 doi:10.20944/preprints202211.0307.v1

Energy efficient centrifugal air extractor for environments contaminated with SARS-CoV-2 (Coronavirus). How to build a motor that saves electricity.

Anderson, Ibar Federico (1), (2), (3), (4), (5) Homepage

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Abstract.
The product is a centrifugal air extractor, whose objective is to extract the stale air of SARS-CoV-2 or Covid-19 (Coronavirus); designed for civil and commercial use, it works with a single-phase alternating current (AC) motor of 220 (V) and 50 (Hz), with high energy efficiency (EE). Developed under the Design Thinking methodology, by electromechanical simulation using NI Multisim 14.0 software, case design using Cfturbo 2020 R2.0 CAD software, and rapid 3D prototyping with the OverLord Pro printer; with a prototype of the conventional stator winding of a synchronous motor with a two-pole PMSM/IPM single-phase alternating current (AC) field winding and a 4000 (Gauss) ferromagnetic ceramic magnet rotor. Innovating online nº 15 of invention patent nº 381968 by Nikola Tesla, 5/1/1888.
One of the objectives is to link the middle level or Technical Schools with the University system (and careers with a Technological profile) through Project B374 located in the Secretariat of Science and Technology (SCyT) of the National University of La Plata (UNLP), whose title is: *"Integrated Management of Design and Innovation. Contributions for a theoretical-conceptual and methodological review"* by the Director: Mg. Federico del Giorgio Solfa. Just as links were sought with the Research and Development Laboratory of the Department of Industrial Design (LIDDI-FBA-UNLP) through its Director D.I. Pablo Ungaro and D.I. Ana Bocos. In 2021, the project participated in the INNOVAR National Contest of the Ministry of Science, Technology and Productive Innovation of the Nation (MINCYT), Argentine Republic; in the "Covid-19 Projects" category, having been selected in the catalog of innovative products, won the 1st. "Covid-19 Projects" position of the National Agency for Research and Technological Development and local innovation (R+D+i) dependent on MINCYT.
The results showed, according to the analysis of the test bench, that the PMSM/IPM type synchronous motor used in the centrifugal fan, with the innovation of the reactance-inductive control in series plus the capacitor in parallel, reduces the power by 67% (Watts) and active energy consumption (kWh), performing 56% more mechanical work (Joules) on the fluid air (with a 50% reduction in carbon footprint). Which leads us to the following conclusion: it is possible to develop centrifugal fans that save electricity (kWh) without the need to resort to (1) the *"Fan Affinity Law"*, nor (2) the use of variable speed drives (VDF) or frequency (which are devices with complex and expensive electronics). Which would bring an enormous saving of the cost of electrical energy.

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Keywords: Centrifugal fan, SARS-CoV-2, COVID-19, energy efficiency, synchronous motor, PMSM/IPM, single-phase alternating current.

Introduction.

The problem of the SARS-CoV-2 Pandemic, as explained later in the bibliographic review of the fundamentals, raised the design and/or development of a centrifugal fan with high energy efficiency.

Therefore, the project is related to one of the scientifically established ways to combat the Covid-19 pandemic because it renews the stale air in closed environments, replacing the air contaminated by Coronavirus, by introducing fresh and virus-free outdoor air (avoiding contaminated aerosols).

Continuous ventilation is always recommended. International standards for closed environments establish the need for 12,5 (liters/second) of fresh outdoor air per person; also run HVAC (Heating, Ventilation, and Air Conditioning) systems in existing buildings (systems must run from 2 hours before with the highest exchange of outside air and up to 2 hours after the building is occupied) building) and use exhaust fans to remove the virus by moving the air outside.

Therefore, one of the central objectives of this study focuses on the industrial and electro-mechanical design of a centrifugal air extractor coupled to a synchronous motor with a two-pole field winding of the PMSM/IPM single-phase alternating current type (AC) and a ferromagnetic ceramic magnet rotor of 4000 (Gauss); innovating in line no. 15 of the invention patent nº 381968 by Nikola Tesla, 5/1/1888 (this conforms to the electro-mechanical design hypothesis).

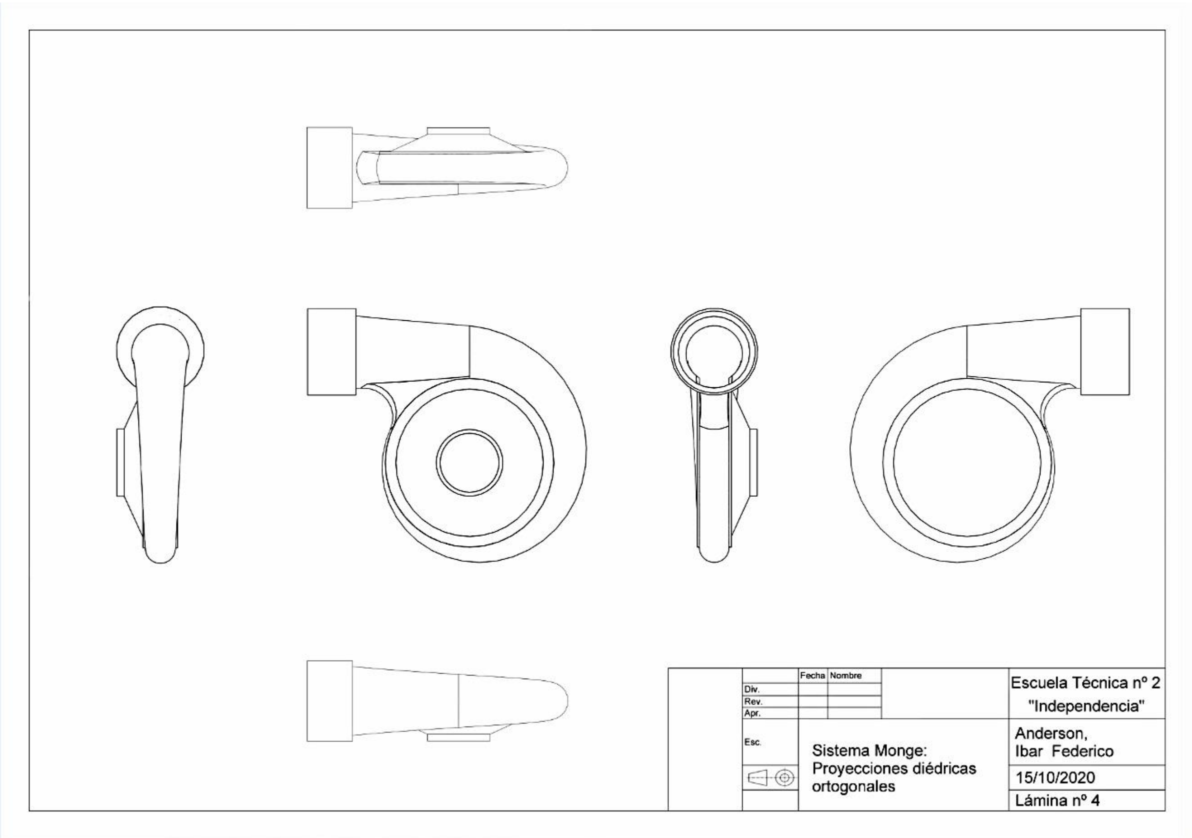

Figure 1. Monge System: Orthogonal dihedral projections of the casing: stator, impeller and volute. Source: self made.

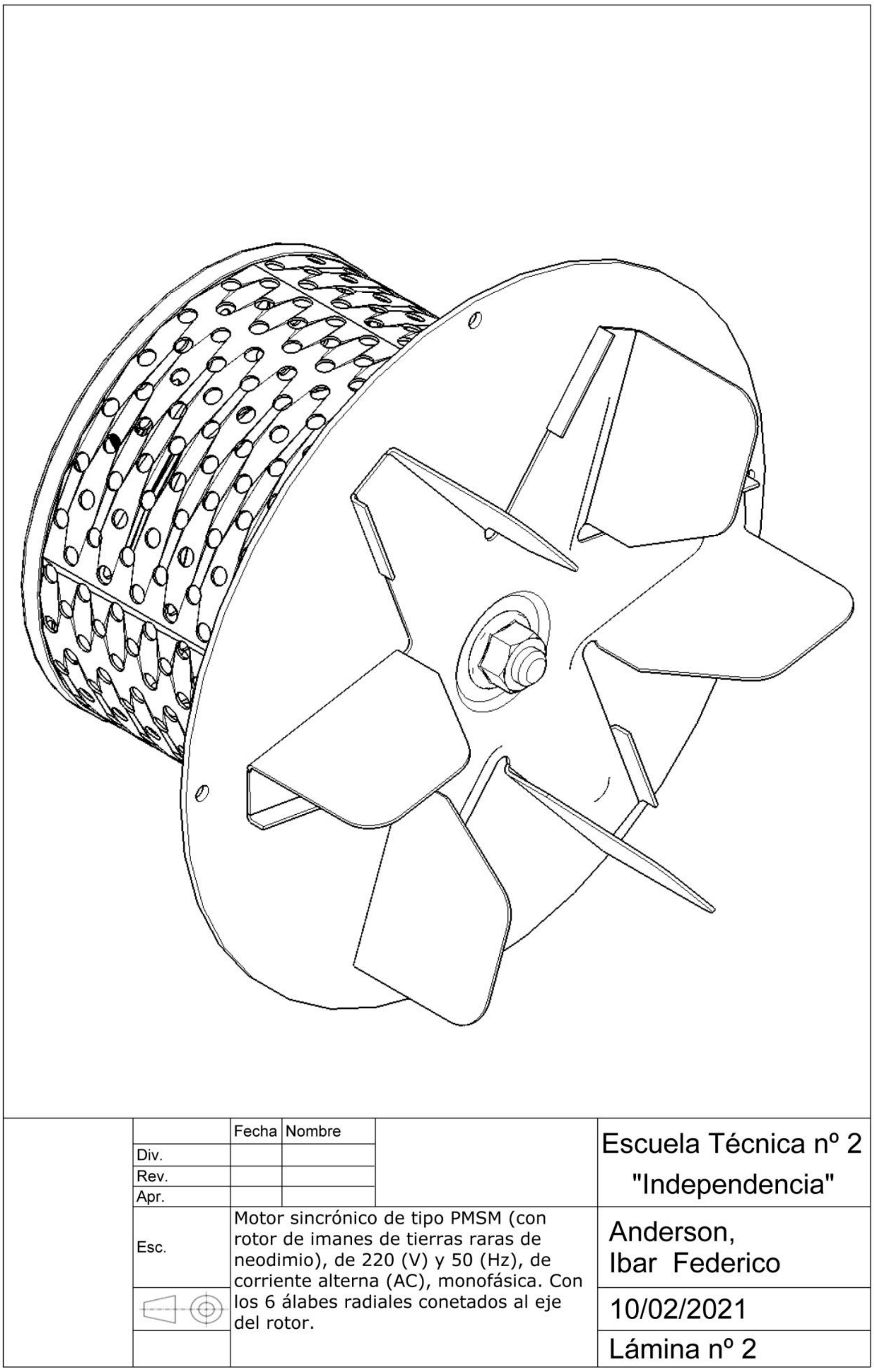

Figure 2. Isometric view of the PMSM/IPM 220 (V) and 50 (Hz) single-phase alternating current (AC) synchronous motor, with the six radial blades connected to the rotor shaft. Source: self made.

Basics.

This work is mainly based on a study on the long-distance airborne transmission of SARS-CoV-2, Covid-19[1] or Coronavirus[2]: rapid systematic review of the cited literature [1]. This rapid review found evidence suggesting that long-distance (>2 m) airborne transmission of SARS-CoV-2 could occur in non-healthcare indoor settings. Based on the results of this review, indoor non-health care settings that could be at risk for long-distance airborne transmission include non-hospitality settings such as restaurants, public transportation, and inadequately ventilated workplaces, as well as settings where activities that result in increased aerosol emission, such as singing or talking loudly. These results highlight the importance of evaluating ventilation, especially in interior spaces where people meet others who do not belong to their household. Special attention should be paid to ventilation in environments with activities that may increase the amount of respiratory particles, for example, singing. Where ventilation is assessed to be inadequate, improvements should be made.

This innovation required taking into account the classical physical principles and the fundamental laws of electricity and magnetism such as the behavior of Ohm's Law in alternating current, Faraday's Law and other known laws in alternating current [2, 3, 4, 5] to cite some examples that represent classical concepts and the theory and practice of rotating electrical machines [6, 7, 8, 9, 10, 11, 12, 13, 14, 15].

On the other hand, attentive to the new and extensive specific bibliography in the approach to environmental problems and in the so-called "carbon footprint". For Energy Efficiency (EE), the study has focused on a specific literature review on ecodesign and energy efficiency in refrigeration systems [16, 17, 18, 19, 20, 21, 22, 23, 24, 25].

Of the seven (7) levels of the so-called Strategic Wheel of Ecodesign approached by Eng. Guillermo Canale, impossible to enumerate and delve into in detail -one by one- in this study; on which the central focus has been decided is at the product structure level and the reduction of the impact during use and the lower consumption of single-phase active energy of 220 (Volts) and 50 (Hertz) available in the distribution system of the domestic and commercial electrical network in the Argentine Republic (non-industrial three-phase). As described throughout this work.

