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EXPERIMENTAL STUDIES OF ELECTROMAGNETIC RADIATION OF A HYBRID VEHICLE

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Annotation. The paper proposes a study of electromagnetic radiation in the cabin of a hybrid car with the presentation of graphs, tables and research methods. The article is intended to substantiate the effective use of electric and hybrid vehicles with the aim of their widespread introduction into production and minimization of environmental hazards of existing internal combustion engines. The theoretical principles of traction systems of environmentally friendly cars are substantiated, the main types of traction systems are given, the energy modes of traction systems are analyzed, their operating characteristics are shown, and the efficiency and performance criteria of environmentally friendly cars are given. Monitoring of the magnetic field as a result of the movement of these vehicles in real time, which is formed for example for environmental, electromagnetic and fire safety, is very important and necessary when operating electric cars and hybrid cars.

According to the WHO, electromagnetic radiation from electric, electronic, transport and other types of machines is several thousand times higher than the natural electromagnetic background. This led scientists, engineers, designers, ecologists to the need to develop hygienic regulations, protection systems against the negative effects of electromagnetic radiation.

An overview of previous research in the relevant field by scientists from different countries of the world is given, emphasizing, in the opinion of the authors of this article, the shortcomings and gaps in the research of electric and hybrid vehicles.

Keywords: battery, safe use, internal combustion engine, source of electromagnetic radiation, electric motor, recuperation, synergetic vehicle, power plant, vehicle motion, rationing, experiment.

Introduction.

Hybrid and electric cars can cause cancer because they emit electromagnetic radiation extremely low frequency (EMF) fields. Recent studies of the EMF emitted by these cars have shown that either they pose a cancer risk to passengers or that they are safe. Unfortunately, much of the research done on this issue has been funded by industrial companies with interests on one side of the issue or another, making it difficult to determine which studies are credible.

Meanwhile, numerous peer-reviewed laboratory studies conducted over several decades have revealed biological effects from limited exposure to CNG EMFs. These studies show that the EMF guidelines created by the self-proclaimed **International Commission on Non-Ionizing Radiation Protection** (ICNIRP) are insufficient to protect our health. Based on the study, more than 250 EMF experts signed **the International EMF Scientists' Appeal** , which calls on the World Health Organization to establish stricter guidelines for EMF and RF EMF. Thus, even if EMF measurements meet ICNIRP guidelines, hybrid and electric vehicle occupants may be permanently exposed to an increased risk of developing cancer and other health problems.

Whereas the International Agency for Research on Cancer of the World Health Organization since 2001 considers magnetic fields **"possibly carcinogenic" to humans, the precautionary principle dictates that we must design consumer products in such a way as to minimize consumer exposure to EMFs.** This is especially true for hybrid and electric vehicles , as drivers and passengers spend a significant amount of time in these vehicles, and health risks increase with longer exposure.

In the beginning of 2014 **SINTEF** , the largest independent research organization in Scandinavia, has offered guidance to a manufacturing project on how magnetic fields can be reduced in electric vehicles (see below). All car dealers must follow their instructions to ensure the safety of their customers. The public

should demand that governments adequately fund high-quality research into the effects of electromagnetic fields on health, independent of industry, to eliminate any potential conflict of interest. In the USA, a large national treasury and educational initiative can be financed for only 5 cents a month without mobile phone subscribers.

More and more battery-powered electric vehicles (e-cars) are being put into operation to help decarbonize mobility. Electric, magnetic, and electromagnetic fields (EMFs) are created in and around vehicles by electrical drive components, battery charging, and other various electronic machines used in modern vehicles. In principle, from a technical point of view, it can be said that all vehicles emit electromagnetic fields, regardless of their drive. In addition to the electrical parameters of the components, the design and selection of materials are significant. The peculiarity of exposure in transport needs is that passengers can be exposed to a large number of sources of different frequencies at once in a very limited space for several hours.

The purpose of this project, in particular, is to check the selection of electric vehicles, as well as to evaluate EMF applications and products with electric drive and interchangeable components with specific criteria for health and safety. and, more detailed explanations. necessary The smallest can be clarified the results of this study, the electric drive, which receives energy from the battery, turns out to be a problem-free additional emf.

