0,4182	0,598093	19,8645
400	302,04	0,4934	0,747437	23,4365
400	342,36	0,5436	0,847214	25,821
400	382,5	0,5945	0,946546	28,23875
400	412,53	0,6335	1,020859	30,09125
400	442,43	0,6731	1,09485	31,97225
400	472,54	0,7145	1,169361	33,93875
400	502,5	0,7581	1,243501	36,00975
400	532,9	0,8064	1,31873	38,304
400	562,8	0,8617	1,392721	40,93075
400	592,8	0,9302	1,46696	44,1845