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[1] The COVID-19 pandemic, also known as the coronavirus pandemic, is an ongoing pandemic resulting from the disease caused by the SARS-CoV-2 virus. Initially it was called "Wuhan pneumonia", since the first cases were identified in December 2019 in the Chinese city of Wuhan, when cases were reported of a group of sick people with an unknown type of pneumonia. The World Health Organization (WHO) declared it a public health emergency of international concern on January 30, 2020 and recognized it as a pandemic on March 11, 2020, when it reported that there were 4,291 deaths and 118,000 cases in 114 countries. As of January 21, 2022, more than 343 million cases of the disease have been recorded in 258 countries and territories, and 5.5 million deaths. On the other hand, by January 2021, 4.5 billion people have been vaccinated with at least one dose, 60% of the world population. The World Health Organization estimates that at least 10% of the world's population had already been infected with this disease (approximately 780 million infected people), due to the large underreporting of cases worldwide.

[2] Coronavirus disease 2019, better known as COVID-19, is an infectious disease caused by SARS-CoV-2. It produces symptoms that include fever, cough, dyspnea (shortness of breath), myalgia (muscle pain), and fatigue. In severe cases, it is characterized by pneumonia, acute respiratory distress syndrome, sepsis, and circulatory shock. Septic shock is the most common form in these cases, but the other types can also occur. For example, obstructive shock can result from pulmonary embolism, a complication of Covid-19. According to the WHO, the infection is fatal in between 0.5% and 1% of cases. There is no specific treatment; the main therapeutic measures are to relieve symptoms and maintain vital functions. The transmission of SARS-CoV-2 occurs through small droplets —Flügge droplets— that are emitted when speaking, sneezing, coughing or exhaling, which when released by a carrier (who may not have symptoms of the disease or may be incubating it) pass directly to another person through inhalation, or remain on the objects and surfaces that surround the emitter, and then, through the hands, which pick it up from the contaminated environment, come into contact with the oral, nasal and ocular mucous membranes, by touching your mouth, nose, or eyes. Aerosol transmission (<5μm) is also documented. or remain on the objects and surfaces that surround the emitter, and then, through the hands, which pick it up from the contaminated environment, come into contact with the oral, nasal and ocular mucous membranes, by touching the mouth, nose or eyes . Aerosol transmission (<5μm) is also documented. or remain on the objects and surfaces that surround the emitter, and then, through the hands, which pick it up from the contaminated environment, come into contact with the oral, nasal and ocular mucous membranes, by touching the mouth, nose or eyes . Aerosol transmission (<5μm) is also documented.

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Methodology.

Following the five (5) stages of Design Thinking[3], which was initially popularized by the Silicon Valley firm ideo[4], and whose steps are: (1) empathize, (2) define, (3) ideate, (4) prototype and (5) test. The product was developed.

Stages (1), (2), (3) and (4) make up the "Work Materials". Stage (5) corresponds to the "Results and Discussion".

Work materials.

1. Stage to empathize with users/customers.

Empathy with customers allows us to understand their needs and discover what they really want or need, looking at products and services from their perspective. It is about observing, understanding and interacting with future users of the product; After empathizing with them, the problem identification phase is reached, that is, the problem that SARS-CoV-2 (Coronavirus) generated in individuals -at the national, regional and global level- various diseases (mainly in the respiratory tract); which makes it necessary to maintain a minimum social distance of two (2) meters in closed environments to avoid aerosols and/or sprays generated by human breathing itself, as investigated in the extensive bibliographic review [1].

2. Definition stage.

To advance in this stage, the following question must be answered: what is the need of individuals and/or consumers in their private sphere (be it the house/home or private address), of commerce or industry regarding the need for certain types of electrical appliances or ventilation systems so that such equipment consumes less electrical energy (kWh) operating continuously?

This question is answered in the following step 3.

3. Innovation ideation stage.

First, an electromechanical simulation was carried out using the NI Multisim 14.0 software, taking into account different variables and electro-mechanical design factors, then the casing was designed using CAD software (Computer-Aided Design) using the Cfturbo 2020 R2.0 program -under license- plus the free software add-on and the creation of 3D prototypes through the OverLord Pro printer. At this stage of ideation, modeling with a 3D printer and CAD software is subsequent to drawing and prior to conventional or traditional prototyping.

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[3] Design thinking is a term used to represent a set of cognitive, strategic and practical processes through which design concepts (product proposals, industrial design products, etc.) are developed. Design thinking is more commonly known as Service Design in Europe. Many of the key concepts and aspects of design thinking have been identified through studies, in different design domains, of design cognition and design activity in natural and laboratory contexts. Design thinking is also associated with recipes for product and service innovation within business and social contexts. An important figure in Design thinking is Hasso Plattner, who founded two important schools: the d.school at Stanford University, USA, and the Hasso Plattner Institute in Potsdam, Germany. These two schools, global benchmarks, today train the majority of design thinking practitioners.

[4] IDEO is a design and consulting firm, with offices in the US, England, Germany, Japan and China. It was founded in Palo Alto, California, in 1991. The company uses the design thinking approach to conceptualize digital products, services, environments and experiences.

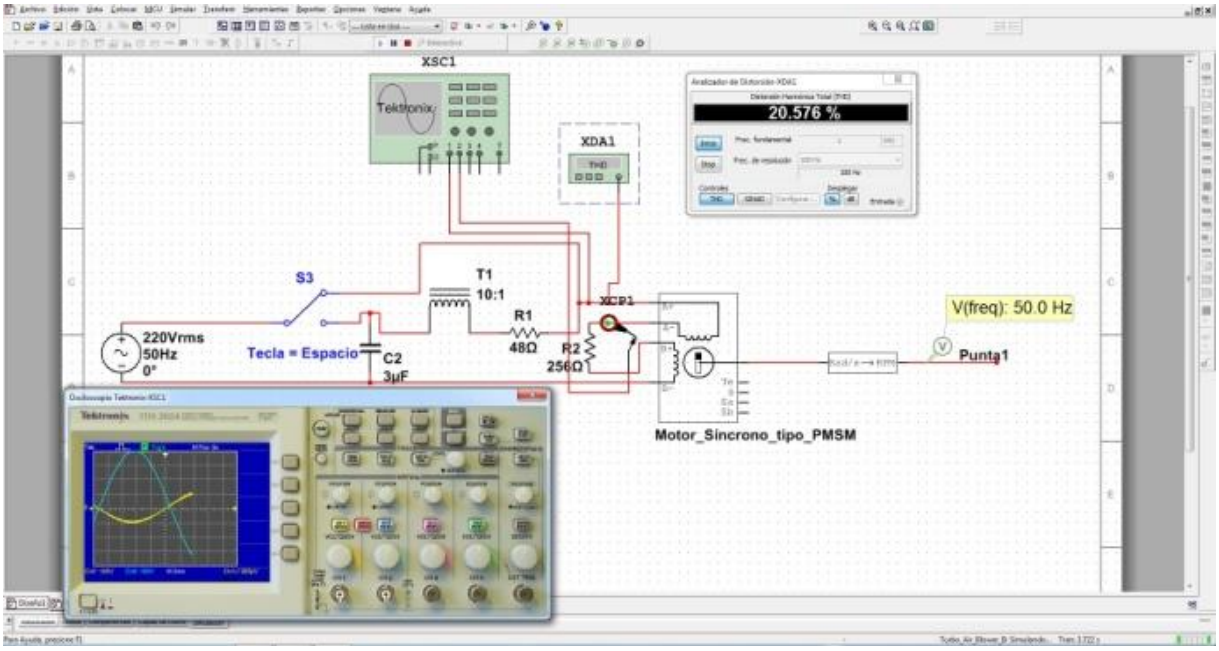

Figure nº 3. As shown in the NI Multisim 14.0 software simulation figure, with the SPDT switch off, the THDv (in voltage) is 20,5%, and it has a THD greater than 5%, which is not acceptable by the user. IEEE 519 standard, the voltage and current are observed on the oscilloscope. Source: self made.

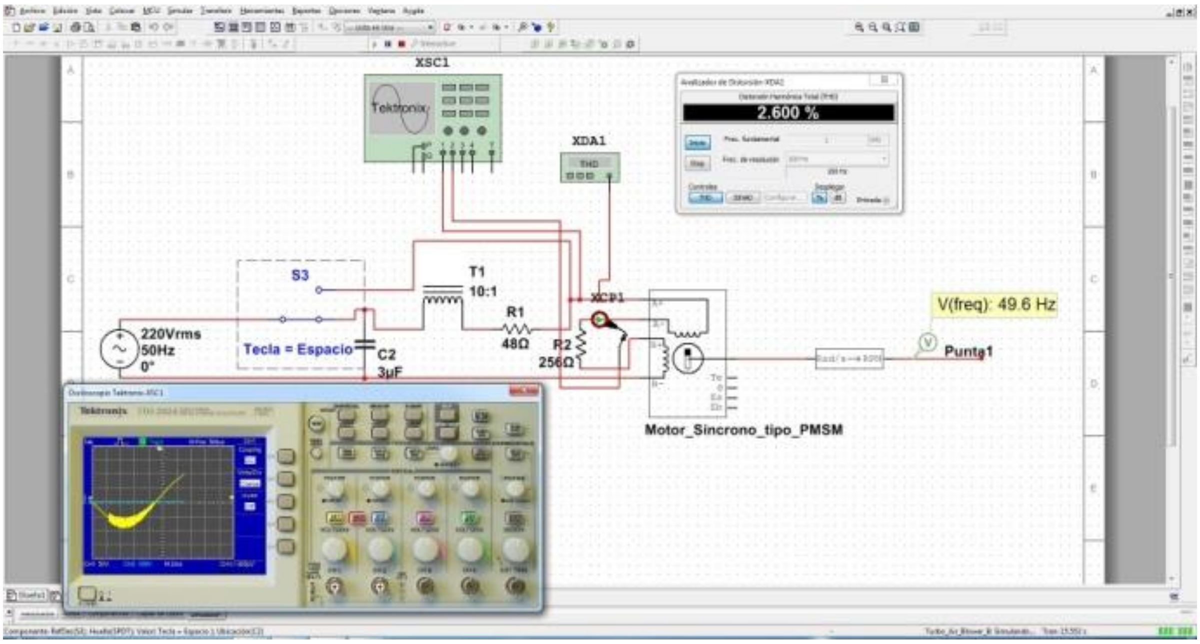

Figure nº 4. As shown in the NI Multisim 14.0 software simulation figure, with the SPDT switch connected to the RCL circuit, the inductive-capacitive type low-pass circuit design that works by analogy with a resistive-capacitive one has a THDv (voltage) less than 5%, which is acceptable according to the IEEE 519 standard. Harmonics in the oscilloscope, in the voltage waveform, are reduced. Everything leads us to assume that the design hypothesis for the manufacture of the prototype is correct. Source: self made.

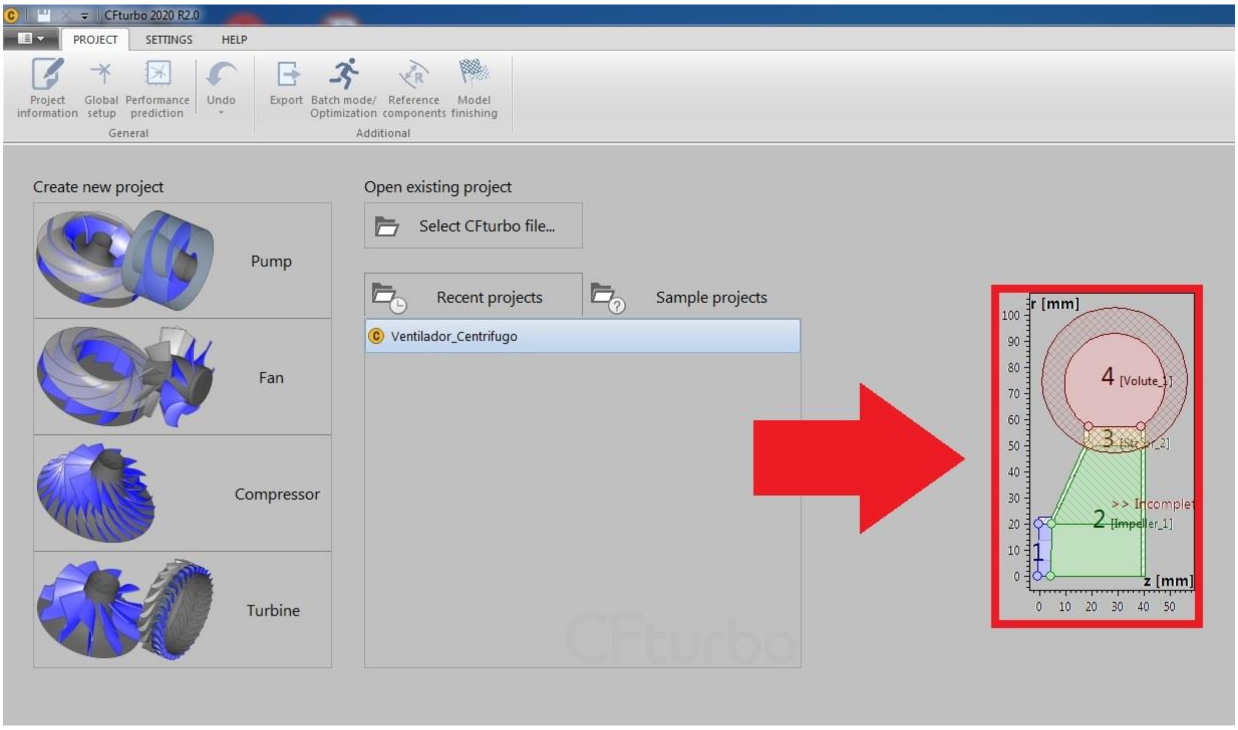

Figure 5. CFturbo 2020 R2.0 software. Development of the centrifugal fan (fan). Opening files, under license: https://www.cfturbo.com Source: Own elaboration.