For this purpose, large-scale measurements of low-frequency and high-frequency EMFs, which are taken under real operating conditions, including charging processes, were carried out on a small selection of mass-produced passenger vehicles (5 electric cars, fully electric and battery-powered). Engine, 1 vehicle with a diesel engine for comparison) with stocks in the vehicle market, so you can count on the possible fuel consumption and people in the vicinity of the vehicle.

Op itation is not had special regulatory acts regarding electromagnetic fields in electric vehicles, the voltage and field of measured electromagnetic fields was classified in accordance with the established international limit recommendations (ICNIRP) . The general and marginal values were identified , extracted in this way and from all sources , were quite low , on average in the region , up to 5% , for low - frequency magnetic fields approx . 10% for high - frequency EMF . Sometimes the peak values of low-frequency magnetic fields are higher than 50% of the limit values .

In general, as is usually the case with magnetic fields in general, these high values are often very localized. Moreover , due to dynamos and so on and storage situations in vehicles often occur more episodic situations , when they can be identified , it is unlikely that they can be directly related to to e electric drive. The results and measurements of this study are consistent with other previous studies. Wireless energy transfer (charging) was not investigated in this project .

Such a high value is often very localized. In addition, due to the dynamic and warehouse situation in vehicles, there are often more episodic situations where they can be identified, it is unlikely that they can be directly tied to the electric drive. The measurement results of this study are consistent with other previous studies. Wireless energy transfer (charging) was not investigated in this project. such a high value is often very localized. In addition, due to the dynamic and warehouse situation in vehicles, there are often more episodic situations where they can be identified, it is unlikely that they can be directly tied to the electric drive. The measurement results of this study are consistent with other previous studies.

Regardless of the parameters of accumulation, attention should be paid to further technological development, especially in view of the trend towards reduction in quantity and digitization. One unsolved problem remains insufficient EMF regulation for vehicle cabins.

Relevance of the research

The intensive use of electrical energy in the modern information society led to the emergence and formation of a new significant environmental pollution factor in the last third of the 20th century - electromagnetic.

The scale of electromagnetic pollution of people's habitat has become so significant that the World Health Organization has included this problem among the most relevant for humanity, and many scientists attribute it to powerful environmental factors with catastrophic consequences for all living things on Earth. The term "global electromagnetic pollution" was officially introduced in 1995 by the World Health Organization (WHO).

Until now, the evaluation of the electromagnetic safety of hybrid and electric vehicles remains unexplored. Applied methods of analysis and synthesis of electromagnetic radiation do not pay enough attention to the multi-criterion of optimization problems that arise. These circumstances do not make it

possible to fully reveal the EMF effects of hybrid and electric vehicles depending on the external operating conditions.

Thus, the problem of evaluating the electromagnetic safety of electric and hybrid cars at the stage of operation becomes relevant, making a significant contribution to the productivity of an environmentally friendly mode of transport.

The purpose of the work is research and assessment of the electromagnetic danger of electric and hybrid cars based on a systematic analysis of the use of these vehicles at the stage of their operation.

Review of previous research in the relevant field

Electromagnetic field in electric and hybrid cars, Author : D Sztafrowski · 2022 · Cited : 2 — The **low-frequency magnetic field that occurs in electric and hybrid cars** was classified in 2002 by the International Agency for .

Hybrid cars are becoming very popular. Their attractiveness is influenced by the reduction of exhaust gas emissions due to the use of electric drives. However, the use of this type of drive also raises some concerns, as people using this type of transport are in close proximity to the car's electrical installation, which creates an electromagnetic field. Large values of current, up to several hundreds of amperes, can be a source of significant values of fields affecting the body of passengers.

In this article, the author did not consider the causes of EMV, their centers and modern technical means of protecting drivers, passengers and the environment.

Author : R Hristov · 2020 . The article Investigation of the electromagnetic field in electric and. Quoted : 8 — It is important to study the values of **electromagnetic field** parameters on board **electric vehicles** to ensure compatibility with . In electric vehicles, passengers are very close to cables and wires, electrical systems that carry significant power, usually for a long period of time. Such relatively high currents that are achieved in these systems and the short distance between power devices and passengers mean that the latter are exposed to the corresponding magnetic fields. With this in mind, it is important to investigate the values of electromagnetic field parameters on board electric vehicles to ensure compatibility with international standards. Measurements were made inside four ordinary cars under standard conditions. The data of international and Bulgarian standards regarding safe levels of electromagnetic fields are presented. After the measurements, it was established that these levels were not exceeded. The author of the article does not reveal the method of researching the parameters of the electromagnetic field on board the electric car.

