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Enter the RPM per volt, current at load, and current at no load into the calculator to determine the BLDC motor power. (Brushless Motor Power) The following equation is used to calculate the BLDC Motor Power. $BLDC = Kv \cdot (I - I_0) \cdot \left[\frac{30}{\pi} \cdot \left(\frac{V}{Kv} \right)^2 \cdot (I - I_0) \right]$ Where BLDC is the brushless motor power Kw is the RPM per volt I is the current at full load I₀ is the current at no load Definition: A BLDC motor power is the maximum power produced by a brushless DC motor. Example Problem: The following example outlines the steps and information needed to calculate BLDC Motor Power. First, determine the RPM per volt. In this example, the RPM per volts is 3.25. Next, determine the current at full load. This is measured to be 50 amps. Next, determine the current at no load. This is measured to be 10 amps. Finally, calculate the BLDC motor power using the formula above: $BLDC = [Kv \cdot (I - I_0)] \cdot \left[\frac{30}{\pi} \cdot \left(\frac{V}{Kv} \right)^2 \cdot (I - I_0) \right]$ $BLDC = [3.25 \cdot (40)] \cdot \left[\frac{30}{\pi} \cdot (3.14159 \cdot 3.25)^2 \cdot (40) \right]$ $BLDC = 15,278 \text{ watts} = 15.278 \text{ kW}$ Powered by @Calculator Ultra Unit Converter Use the citation below to add this to your bibliography: {{ citationMap|activeStyle| }} Find More Calculator ▾ The formula for calculating the power of a BLDC motor is given by: $P_{BLDC} = [Kv \cdot (I - I_0)] \cdot \left[\frac{30}{\pi} \cdot \left(\frac{V}{Kv} \right)^2 \cdot (I - I_0) \right]$ where: P_{BLDC} is the brushless motor power in watts, Kv is the RPM per volt (the motor's speed constant), (I) is the current at full load in amps, (I_0) is the current at no load in amps. How to Use the Calculator Input the RPM/Volt (Kv): This is a measure of the motor's speed constant, indicating how many revolutions per minute the motor will make per volt of electricity without load. Input the Current at Load (I): Enter the current in amps when the motor is under full load. Input the No Load Current (I₀): This is the current in amps when the motor is running without any load. Calculate: Press the calculate button to determine the BLDC motor power. Reset: If you need to perform another calculation, use the reset button to clear all fields. Understanding the power output of a BLDC motor is crucial for selecting the right motor for your application, ensuring it meets the required performance without being over or underpowered. This calculator makes it easy to evaluate potential motors based on your specific requirements. By Emrik Joner Introduction: Understanding efficiency is the first step to improving the performance of devices and vehicles containing brushless DC (BLDC) motors. This article explains the key formulas for calculating brushless motor efficiency and demonstrates how they can be used in experimental situations. This article will help you gain an understanding of how a brushless DC motor operates by providing examples with real data. If you are a drone designer, this knowledge will also help you develop strategies to maximize the flight time and payload of your vehicle. Table of Contents Assumptions Brushless motor power and efficiency formulas Torque, speed and mechanical power calculations Overall motor efficiency formula Heat losses and the best operating point In the experiments described, we used a Series 1585 thrust stand for data acquisition and powertrain control. The theoretical analysis is done in Octave. Assumptions: There are two main efficiencies to consider in a brushless system: motor efficiency and propeller efficiency. In order to focus on motor efficiency, we will simplify propeller efficiency and say that the bigger the propeller, the higher its efficiency. Motors, on the other hand, have a high efficiency when spinning at high speed with relatively low torque. Operating at high torque results in the motor heating up and losing efficiency. That said, the reduced efficiency might be a worthy compromise in order to use a larger, more efficient propeller and to avoid using a gear box, which adds complexity and leads to heat losses. The theoretical model we use assumes that motor Kv does not change, though this is not exactly true due to the electronic speed controller (ESC). We also simplify heat losses as a simple resistance for use in the calculations, while in a real circuit there is a more complex impedance. These assumptions and simplifications lead to differences between the theoretical and experimental results, which are interesting to observe through testing. Further reading: How to Measure Motor Torque and Why You Should Formula Explanation: There are several key formulas for understanding brushless motor performance. You can see how motor power and efficiency are closely related and dependent on factors such as torque, RPM, current and voltage. The Torque-Speed Plot and Mechanical Power: The torque-speed plot helps us to understand how these two factors are related, as well as what happens when one of them is intentionally set to '0'. Let's first look at formula 2, which relates the two parameters and describes how to calculate mechanical power; Mechanical power is the product of torque and RPM, so when there is either no torque or no rotation, no power is produced. Figure 1 provides a visual reference for what this looks like in practice, where we present data from several motor tests. Figure 1: Mechanical power for a 1500 Kv brushless DC motor Along the horizontal axis