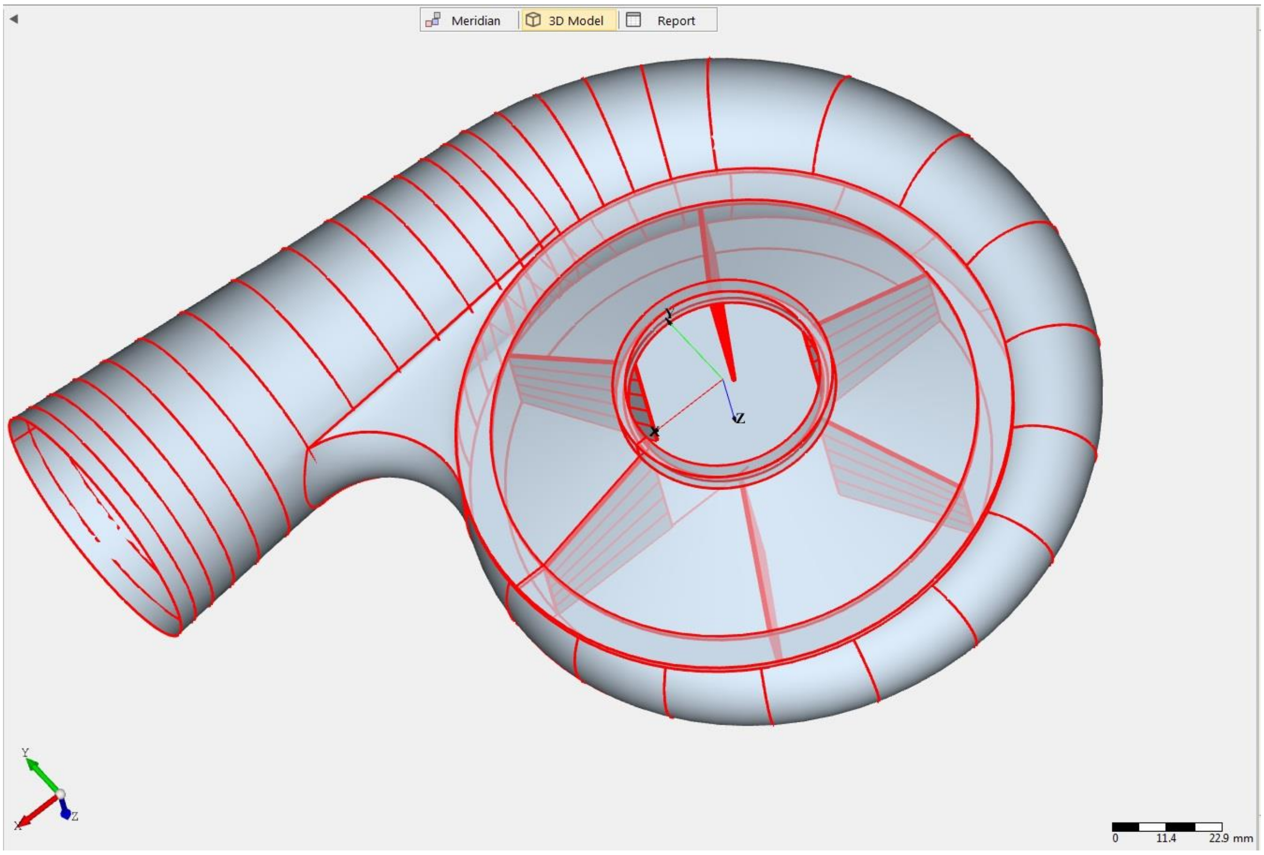

Figure 6. CFturbo 2020 R2.0 software. Selection in 3D modeling of stator, impeller and volute. Source: self made.

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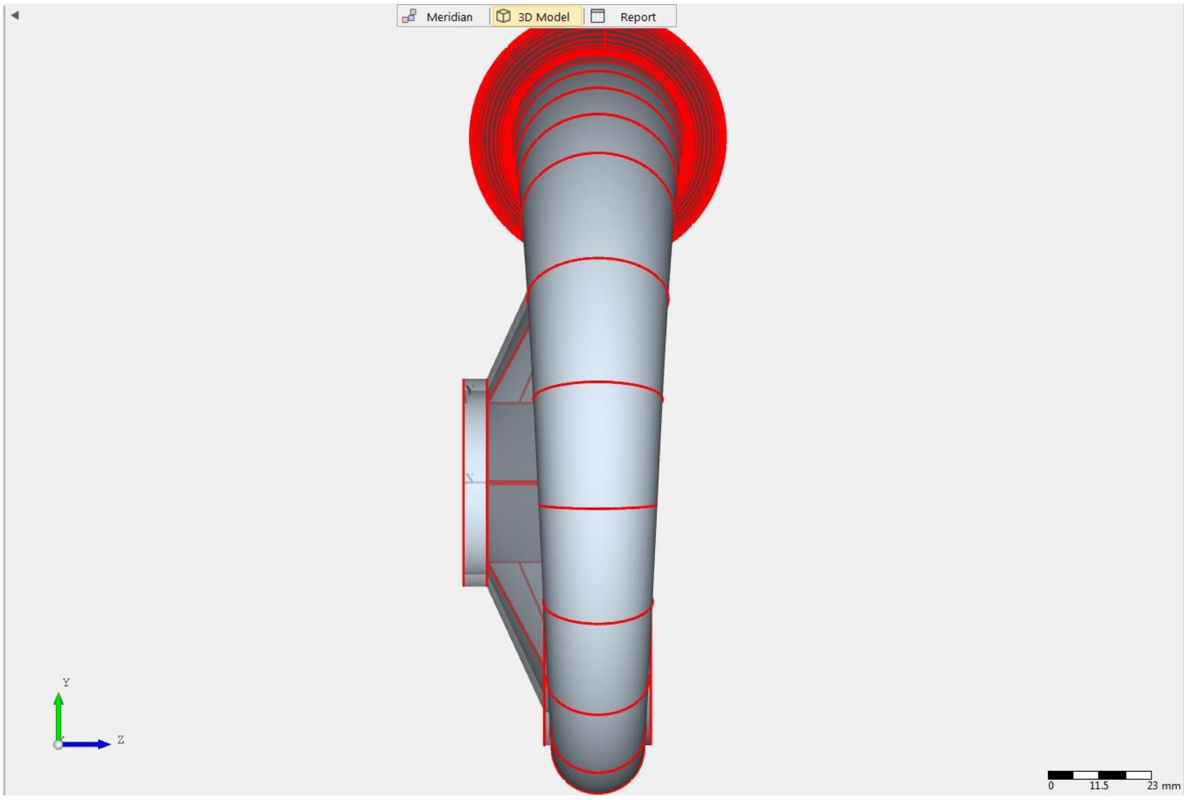

Figure 7. CFturbo 2020 R2.0 software. Selection in 3D modeling, X axis. Source: Own elaboration.

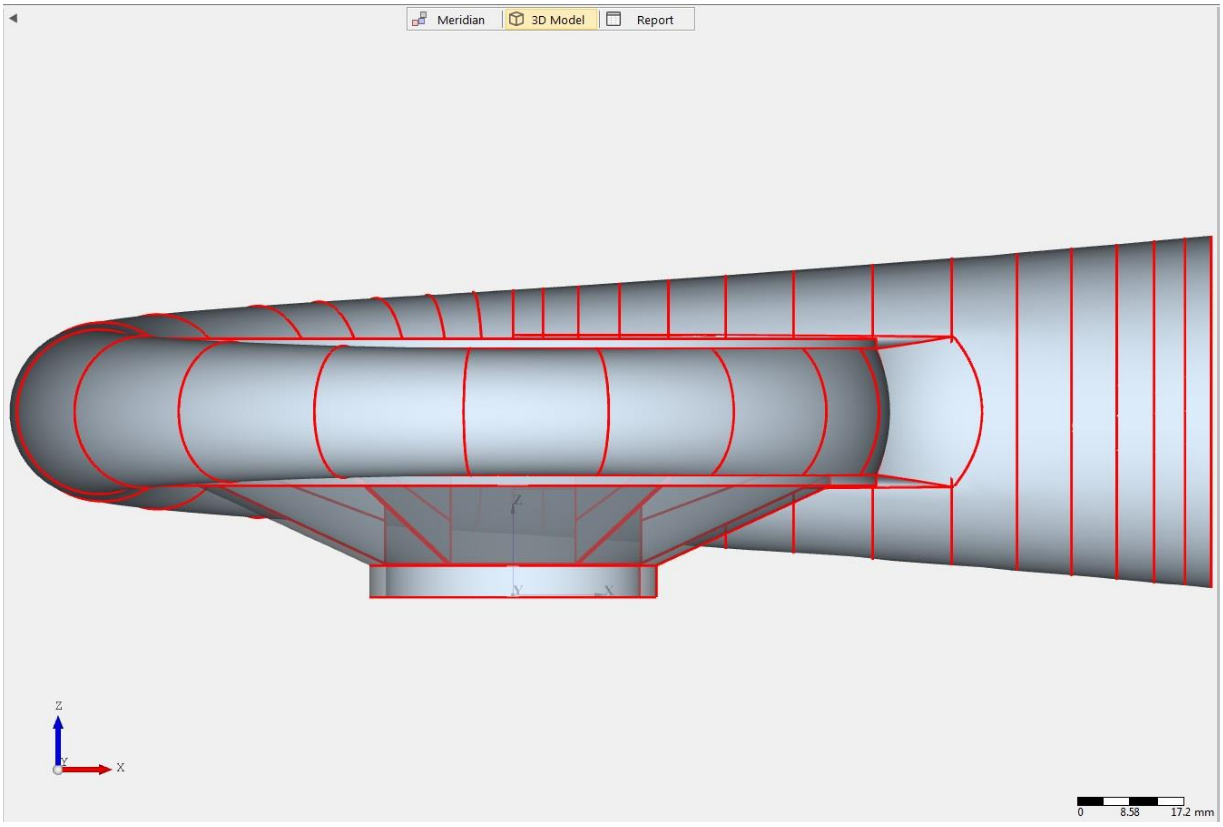

Figure 8. CFturbo 2020 R2.0 software. Selection in 3D modeling, Y axis. Source: Own elaboration.