Author: X Dong · 2023 · Cited: 2 — The numerical results of this study could also effectively supplement the study of the **electromagnetic** environments of pure **electric vehicles** and provide some ... in the article "Electromagnetic exposure level of a pure electric" To quantitatively analyze the electromagnetic radiation dose of the inverter in a pure electric vehicle on the driver's body and evaluate the safety of electromagnetic radiation based on a model of real human anatomy in a virtual house project, a real human model with several organs and tissues including muscle, bone, heart, lung, liver, kidney, bladder, skull, scalp, white matter, and cerebellum. The inverter of a pure electric car is considered a source of electromagnetic radiation; for this study, an equivalent electromagnetic environment model consisting of a real human body, an inverter, and a car body was constructed. The author does not indicate the final results of protecting a person's background from the negative effects of EMF.

Author : J Li · 2022 · Cited : 1 — Biological **experimental study on** cumulative effect of **vehicle electromagnetic radiation** ... With the acceleration of the comprehensive electrificati Or cumulative effect electromagnetic radiation transport tool affects on I 'm healthy passengers , there are subject general concern consumers . At present, there is still a lack of relevant research and standards on the cumulative effect of car electromagnetic radiation at home and abroad. In this paper, a pure electric vehicle is taken as the test object, and the test mice are taken as an example to test whether the cumulative effect of the vehicle's electromagnetic radiation affects the body weight and immune blood cells of the mice. The results showed that there were significant gender differences in body weight. However, the testing time needs to be further extended to determine if the exposure is causing a cumulative effect. The author does not reveal the cumulative effect of the negative impact of EMF on a person and protection against it.

Author : V Kozlovskiy · 2020 — Abstract. This article covers a **hybrid car** interference immunity **research** . A combined unit-power plant **vehicle** prototype (a **hybrid car**) of a famous. Experimental studies of a hybrid car and electricity. This article examines the study of hybrid vehicle resistance to obstacles. Prototype vehicle with a combined power plant (hybrid vehicle). Its configuration included an engine, a control center in the trunk of the car and a standard internal combustion engine, control system (DVZ) with updated software for joint operation. In this article, the author does not provide the main

environmental safety features of a hybrid car and measures to protect the driver and passengers from EMF effects.

1. Experimental studies of electromagnetic radiation of a hybrid car

Hybrid electric vehicles include an internal combustion engine (ICE), a traction electric motor and a battery. Some drivers call these vehicles "petrol electric cars". When driving on a country highway, the internal combustion engine works in the hybrid. In the city, the hybrid is powered by the current of the traction battery and the electric motor. At night, traction batteries can be recharged from the electrical network.

Parallel, serial and mixed schemes of hybrid power plants are known (Figure 1).

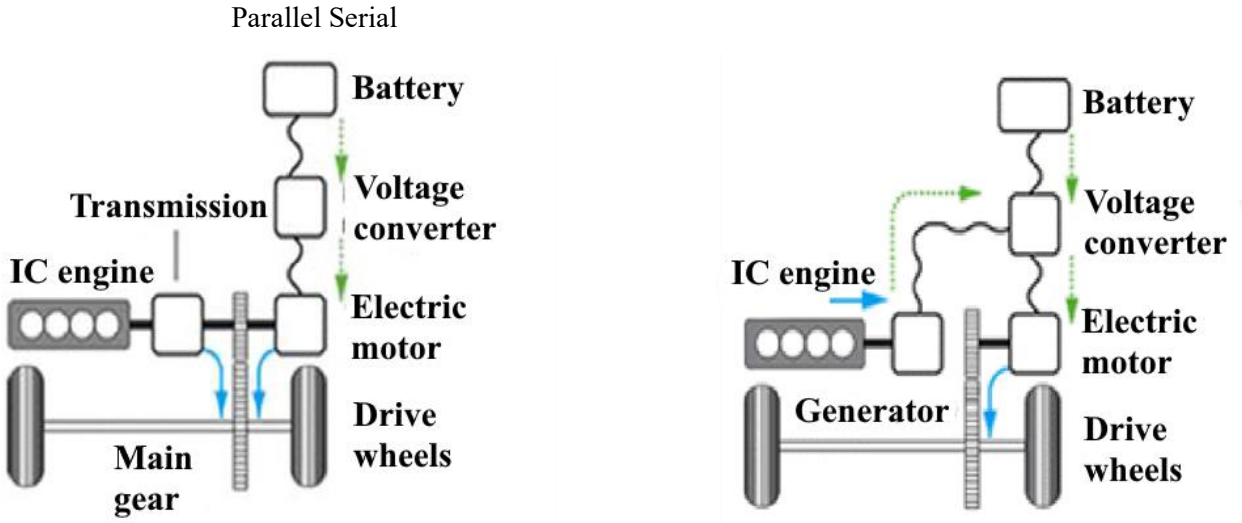

Fig. 1 – Parallel and serial schemes of hybrid power plants

1.1. Structural diagram of the EMF magnetic induction measurements of a hybrid car

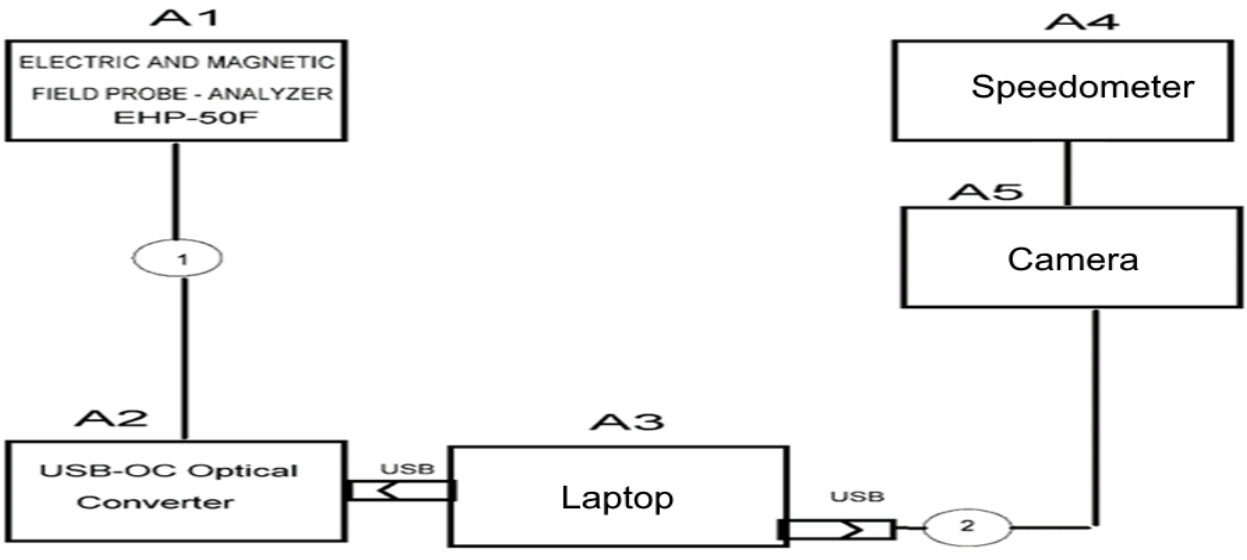

Fig. 2 – Structural diagram of hybrid car magnetic induction measurements

To measure the magnetic induction in the interior of the hybrid car, a NARDA EHP-50F A1 magnetic induction meter was used, the measuring unit of which is located at the seat of the passenger on the right. Data from the measurement unit A1 via optical cable 1 and signal converter A2 in USB format were sent to a personal computer (PC) - laptop A3 powered by a battery. The result of the measurements was indexed on the laptop display in the form of a spectrum in the frequency range of 1...10 Hz and digital data of the frequency and level of magnetic induction.

The speed of the car was measured using the standard speedometer of the A4 car. Speed readings were recorded using an A5 video camera connected to the second USB port and the computer via cable 2.

The result of speed measurements was also displayed on the laptop display. Both measurement results, as well as speech comments from the microphone in the video camera, were recorded in real time in an mp4 format video file using a computer screen recording program .

EHP-50F NARDA (Fig. 3) is a low-frequency probe-analyzer for measuring electric and magnetic fields.

Fig. 3 - Magnetic field induction meter EHP-50F NARDA

The electric and magnetic field is measured by three sensors on the orthogonal axes X, Y and Z. The digital signal processing unit provides analog-to-digital signal conversion and spectral analysis in the frequency range from 1 Hz to 400 kHz in a high dynamic range and at eight different values of the frequency range. An internal optical converter allows connection to external devices via optical fiber, so the EHP-50F can be used both with the NBM-550 portable field display and with a personal computer.