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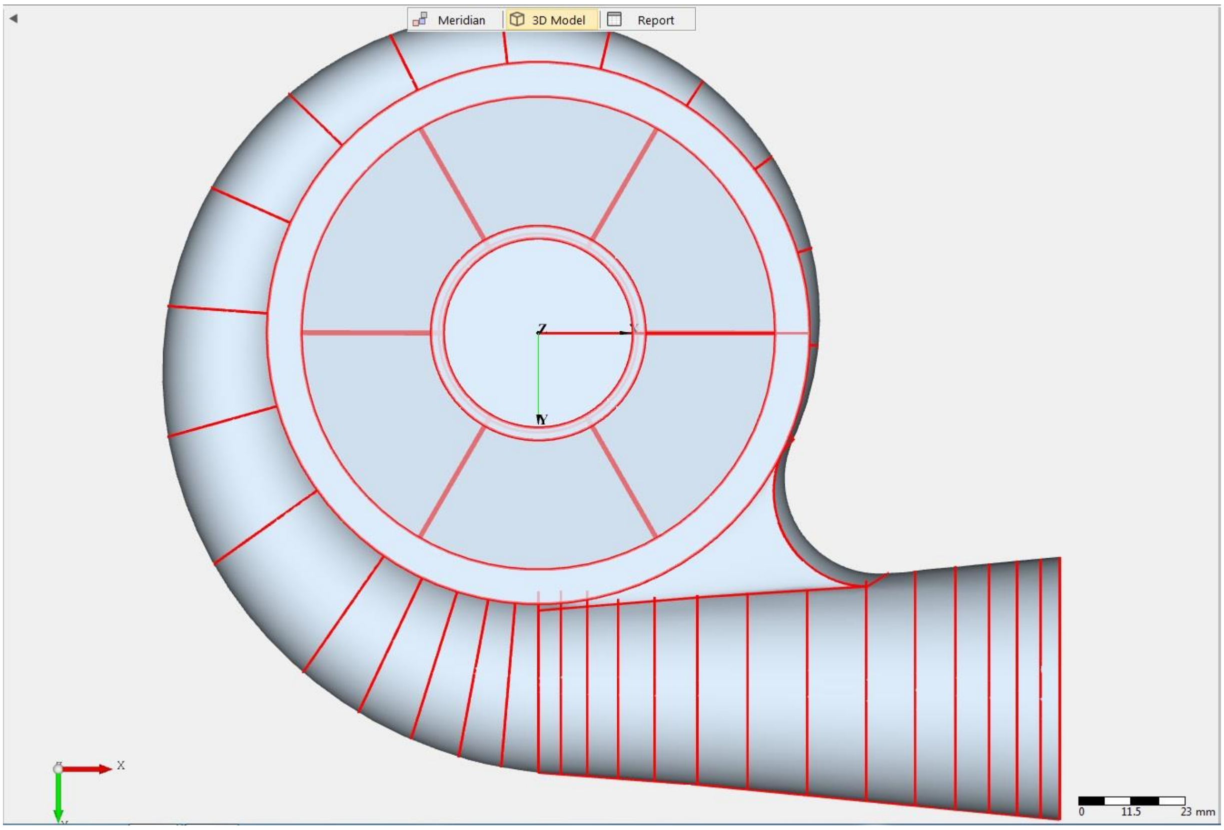
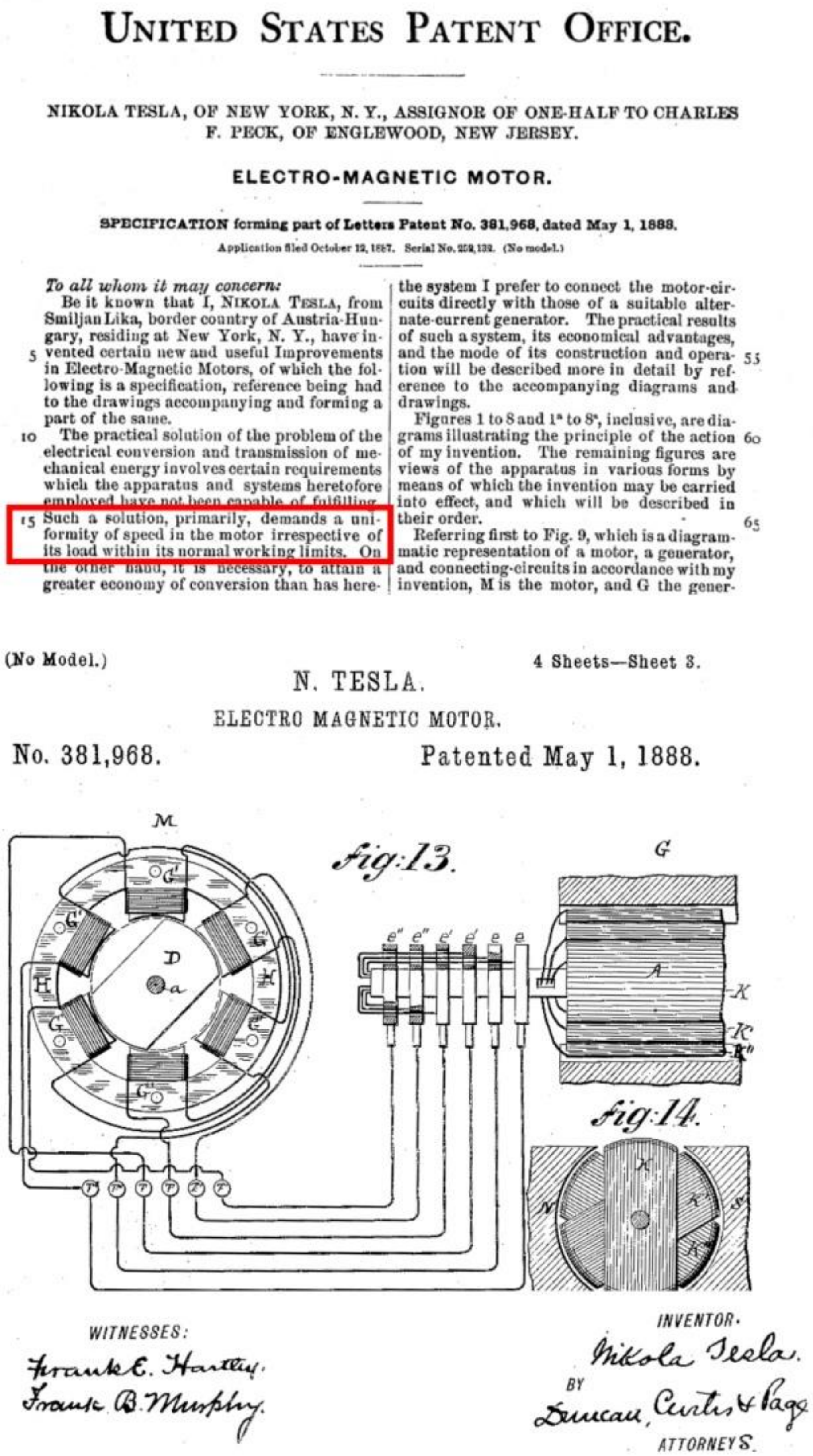


Figure 9. CFturbo 2020 R2.0 software. Selection in 3D modeling, Z axis. Source: Own elaboration.

After its simulation in three dimensions (3D), the physical construction of the product and its parts was carried out. 3D simulation is generally used as a procedure, among other things, to save money and experimental time; to correct variables such as dimensions, volumes, sizes, assemblies between parts and pieces, relationships of form and function, aspects that are not only functional and aesthetic, but also ergonomic, etc. This is analyzed in the next stage of prototype fabrication.

The central idea of the technological innovation (R+D+i) of Energy Efficiency (EE), is inspired by line no. 15 of invention patent no. 381968 of the electrical engineer Nikola Tesla, dated May 1, 1888 (inventor of the alternating current system that today is used throughout the world), in effect as cited in point n° 15 of the aforementioned patent: *"15: Such a solution, mainly, requires a uniformity of speed in the motor regardless of its load within its normal working limits"* (Tesla, 1887: US381968A) [26].



UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y., ASSIGNOR OF ONE-HALF TO CHARLES F. PECK, OF ENGLEWOOD, NEW JERSEY.

ELECTRO-MAGNETIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 381,968, dated May 1, 1888.

Application filed October 12, 1887. Serial No. 252,132. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, from Smiljan Lika, border country of Austria-Hungary, residing at New York, N. Y., have invented certain new and useful Improvements in Electro-Magnetic Motors, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The practical solution of the problem of the electrical conversion and transmission of mechanical energy involves certain requirements which the apparatus and systems heretofore employed have not been capable of fulfilling. Such a solution, primarily, demands a uniformity of speed in the motor irrespective of its load within its normal working limits. On the other hand, it is necessary, to attain a greater economy of conversion than has here-

the system I prefer to connect the motor-circuits directly with those of a suitable alternate-current generator. The practical results of such a system, its economical advantages, and the mode of its construction and operation will be described more in detail by reference to the accompanying diagrams and drawings.

Figures 1 to 8 and 1a to 8a, inclusive, are diagrams illustrating the principle of the action of my invention. The remaining figures are views of the apparatus in various forms by means of which the invention may be carried into effect, and which will be described in their order.

Referring first to Fig. 9, which is a diagrammatic representation of a motor, a generator, and connecting-circuits in accordance with my invention, M is the motor, and G the gener-

(No Model.) 4 Sheets—Sheet 3.

N. TESLA.

ELECTRO MAGNETIC MOTOR.

No. 381,968. Patented May 1, 1888.

Figure 10. Photomontage made with the images and texts of the Tesla patent, to indicate where the inspiring idea was obtained, own creation based on the patent. After the years of legal protection, the patent is of free utility to mankind. Detail of line nº 15 of the invention patent No. 381,968 of the

electrical engineer Nikola Tesla and his drawing, dated May 1, 1888 (father of the world alternating current system). Source: Tesla, 1887: US381968A.

But the patent of the invention here innovated, not in conventional a-synchronous induction motors (as originally proposed by Tesla), but in PMSM/IPM (Permanent Magnet Synchronous Motor/Interior Permanent Magnet) type synchronous motors; to increase the energy efficiency (EE) of motor performance without the need for complex electronics such as variable frequency drives (VFDs) or variable speed drives commonly used in induction motors.

A synchronous machine is an alternating current rotating electrical machine whose speed of rotation in permanent regime is linked to the frequency of the voltage at the terminals and the number of pairs of poles. The speed variation problem has been solved by altering the "scalar control" of the Law of Command; that is, keeping the voltage/frequency relationship (Volts/Hertz) non-constant. The principle was solved by electromechanical means, physically more resistant to work and with less generation of harmonics than an electronic design with Triac. Which constitutes a study prior to the development of another prototype, antecedent of this development, where the use of electronics was analyzed [16, 17].

How motors produce torque due to flux in their rotating field. When operating below its base speed, torque is delivered by keeping the voltage/frequency ratio (Volts/Hertz) applied to the motor constant. This is what VFDs do to regulate speed while maintaining torque. So if the speed of the motor is reduced, because the voltage drops, the frequency must drop for the voltage/frequency ratio to remain constant. If the Volts/Hertz ratio is increased by reducing the frequency to slow the motor, the current will increase and become excessive. If, on the other hand, the Volts/Hertz ratio is reduced by increasing the frequency to increase the speed of the motor, the torque capacity will be reduced.

But in the design proposed here, the Volts/Hertz ratio is not constant and we reiterate that the decrease in torque does not affect the normal operation and/or work of the motor; on the contrary, it reduces the vibrations, the decibels (not measured), and consequently the increase in temperature of the parts and/or mechanical parts of the electrical machine due to the transformation of electromechanical energy into thermal energy is reduced. Which results in an improvement in Energy Efficiency (EE).

Since the motor operates with a light load (air fluid), the Volts/Hertz ratio can be reduced to minimize the motor current, and since a lower voltage is applied, the magnetizing current is reduced and consequently, a lower current is produced as well. The lower torque is still tolerable by the engine.

As stated, reducing the Volts/Hertz (V/Hz) ratio with increasing frequency to increase motor speed will reduce torque capacity. Indeed, although the motor torque decreased, what is truly surprising is that for the load (propellers connected to the motor shaft) the rotational speed (RPM) of the six (6) blades connected to the rotor shaft did not decrease (verifying what he said Nikola Tesla in line nº 15 of his patent: US381968A of 1887); therefore, the capacity to perform mechanical work (Joules) on the fluid air did not decrease (although he was referring to a-synchronous and non-synchronous induction motors, such as the one proposed in this development). This is technological innovation.

The motor presents a drop in the nominal power of the motor of 17,7 (Watts) with the Energy Efficiency (EE) circuit "off", when "turning it on" it was reduced to 6,3 (Watts), in the total of the circuit RCL. Without losing speed in the rotation of the rotor (6 radial blades); that is, without reducing the capacity to perform mechanical work (Joules) on the blades of the centrifugal turbine. This is known as energy efficiency (EE).

Since the motor runs on a light load (air fluid), the Volts/Hertz ratio can be reduced to minimize motor current; and because a lower voltage is applied, it is also possible to reduce the magnetizing current and consequently produce a lower torque which is still optimal for normal operation of the motor (taking it to the limit of its operable physical capabilities as

you described in his Nikola Tesla patent). Keeping the voltage/frequency ratio not constant, although with a decrease in torque.
That is why, with the aim of obtaining a voltage wave (Volts) and current intensity (Amps) attenuator, which works as a limiter of the electric current as well as an EMI (ElectroMagnetic Interference) filter of low-pass type (LPF); the Energy Efficiency (EE) circuit was designed with passive elements whose topology is inductive-capacitive: LC.
In the design proposed here, the inductor "L" is connected in series and the capacitor "C" is connected in parallel", forming an LC design for the low-pass filter, which reduces the ripple ripple in the input voltage. output and produces a drop in the average input voltage (Vavg).
The innovation here lies in the fact that the first-order linear filter circuit analysis has a cutoff frequency ($\omega c=1/LC$) of the inductive-capacitive type that works by analogy to a resistive-capacitive one, that is ($\omega c=R/L$). Since we can assume that in the inductor the inductive-reactance operates simultaneously as a resistance that reduces the flow of electric current (Amps) with the consequent voltage drop (Volts) from the output to the load and as an energy storage tank in the form of a magnetic field that is returned to the network for consumption; while in the capacitor the capacitive-reactance stores the energy in the form of an electric field, both linear circuits filter the harmonics present in the sinusoidal wave of the alternating current.
The importance of using an inductive reactance has a double meaning: (a) as a passive component of the low pass filter (LPF), since it reduces the ripple ripple in the output voltage by acting as a harmonic filter and subsequently; (b) produces a drop in the average input voltage (Vavg), that is, it produces a voltage drop from 220 (Volts) to 110 (Volts), which in the calculation of the active power formula will produce a drop in the engine power (no loss of RPM or engine speed). That is, without affecting its ability to perform mechanical work (Joules).

Prototype manufacturing stage.

The activities carried out for the construction of said prototype, of a centrifugal air blower for civil and commercial (non-industrial) use, were the following.
According to NEMA (National Electrical Manufacturers Association), the synchronous motor that they decided to build is of the PMSM/IPM type with ceramic magnets inserted tangentially in the rotor. The magnets are ceramic ferrite with a magnetic field of 2000 to 4000 (Gauss) or 0,2 to 0,4 (Tesla), the cheapest on the market; interacting with a stator of 482 (Ω) impedance (Z). In the future, it is planned to replace ferrite magnets with neodymium rare-earth magnets (Nd2Fe14B) between 11000 and 14000 (Gauss) or 0,2 to 0,4 (Tesla) magnetic field strength; which is a key factor to increase energy efficiency.
The activities carried out for the construction of the prototype were: (a) coupling a synchronous or self-excited motor type PMSM/IPM obtained from the rotor-stator of a dishwasher electric pump of 65 (watts) of nominal power; connecting it to (b) the six radial blades of the impeller obtained from a rotor of a shaded-pole asynchronous motor (frager's coil or short-circuit coil) of a hair dryer. In this preliminary experimental stage, only an experimental prototype (verifiable) was thought of, before obtaining a minimum scalable product for industrial production for commercial-single-phase use.
The control achieved with the design of an LC circuit consisting of a capacitive reactance and an inductive reactance are responsible for processing the binomial expression of the impedance ($Z=A+jB$). The capacitive reactance is obtained from a 3 (μF) capacitor connected in parallel to the two phases of the 220 (V) and 50 (Hz) single-phase alternating current (AC) source of emf (electromotive force) and whose function is power factor correction (cos phi). The inductance is obtained from a coil analogous to a 48 (Ω) magnetic ballast connected in series to one of the phases of the source of emf (electromotive force), whose function is to limit the passage of current or intensity (Amps) that passes through it (due to its inductive reactance),

Finally, the conventional prototyping of a single-phase alternating current (AC) 220 (Volts) and 50 (Hz) 2-pole PMSM/IPM synchronous motor with a volute made of GFRP (Glass-Fiber Reinforced Plastic) composite material was completed and six (6) 105 (mm) diameter blades, with the exact dimensions of a microwave fan.
Therefore, the invention belongs to the technical field of starting control in PMSM/IPM electric motors and provides a method for the motor-system to control the starting of the outer radial blades of the centrifugal fan/air extractor and its subsequent energy efficiency (EE).
The starting method includes: (1) a start at rated motor power of 17,7 (Watts) active power and, (2) a step to the EMI-LC filter activated by the SPDT switch at 6,6 (Watts) active power in total that make up the RLC set (capacitor + inductor coil + motor stator).

Results and Discussion.
This proof or testing stage will end up confirming (affirming) as "true" line 15 of invention patent n° 381968 by Nikola Tesla, dated 5/1/1888 (which forms the electro-mechanical design hypothesis with which this job was initially run). As anticipated in the introduction.
The load on the motor shaft is the centrifugal blades, whose value is expressed in ω, which is the angular speed measured in radians/second: 314,159 (rad/s). Equivalent to 3000 revolutions per minute (RPM) obtained by the converter from (rad/s) to (RPM). Said 3000 (RPM) correspond to a frequency of 50 (Hz).
The formula for the average active power (Pmed), in a general alternating current (AC) RCL circuit, is equal to the product of the effective voltage (Vrms), by the effective intensity of the electric current (Irms), multiplied by the factor of power or cos phi: cos (Φ).
Exactly, according to some classic authors of physics, electricity and magnetism: *"Pmed = ½.V.I.cos (Φ) = Vrms.Irms.cos (Φ)"* (Sears-Zemansky, 2009:1076). Values that were taken with the corresponding instruments of true effective value or RMS (Root Means Square).
Then, considering the stability of the frequency (Hz) of the alternating current (AC), which in the Argentine Republic is 50 (Hertz), which ensures a constant rotation at 3000 RPM (revolutions per minute) of the motor shaft. If the pole pair of the synchronous machine is equivalent to two (2) poles (north-south) in the stator. Being p=2, the number of poles used in the design of the prototype -according to authors in the field of electrical machines- has the following formula:

The rotor and stator always have the same number of poles (...), the number of poles determines the synchronous speed of the motor: ns = 120 . f/p
Where:
ns = motor speed (r/min)
f = source frequency (Hz)
p = number of poles (Wildi, 2019: 379)

Characterized by the following formula:

$$ns = \frac{120.f}{p} = \frac{120.50}{2} = \frac{6000}{2} = 3000\ (RPM)$$

As mentioned earlier:
F: Frequency of the network to which the machine is connected (Hz).
p: Number of poles that the machine has.
ns: Machine synchronous speed or revolutions per minute (RPM).
Calculation with which the constant data of the revolutions per minute (r/min or RPM) are obtained, according to the frequency of the current in the Argentine Republic: ns = 120.50

(Hz)/2 = 3000 (r/min), or 3000 (RPM). The rotor, unlike asynchronous machines, rotates without slip at the speed of the rotating field.
The 3000 (revolutions/minutes) or 3000 (RPM), as indicated above, is a consequence of the frequency of the alternating current (AC). As the motor is PMSM type; the poles (north-south) of the rotor magnets are aligned with the poles (south-north) of the stator (through which the single-phase alternating current flows), synchronously following the speed of rotation.
We had previously argued that the centrifugal motor presented here does not decrease its rotor revolutions per minute (RPM), when the active power consumption is reduced; decreasing the active power (Watts), ergo: your active energy consumption (kWh) decreases. But it had been noted that the same did not happen with torque, since it drops to the minimum limit, without affecting the capacity of the rotor blades to perform mechanical work (Joules) on the air.
In the International System of Units (SI), the unit of torque (also called: motor torque) is the physical quantity: Newtons.meters (abbreviated: Nm). Torque is the moment of a force exerted on the power transmission shaft (rotor). According to certain authors, by the rotational power formula we know that: "$P=.\omega.\tau$"(Tipler-Mosca, 2006:265).
Where each algebraic symbol means:
P, is the power (measured in Watts).
τ, is the motor torque (measured in N.m). Represented by the letter of the Greek alphabet: tau.
ω, is the angular velocity (measured in rad/s). Represented by the letter of the Greek alphabet: omega.
In both situations (without inductive reactance and with inductive reactance connected in series to one of the phases), the angular speed ω (represented by omega), or speed of rotation measured in radians/second (rad/s) is the same: 314,159 (rad/s). Equivalent to 3000 (RPM) obtained by the alternating current frequency of 50 (Hz).
Analyzing the power values at the motor input, only of the motor and not of the total RCL circuit, we obtain the following values with the Energy Efficiency (EE) circuit: "off" and "on". Solving for the motor-torque (tau) or torque, we obtain the following values: 0,057 (Newtons*meters) with the key "off" and 0,025 (Newtons*meters) with the key "on".

Table 3. Torque table (represented by the letter of the Greek alphabet: tau) or torque measured in Newtons.meters (N.m), from the calculation of power/angular speed (Watts)/(Rad/s): $\tau = P/\omega$. Source: self made.

Key (S3) to the R-C-L circuit Energy Efficiency (EE)	**active power (Watts)**	**Torque (Newtons.meters)**
Key (S3) "off"	18	0,057
Key (S3) "on"	7,9	0,025

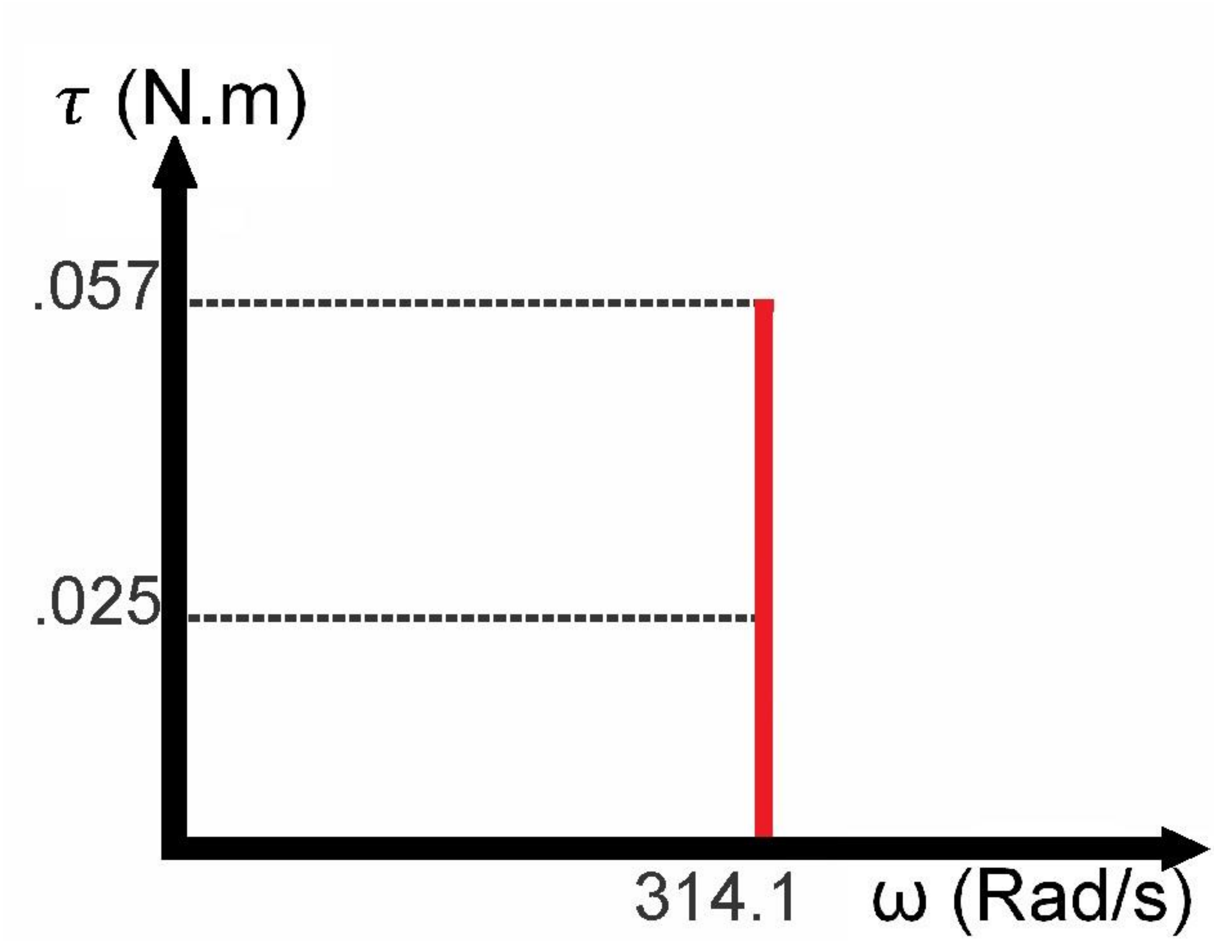


Figure nº 11. Graph of the torque-speed curve, where the synchronous speed ω=314,159 (Rad/s) of the rotor as a function of the minimum torque of τ=0,025 (N.m) and the maximum torque of τ=0,057 (N.m). Remembering that the speed of rotation of a synchronous motor is directly proportional to the frequency of the network in which it is connected to 50 (Hz). Being: 314,159 (Rad/s)=3000 (RPM). Source: self made.

According to the *"Fan affinity law"* specified in the UNE 100-230-95 standard, the power absorbed by a fan with an asynchronous motor varies with the cube of its speed. This means that for a small variation in speed of rotation, the power is modified considerably. This has great implications from the point of view of energy efficiency (EE) since by reducing the speed of rotation of the centrifugal fan blades by 23,7% (measured in revolutions per minute), the mechanical power (measured in watts) supplied to the ventilator is reduced by 56%. Power (W) and speed (RPM) variables determined according to International Standards ISO 5801-96(E) and WD 13348-1998.
Considering that the "Fan Affinity Law" applies to a-synchronous motors and does not apply to synchronous motors, such as the one used in the project; the energy efficiency (EE) advantage is notably higher (and impossible to compare since there is no International Standard that establishes such comparison parameters). Given that in the conventional a-synchronous motor (single-phase induction) the speed of rotation of the blades should be reduced by 23,7% for a reduction of 56% of the active power (Watts) of the motor; here the speed is not reduced because the motor is synchronous and maintains the 3000 (RPM) as a consequence of the frequency of the alternating current: 50 (Hz).
Which, on the other hand, induced the motor to operate by reducing the Volts/Hertz ratio and decreasing the torque of the motor and its ability to provide constant power output.

How motors produce torque due to flux in their rotating field. When operating below its base speed, torque is carried out by keeping the voltage/frequency ratio (Volts/Hertz) applied to the motor constant. This is what VFDs (Variable Frequency Drives) do to regulate speed while maintaining torque. So if the speed of the motor is reduced, because the voltage drops; the frequency must drop so that the voltage/frequency ratio remains constant and the motor core does not become saturated, generating harmonic distortion (THD).