The graph of the spectrum of magnetic induction oscillations and the speedometer readings of the hybrid are shown in Figure 4. This spectrum has smaller harmonics than that of a conventional car. According to the results of the measurements, the largest level of the amplitude of the magnetic induction, which corresponds to the frequency of the first harmonic, was taken.

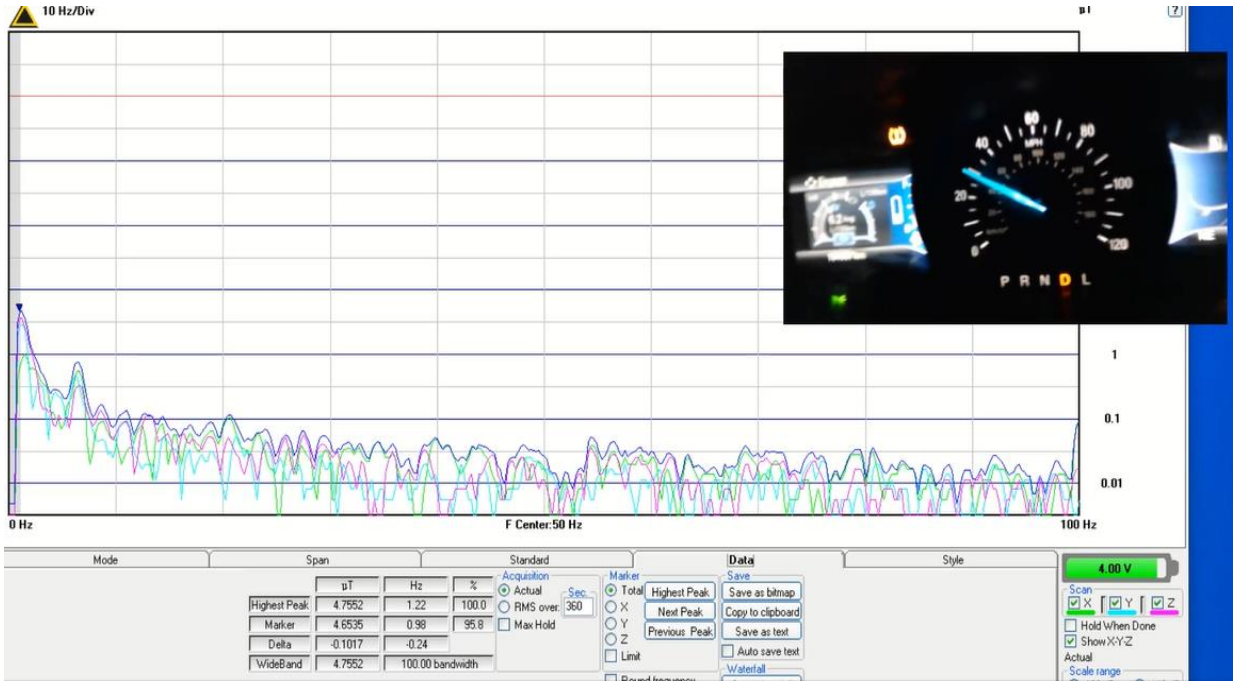

Fig. 4 – Spectrum of magnetic induction oscillations and EMF measurement data in the car interior

Figure 4 shows the spectrum of magnetic induction oscillations and measurement data in the interior of a hybrid car.

After the end of the experiment - i.e., driving along the track mp4 files in and deo were looked at and the results were recorded every second . Readings with a frequency of the electrical network of 50 Hz were excluded as misses. The results are shown in the tables of Appendix 1.

the data , their statistical and correlational analysis was carried out .

The drive of a car with a hybrid engine was carried out according to the staff of the scientific center NC-5 NSC " Institute of Metrology " on 12.27.2022. Experimental studies are recorded in the file Video_221227165252_.mp4 . Time in motion 9 min. 21 p. The average speed is 55.04 km/h. The estimated distance is 8.57 km. The induction and frequency data are given in Appendix A3.

A typical graph of the magnetic induction oscillation spectrum and speedometer reading of a hybrid car is shown in Figure 3. The spectrum has fewer harmonics than in a car. The largest level of the induction amplitude corresponding to the frequency of the first harmonic was taken as the result of the measurements.