Table 1. The data of the PMSM/IPM type synchronous motor calculated by formulas and data extracted by laboratory instruments (with the energy efficiency system "off") are detailed below in the following table with their respective formulas, values and units physical. Source: self made

Denomination	**Formula**	**Worth**	**Units**
active power	$P = V_{rms}.I_{rms}.\mathrm{Cos}\,\emptyset$	17,7	(W) : Watts
effective tension	$V_{RMS} = \frac{V_{pico}}{\sqrt{2}}$	220	(V) : Volts
effective current	$I_{RMS} = \frac{I_{pico}}{\sqrt{2}}$	0,456	(A) : Amps
Power factor (cos phi)	$\mathrm{Cos}\,\emptyset$	0,17	(fdp)
Reactive power	$Q = X_L.I_{RMS}{}^2$	98,73	(VAr) : Reactive Volt-Amps
Apparent power	$S = V.I$	100,32	(VA) : Volt-Amps
Total impedance RL	$Z_{RL} = \frac{V_{RMS}}{I_{RMS}}$	482,4	(Ω) = Ohms
Endurance	$R = \frac{P}{I_{RMS}{}^2}$	85,12	(Ω)
inductive reactance	$X_L = \sqrt{Z^2 - R^2}$	474,83	(Ω)
Total impedance RL	$Z_{RL} = \sqrt{R^2 + (2.\pi.f.L)^2}$	481,93	(Ω)
Angular frequency (beats)	$\omega = 2.\pi.f$	314,159	(Rad/S) : Radians/Seconds
network frequency	f	fifty	(Hz) : Hertz
Inductance	$L = \frac{X_L}{2.\pi.f}$	1,51	(H) : Henrys
Phase shift between total voltage and total current$(V_T)(I_T)$	Inductive circuit, the voltage leads the current.	79,82 (º) 1,39 (rad)	(º) : Degrees (Rad) : Radians
Impeller blade speed	$ns = \frac{120.f}{p}$	3000	(RPM) : Revolutions per minute

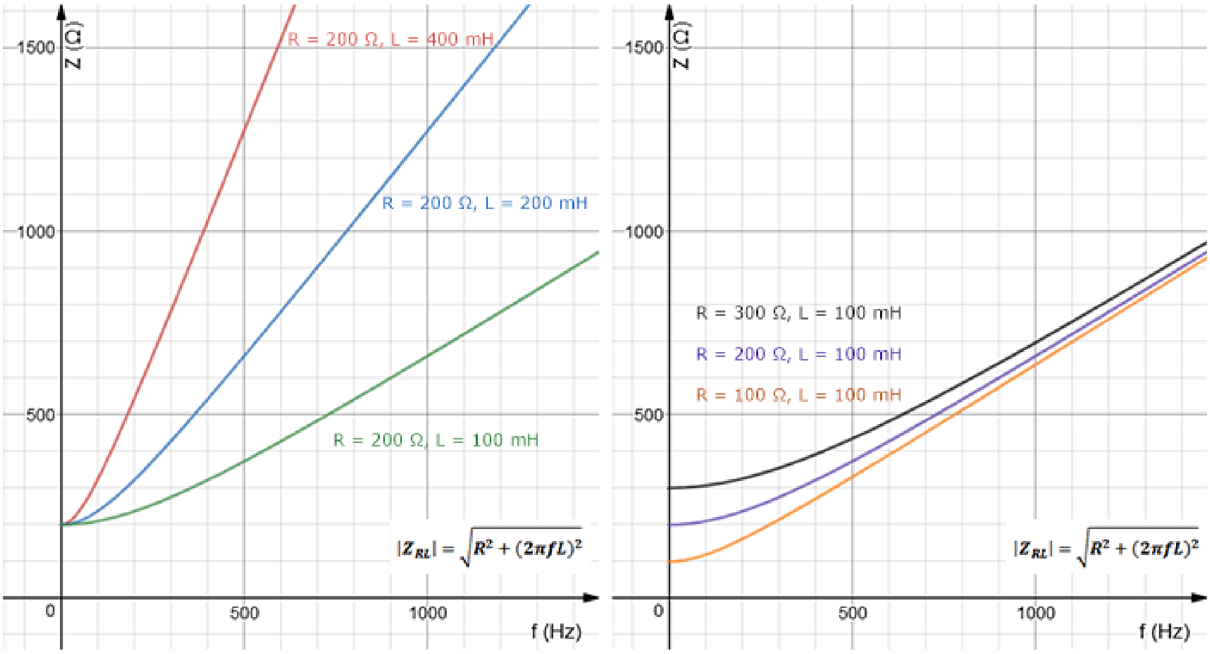


Figure nº 12. A plot of the series RL circuit ZRL impedance against frequency f for a given inductance and resistance

PMSM type motors provide shaft rotation at a fixed speed in synchronism with the frequency of the power supply regardless of the fluctuation of the mechanical load – greater or lesser – that produces resisting torque. The voltage (Volts) and intensity (Amperes) of the current decrease when the inductive reactance (Z1) acts together with the capacitor (C1); and the motor runs at synchronous speed anyway, as long as the mains frequency is constant, in this case 50 (Hz) for any torque up to the motor's operating limit.

This joint effect is achieved by the combined work of the impedance (Z1) in series with one phase plus the capacitor (C1) in parallel with the two phases.

A perfect inductor would generate no Joules losses, limiting the current through the inductor without resulting in lower efficiencies. In reality, an inductor has some internal resistance, and consequently Joule effect losses are minimized but not eliminated. But used in the energy efficiency (EE) system design for the motor, its reactance limits the available current with minimal power losses in the inductor. The ballast is commonly known as reactance, since due to the alternating current the coil presents an inductive reactance.

Impedance (Z) is a measure of the opposition a circuit presents to a current when a voltage is applied. Impedance extends the concept of resistance to alternating current (AC) circuits, and has both magnitude and phase, unlike resistance, which only has magnitude. When a circuit is powered with direct current (DC), its impedance is equal to the resistance, which can be interpreted as the impedance with zero phase angle.

By definition, impedance (Z) is the ratio (quotient) between the voltage phasor and the current phasor.

In electronics and electrical engineering, reactance is the opposition offered to the passage of alternating current through inductors (coils) and capacitors (capacitors), it is measured in ohms and its symbol is (Ω). Together with the electrical resistance, they determine the total impedance of a component or circuit, in such a way that the reactance (X) is the imaginary part of the impedance (Z) and the resistance (R) is the real part, according to the following equality:

$Z = R + jX$, binomial representation.

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When alternating current flows through one of the two elements that have reactance, the energy is alternately stored and released in the form of a magnetic field, in the case of coils, or an electric field, in the case of capacitors.

However, real coils and capacitors have an associated resistance, which in the case of coils is considered to be in series with the element, and in the case of capacitors in parallel. In those cases, as already indicated above, the impedance is (Z).

When the inductive reactance (Z1) its value is Z=48 (Ω) it is activated with the key (S3), said reactance is in charge of processing the binomial expression of the impedance (Z=A+jB); where (A=Resistance) is the real part, (j) is the imaginary unit and where (B=X) is the reactance in ohms, it causes the motor input voltage to drop from 220 (V) to 97 (V) and the current drops from 0,6 (A) to 0,105 (A). But the synchronous speed of the motor shaft connected to the six (6) radial blades of the impeller do not lose speed. Which demonstrates energy efficiency (EE).

The incorporation of the inductive reactance (Z1) in one of the phases, which has improved the power factor or cos phi, from 0,22 to 0,41 and without the capacitor (C1) (which meant a considerable increase or improvement in the energy efficiency). With the capacitor connected, this value rises from 0,17 to 0,81 and can still be improved closer to 0,99 by changing the capacitor to 2,5 (μF).

The testing was carried out on a test bench, designed for this purpose, with two (2) oscilloscopes -one analog and one portable digital- to observe and quantitatively and qualitatively measure the waveform (signal harmonic distortion: THD), peak-to-peak voltage wave signal meter (Voltsp-p), true effective value (or True RMS) of the average voltage (AVG) or average voltage (Vavg). With a digital multimeter that measures voltage (Vrms), a frequency meter that measures alternating current oscillation (Hz), an amperometric clamp that measures amps (A), a cometer that measures the cosine of phi (cos Φ), a wattmeter that measures power active in watts (W),

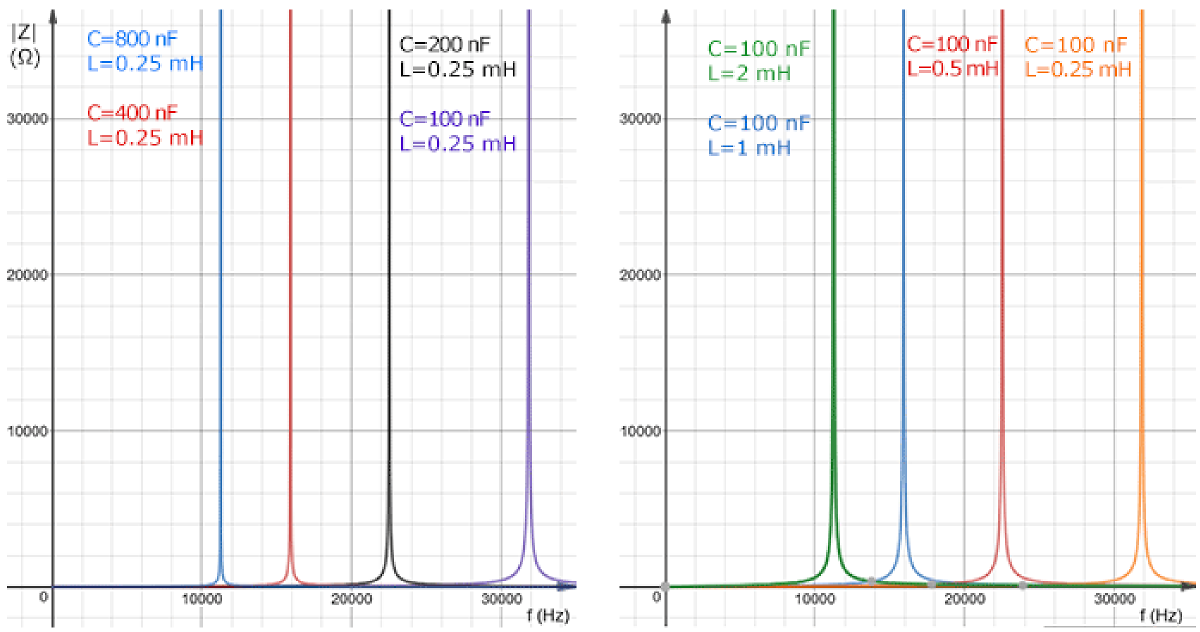

Figure nº 13. A plot of ZLC impedance against frequency f of several parallel LC circuits for a given inductance and capacitance shows infinitely large impedance at resonant frequencies.

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Table 2. PMSM/IPM type synchronous motor values calculated by formula and other data obtained by laboratory instruments are detailed below in the following table (with the energy efficiency system "on") with their respective formulas, values and physical units . Source: self made.

Denomination	**Formula**	**Worth**	**Units**
active power	$P = V_{rms}.I_{rms}.\text{Cos}\,\emptyset$	6,3	(W) : Watts
effective tension	$V_{RMS} = \frac{V_{pico}}{\sqrt{2}}$	110	(V) : Volts
effective current	$I_{RMS} = \frac{I_{pico}}{\sqrt{2}}$	0,106	(A) : Amps
Power factor (cos phi)	$\text{Cos}\,\emptyset$	0,8	(fdp)
Reactive power	$Q = \text{Sen}\,\emptyset.\ \frac{P}{\text{Cos}\,\emptyset}$	4,725	(VAr) : Reactive Volt-Amps
Apparent power	$S = \sqrt{P^2 + Q^2}$	7,875	(VA) : Volt-Amps
Total impedance RL	$Z_{RL} = \frac{V_{RMS}}{I_{RMS}}$	482,4	(Ω) = Ohms
Endurance	$R = \frac{P}{{I_{RMS}}^2}$	85,12	(Ω)
inductive reactance	$X_L = \sqrt{Z^2 - R^2}$	474,83	(Ω)
capacitive reactance	$X_c = \frac{1}{2.\pi.f.C}$	1,061	(kΩ) : Kilohms
Total LC Impedance	$Z_{LC} =$	857,97	(Ω)
Angular frequency (beats)	$\omega = 2.\pi.f$	314,159	(Rad/S) : Radians/Seconds
network frequency	f	50	(Hz) : Hertz
Inductance	$L = \frac{X_L}{2.\pi.f}$	1,51	(H) : Henrys
Capacitance	$C = \frac{1}{\omega.X_c}$	3	(μF) : Microfarads
Phase shift between total voltage and total current$(V_T)(I_T)$	Inductive circuit, the voltage leads the current.	90 (º) 1,5708 (rad)	(º) : Degrees (Rad) : Radians
Impeller blade speed	$ns = \frac{120.f}{p}$	3000	(RPM) : Revolutions per minute
resonance frequency	$f = \frac{1}{2\pi\sqrt{L.C}}$	74,77	(Hz) :Hertz

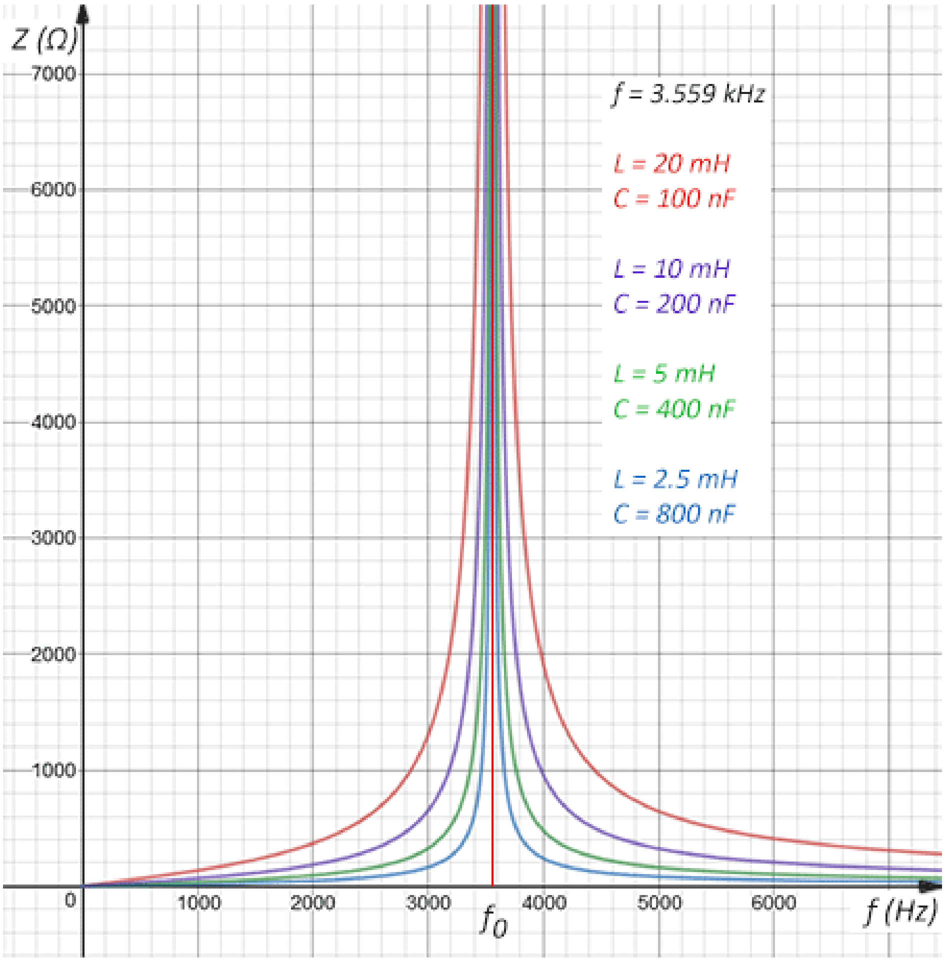

Figure nº 14. A plot of ZLC impedance versus frequency f of several ideal parallel LC circuits for a given inductance and capacitance; the resonant frequency 3.559 kHz is the same for all LC circuits

An LC Circuit, also called a resonant circuit or LC oscillator, is an electrical circuit formed by a coil, represented by the letter L, and a capacitor, represented by the letter C, which are connected to each other. The circuit acts as an electrical resonator, like an electrical analogy to a tuning fork, based on the storage of oscillating energy at the resonant frequency of the circuit.

LC circuits are used to generate signals at a specific frequency, or to select a signal of a specific frequency from a more complex signal; This function is called a band pass filter. They are fundamental components in many electronic devices, particularly radio equipment, where they are used in circuits such as oscillators, filters, tuners, and frequency mixers.

An LC circuit is an idealized model, since it is assumed that there is no power dissipation due to no electrical resistance. Any practical implementation of an LC will always have losses due to a small resistance (which is not equal to zero), between the components and the connection cables. Even though circuits in real life will have losses, it is important to study this circuit model to understand the phenomenon and have physical intuition. For a circuit model that includes resistance, please see the RLC circuit.

Here are some images (photos) and experimental illustrative descriptions.

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Figure nº 15. Test bench connected to SARS-CoV-2 or Covid-19 (Coronavirus) stale air extractor/centrifugal blower motor: Turbo. With digital multimeter (volt meter in AC), clamp meter (current intensity meter in AC), frequency meter (Hertz meter), laser photometer (speed meter in RPM), digital oscilloscope waveform meter the alternating current in voltage (Vpeak-peak, Vavg, Vrms), to calculate the harmonic distortion crest factor, analog oscilloscope for qualitative observation of the THD (harmonic distortion of the alternating current), wattmeter (active power meter in watts or watts), power factor (cosine phi), power-meter (active energy consumption meter in kilowatt-hours: kwh). Source: Own elaboration.

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Figure nº 16. View of the frequency meter turned on indicating the 50 (Hertz) of the alternating current (AC), next to the digital multimeter (voltmeter) turned off. Source: Own elaboration.

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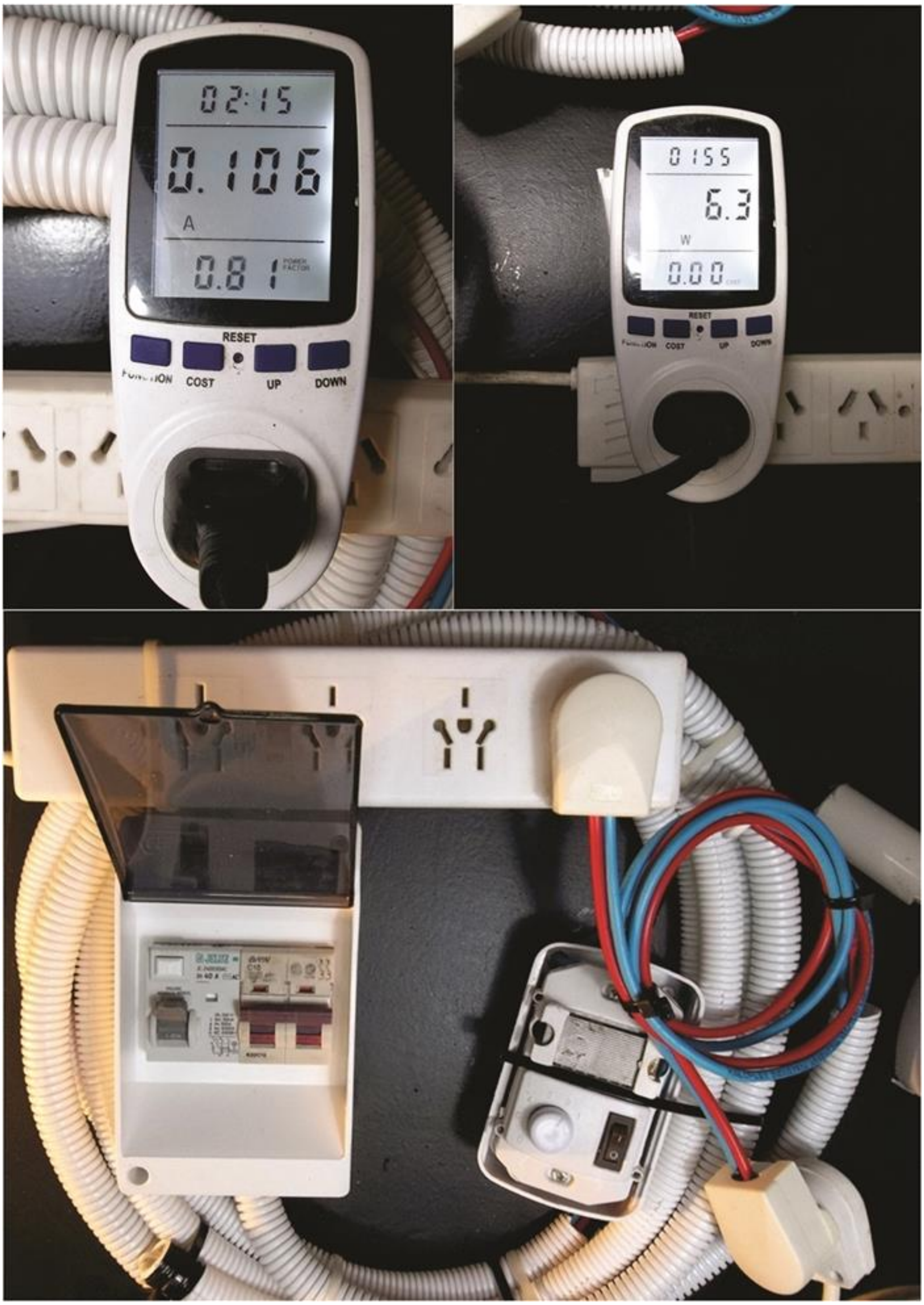

Figure nº 17, 18 and 19. Top left, tested PMSM/IPM type synchronous motor with energy efficiency (EE) circuit on. Active power 6,3 (watts) in all R-C-L circuit. Top right, power factor (f.d.p.) equivalent to 0,81 (cosine Φ). Below, detail of the electrical connections of the thermal switch and the differential circuit breaker of the test bench and the inductive reactance connected in series to one phase, inside it together with the capacitor in parallel to the two (2) phases at the coupling point

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(downstream). The parallel capacitor connected to the two phases is linked to the inductive-reactance in series to one of the phases, which is the secret of the operation of the PMSM/IPM synchronous motor with low energy consumption and high Energy Efficiency (EE); its secret is kept for the claim according to the Patent Law Nº 24481 modified by its similar Nº 24572 (to 1996) and its Regulations (not shown to preserve novelty and no prior disclosure). Source: Own elaboration.

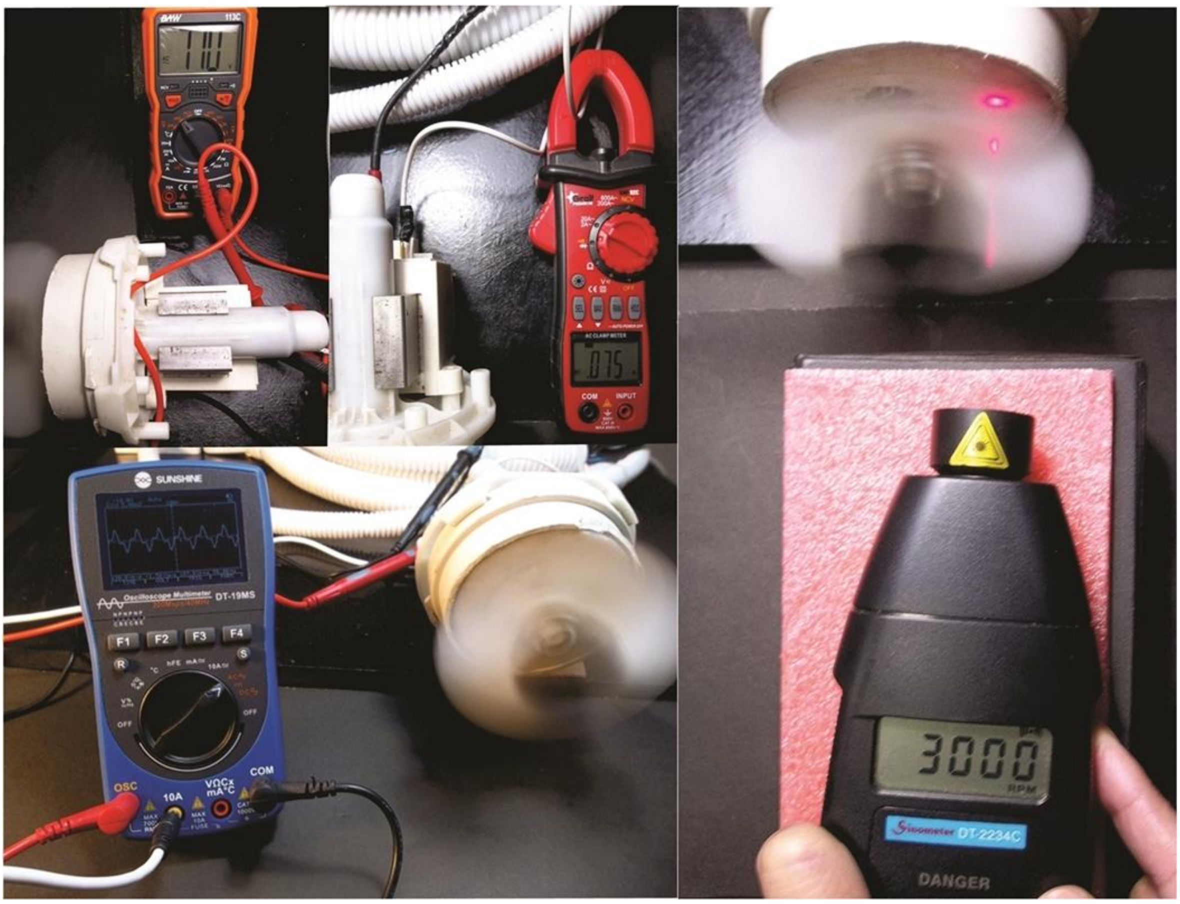

Figure nº 20, 21, 22 and 23. PMSM/IPM type synchronous motor connected to the oscilloscope showing the non-linear voltage waveform, also connected to the digital multimeter showing the voltage drop of 110 (volts), and to the amperometric clamp showing the drop in current flow electrical to 0.075 (amps) and the constant in the speed of the blade to 3000 (RPM). Source: Own elaboration.