For the analysis of the work, a graph was built, on which the points of induction in μT at different speeds of the hybrid vehicle, km/h, were marked (Figure 5).

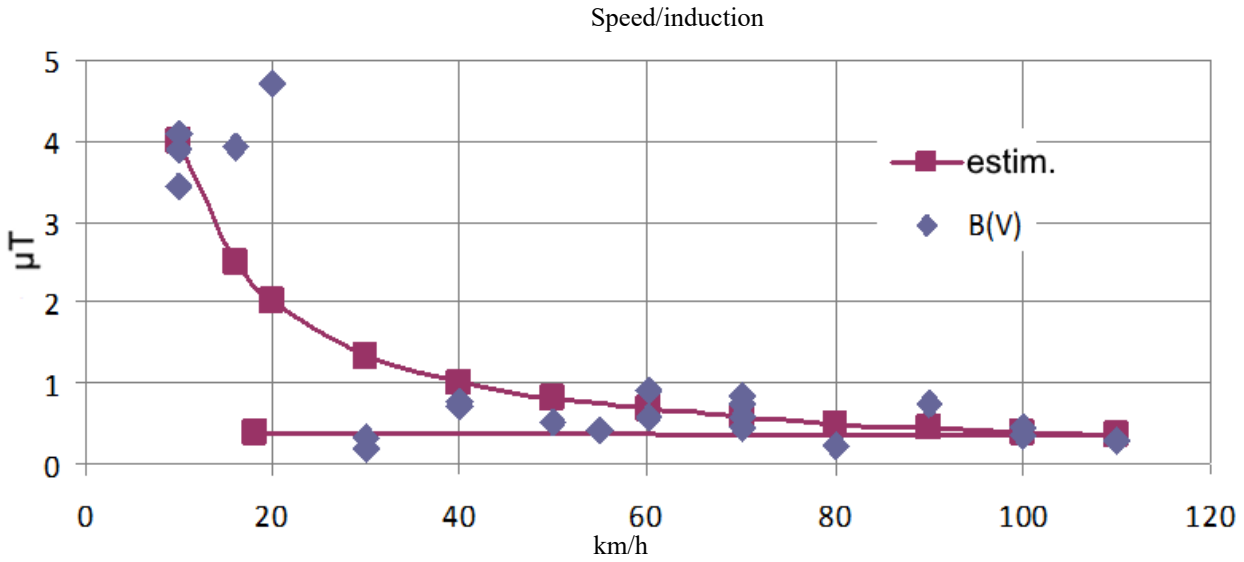

Fig. 5 – Value of induction in μT at different speeds km/h

The diagram also shows a trend graph - an inverse-proportional function, which shows that the induction decreases on average with an increase in the speed of the car. At the same speeds, there are different inductions. The average frequency is 7.3 Hz.

The speed/induction correlation coefficient is 0.72 more by the modulus of 0.7, which means that the specified values are statistically dependent. Statistical analysis of the data is given in Table 2.

Table 2. Statistical analysis of data

This is normal	'5
Standard error	0.298
Honey and Ana	0.665
Fashion	#N/A
Standard deviation	1,465
Disperse and I in and fights	2.135 2
Excess	0.630
Asymmetri c and st	1,527
And the interval	4.49
Minimum	0.21
Maximum	4.7
Score level	24
over her nost and (95.0%) 1.28	0.61790 1

Pocket	*Frequenc y*
0.21	1
1.3325	18
2,455	0
3.5775	1
That 's it	4

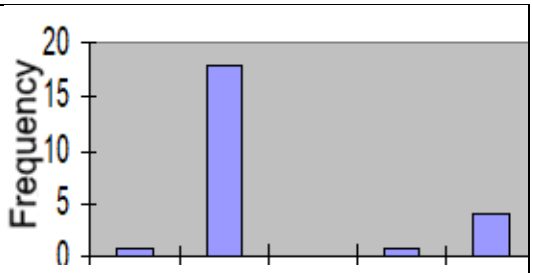

Figure 1Histogram

The histogram shows a probability distribution law close to normal

Conclusion . The value of the induction of the magnetic field in the interior of the electric car of this model does not depend on the speed and has an average value of B=1.28 μT. The measurement uncertainty is 0.61 μT with a coverage factor of K=2 with a confidence probability of P =0.95.

Thus, the induction of the magnetic field in the cabin of a hybrid car of this brand is greater than that of an electric car and has a tendency to depend on speed.

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