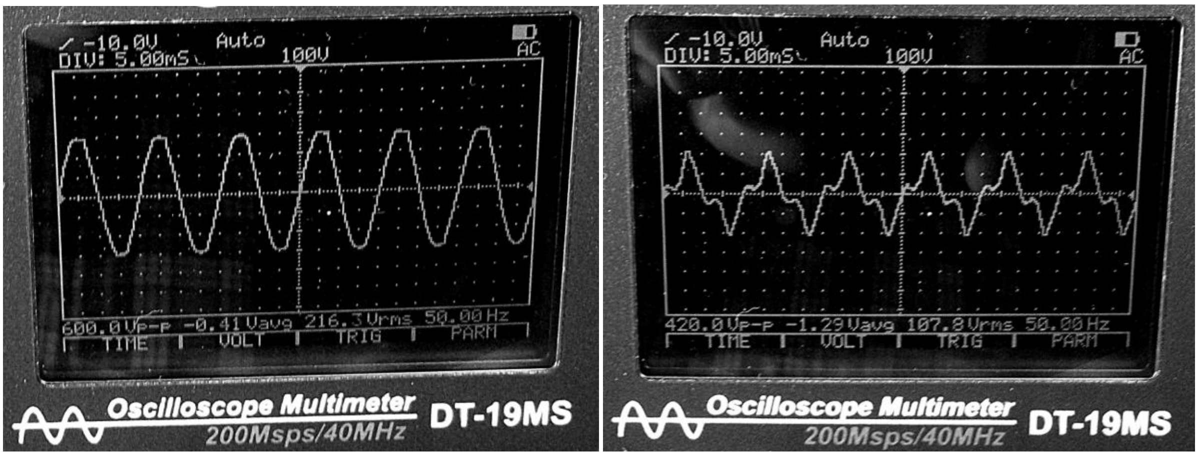

Figure nº 24 and 25. Enlargement of the image observed in the oscilloscope, the wave signal is perfectly sinusoidal when it is not connected to the Energy Efficiency (EE) system. No presence of

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harmonics (THD) are observed. Peak voltage 600 ($Volts_{peak}$) y 216 (V_{RMS}), 50 (Hz). The basic equipment used for the analysis of non-sinusoidal voltages and currents is the oscilloscope. The graph of the waveform on the oscilloscope provides immediate quantitative information about the degree and type of distortion; Sometimes resonance cases are identified through the visible distortions that are present in the voltage and current waveforms. No harmonic distortion is observed. Source: Own elaboration. The crest factor (CF) is an indication of harmonics caused by the non-linear load connected to the inductive-reactor power control in series to one of the phases, which demands a distorted or non-sinusoidal current. . For a current and voltage measurement, the crest factor value is (CF)=1,9. Source: Own elaboration.

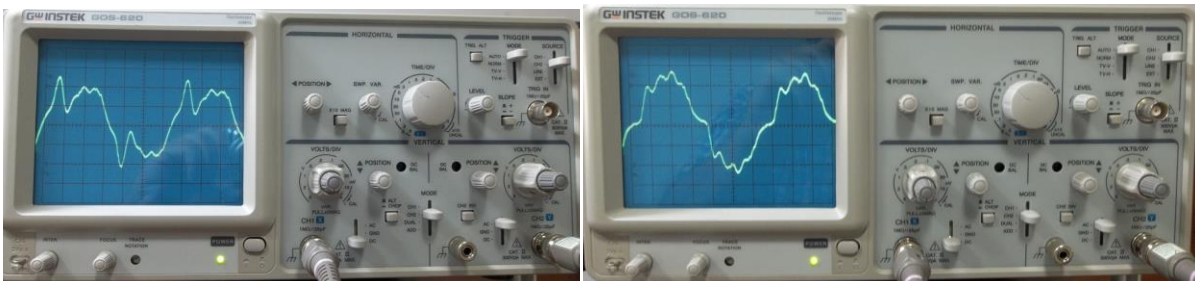

Figure nº 26 and 27. To observe the harmonic distortion (THD) of the alternating current, upstream of the energy efficiency RL circuit, an AC step-down transformer was used without filtering at the output of the capacitive-inductive reactance. The oscilloscope image above shows the waveform without filtering, and the waveform filtered with an EMI (ElectroMagnetic Interference) low-pass filter (LPF) with passive elements is observed in the image below. Source: Own elaboration.

Magnifying the image observed in the oscilloscope the wave signal is perfectly sinusoidal when not connected to the Energy Efficiency (EE) system. No presence of harmonics (THD) are observed. Peak voltage 600 ($Volts_{peak}$) and 216 (V_{RMS}), 50 (Hz). The basic equipment used for the analysis of non-sinusoidal voltages and currents is the oscilloscope. The graph of the waveform on the oscilloscope provides immediate quantitative information about the degree and type of distortion; Sometimes resonance cases are identified through the visible distortions that are present in the voltage and current waveforms. No harmonic distortion is observed.
The crest factor (CF) is an indication of harmonics caused by the non-linear load connected to the inductive-reactor power control in series to one of the phases., which demands a distorted or non-sinusoidal current. For a current and voltage measurement, the crest factor value is (CF)=1,9.

The data of the value of the crest factor (CF) was calculated with the following formula:

$$CF = \frac{V_{peak}}{V_{rms}} = CF = \frac{420\ (Volts_{peak})}{2} = 210\ (Volts) \rightarrow \frac{210\ (Volts)}{107.8\ (Volts_{RMS})} = 1{,}948$$

Conclusions.
The non-smooth start of the motor, at the beginning of its ignition, is due to the need for the rated active power of the static starting torque required by the mass of the load (radial blades connected to the rotor shaft) that must be accelerated. Non-soft start does not save energy due to the initial power demand of the motor at start-up; but this only lasts for an instant (2-3 seconds), once the 3000 sync speed (RPM) is reached, it is manually switched to Energy Efficiency (EE) mode. Mode change to Energy Efficiency (EE) is achieved via mechanical contacts or SPDT switch.
Regardless of whether the SPDT switch is in the "off" or "on" mode in energy efficiency (EE) mode, in both cases the frequency of the alternating current always acts with 50 (Hertz).

For this reason, the motor, although it decreases its torque, does not decrease its speed or its ability to perform mechanical work on the radial blades (as long as the motor torque does not decrease the torque below the minimum limit required to keep the rotor running at speed). sync speed).

Indeed, the electromechanical design hypothesis is clearly oriented in the right direction, since the harmonics decrease (the sinusoidal signal of the alternating current is rectified, as observed in the form of the voltage wave observed in the oscilloscope), although the signal indicates that the load is still non-linear and requires a low-pass type EMI (electromagnetic interference) filter (LPF) with passive elements in its construction.

Additionally, other information that resulted from the analysis of the data is that there is no harmonic alteration of the frequency of 50 (Hz), since the electromechanical design of the passive low-pass filter "LC" acts in a double sense as:

-(a) a voltage reducer producing a voltage drop from 220 (Volts) to 110 (Volts) and the current from 0,45 (Amperes) to 0,1 (Amperes) raising the power factor of 0,17 (Cos Φ) to 0,81 (Cos Φ) which in the calculation of the active power formula in alternating current (AC) circuits will produce a drop in motor power without loss of rotor speed (RPM); that is, without affecting its ability to perform mechanical work (Joules). Meanwhile, active power (Watts) and energy consumption measured in kilowatt-hours (kWh) decrease by 56%, with no drop in revolutions per minute (RPM) of the centrifugal blades connected to the synchronous rotor shaft.

-(b) as an output voltage ripple reducer or electromechanical interference (EMI) low-pass filter (LPF) allowing total harmonic distortion values to be maintained at: THDv<5% (normal situation) and THDi<10% (normal situation), according to IEEE 519 standard. Reducing the ripple in the output voltage acting as a harmonic filter.

Reiterating that, while the active power (watts) decreases and the consumption of active energy measured in kilowatt-hours (kWh) also decreases, the same does not happen with its working speed (as is usually the case with any conventional centrifugal extractor / fan). connected to an asynchronous motor).

From the experimental conclusions, evidently the PMSM/IPM type synchronous motor does not lose speed, since it works at 100% of its maximum speed of 3000 (RPM), with only 35,6% of its maximum active power, using only 6,3 (Watts) of the nominal 17 with which it operates at startup. Although it is built to work up to an operating limit of 50 (Watts).

By way of comparison, a single-phase induction motor, one of those normally used in refrigeration or ventilation equipment, is a "frager" type brushless synchronous motor (in short circuit) and works with a maximum speed of 1690 (RPM) with 100% of its maximum active power of 19 (Watts); which means 44% less speed when compared to the highly energy-efficient motor developed here. Instead, the PMSM/IPM type synchronous motor designed for this project (with the energy efficiency system “on”) works at 100% of its maximum speed of 3000 (RPM) with only 35,6% of its active power maximum, using only 6,3 (Watts);

So we can ensure that the synchronous motor saves 67% of active energy (kWh), performing 56% more mechanical work on the air fluid with the same active power (Watts).

It should be clarified that in other countries where the alternating current (AC) frequency is 60 (Hertz) the efficiency of this electro-mechanical design would be higher, taking the motor speed from 3000 (RPM) to 3600 (RPM); much more than the 1690 (RPM) of the same a-synchronous motor at 60 (Hz) but with a 64,4% higher active power consumption. That is to say that if in the country where the single-phase alternating current is 60 (Hz), the a-synchronous motor of 19 (Watts) of active power, would have a speed of 1690 (RPM); but in the same country of 60 (Hz) the PMSM/IPM type synchronous motor with 6,3 (Watts) would have a speed of 3600 (RPM) with the same six (6) radial blades (same weight and impeller diameter or impeller vanes of the air fluid).

Another advantage of the PMSM/IPM type synchronous motor is the following, if we apply the so-called "Fan affinity law", specified in the UNE 100-230-95 Standard, the way in which the power variables (Watts) and speed (RPM) (determined according to international standards ISO 5801-96(E) and ED 13348-1998) is as follows: a-synchronous motor, with a power of 19 (Watts) at 1690 (RPM) speed of the impeller blades would require 106 (Watts) of active power to match the 3000 (RPM) of the PMSM/IPM type synchronous motor. This means that normally any cooling single-phase a-synchronous induction motor would require 16,8 times more active power to match this highly energy-efficient design.

Therefore, this experimentally proposed design reduces active power (Watts) and active energy consumption (kWh) by 67%. Performing 56% more mechanical work (Joules) on the fluid air (with a 50% reduction in carbon footprint).

That is why we say that the experimental prototype presented here is more energy efficient (EE), because it performs more mechanical work (Joules) on the impeller blades in the fluid air, with less power (Watts) consuming less electrical energy measured in kilowatt-hours. (kWh) than the brushless a-synchronous motor (frager type or conventional induction used in centrifugal air blower/exhaust equipment) but at higher revolutions per minute (RPM) than the conventional a-synchronous motors used in the equipment ventilation, extractors and blowers. The advantage is twofold.

Therefore, based on the experimental results, it is observed that centrifugal fans can be developed that save electrical energy (kWh) without the need to resort to: (a) the use of variable speed drives (VDF) or frequency, nor (b) the *"Law of affinity of fans".* The latter would change everything that is known in the world about the "*Law of affinity of fans"* and would imply a new bibliographic review and experimental development (new comparative studies such as the one developed here); because it is estimated that new and substantial comparative advantages could be created and developed that lead to energy saving and efficiency (never studied before, creating new fields and lines of research). Which would bring a huge global savings in electricity costs with a simpler technology, although rudimentary and limited; but effective, economical, rustic (electromechanical and not electronic) and resistant to extreme working conditions.

The added value proposal comes hand in hand with Energy Efficiency (EE), which determines the reduction of the "carbon footprint"; where we went from consuming 202 (kWh) per year equivalent to 0,1 tons of CO_2 to 97 (kWh) per year equivalent to 0,05 tons of CO_2 (which means a 50% reduction in the carbon footprint) that our development of the prototype leaves on Planet Earth (at the small scale of the experienced prototype). Therefore, the relationship with the carbon footprint is directly proportional to the power of the motor and to future prototypes with greater power (the relationship in industrial three-phase motors has not been studied).

Obtaining this experimental minimum viable product is estimated to be scalable to higher single-phase power either for commercial use and to a three-phase model (star-delta type connection) for industrial use (although the latter has not been experimented with).

For which we could well describe this technological innovation as a hertzian motor.

Acknowledgements.

To the Director of the Project (Code: B374) based in the Secretariat of Science and Technology (SCyT), Department of Industrial Design (DDI), Faculty of Fine Arts (FBA), National University of La Plata (UNLP). Whose title is: *"Integrated Management of Design and Innovation. Contributions for a theoretical-conceptual and methodological review"* Mg. D.I. Federico del Giorgio Solfa. To Ing. Guillermo Canale and the D.I. Rosario Bernatene for having introduced the *"Ecodesign"* Postgraduate course in the DDI of the FBA, UNLP.

Figure nº 28. We observe the Certificate of the COVID-19 WINNING PROJECT (above left declared as: "PROYECTO GANADOR") of the INNOVAR 16th National Contest (year 2021) Edition of the National R&D Agency and the Ministry of Science, Technology and Innovation of the Argentine Republic: ID 21751. Name: *"TURBO: air extractor/blower for environments affected by COVID-19".* Presented by Ibar Federico Anderson.

Figure nº 29. We observe the photo of the trophy of the Covid-19 winning project of the INNOVAR 16th National Contest (year 2021) Edition of the National R&D Agency and the Ministry of Science, Technology and Innovation of the Argentine Republic: ID 21751. Name: *"TURBO: air extractor/blower for environments affected by COVID-19".* That accompanies the certificate shown in the previous photo (figure n° 24) Presented by Ibar Federico Anderson.

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