you'll see several blue circles, these data points were recorded during a no-load motor test. As you can see, when the motor is spinning freely with no load (i.e. no propeller), no torque is generated. An increase in voltage increases the motor's speed along the horizontal axis, but the mechanical wattage remains at zero. The dynamometer used for the test confirmed the results, also indicating zero torque and zero mechanical power. The other extreme is to have no rotation speed while slowly increasing the torque, achieved by sending power to the motor but not letting it spin. In theory, this mode of operation would produce a vertical line of data points along the vertical axis with increasing torque but no speed. In practice, motors used by UAVs and drones are not designed to work at very low speeds and would overheat with high torque. We did not want to subject our motors to this much stress, so we only performed this test at low torque, which is why there is only one data point above zero on the vertical axis. In reality, your motor will operate between these two extremes. The six other power curves in figure 1 demonstrate the results of tests performed with unobstructed motors with propellers. Each dataset represents a different propeller, with the corresponding sizes listed in the legend on the right-hand side (diameter, pitch). As you can see, these propulsion systems occupy the middle of the graph between the two extremes, where regular operation occurs. The Torque-Speed Plot and Electrical Power: Electrical power can be determined experimentally or theoretically, and it can be a fun exercise to compare your test results to your theoretical calculations. Experimental Approach: When calculating electrical power we can use formula 3, where electrical power is the product of current and voltage. We can also calculate electrical power using formula 4, where it is the sum of mechanical power (RPM*torque) and heat losses. Figure 3 shows how electrical power relates to torque and RPM. The data points represent the test result from motors equipped with propellers of different sizes and pitch. Similarly to the 3D display of mechanical power in figure 1, the electrical power is proportional to the motor's torque. However, even when there is no rotation (RPM = 0) and torque is applied, there is still production of electrical power. This is unlike mechanical power, where for all torque values at 0 RPM no power is produced. Further reading: Drone Design Calculations and Assumptions Each curve represents a different load (propeller) with speed and torque values plotted. The theoretical values are displayed as a 3D plot represented as a coloured surface, the brighter the shade, the higher the electrical power at that point. Figure 3: Electrical power for a 1500 Kv brushless DC motor Theoretical Approach: To calculate a motor's electrical power theoretically we use formula 4. To allow us to input values into the formula, we replace 'mechanical power' with the right side of formula 2, and 'heat losses' with the right side of formula 5, to give formula 6. Here, R represents the resistance in the circuit generated by the motor (inversely proportional to the torque). The theoretical model assumes that the Kv does not change, which is not exactly true due to the electronic speed controller (ESC). We also simplify heat losses as a simple resistance, while in a real circuit there is a more complex impedance. These distinctions lead to differences between the theoretical and experimental results. Using the test results we are able to make a 3D plot and fill in most of the variables in formula 7 (torque, RPM, current, and voltage), then we can use this information to find the R value closest to that observed in the experiments. The software Octave makes the 3D representation so the error between the estimated power usage and the real power usage is as small as possible, giving the R value. Technically, Octave performs a linear regression with the cost function defined as the error of the estimated electrical power used. Formula 7 can also be rearranged to solve for R. Now that we have the R value for our motor, we plug in the values to formula 6 to calculate electrical power. Overall Efficiency: The efficiency of a motor is determined by dividing the mechanical power output by the electrical power input (formula 1). A goal for vehicle design is therefore to maximize this ratio and optimize the overall system efficiency by using the biggest propeller possible without overloading the motor. This is why testing is so important. Using a giant propeller would drastically increase the propeller efficiency, but the motor would struggle so much to make it spin that its efficiency would be ridiculously low. Doing the opposite isn't great either as making a tiny propeller spin very fast would lower both the motor and the propeller efficiency. The best solution is to balance both efficiencies to get the highest overall performance and system efficiency. To achieve the highest efficiency the motor has to operate in the yellow zones of Figure 4 and 5 where there is a balance between torque and RPM. Testing various motors can help you figure out which size, Kv, and brand of motor will get you to that sweet spot for your operations. Figure 4: Motor efficiency for a 1500 Kv brushless DC motor Figure 5: Motor efficiency for a 1500 Kv brushless DC motor in 3D Interpretation - Best Operating Point The three graphs in figure 6 demonstrate how motor parameters vary and how to optimize them to achieve higher performance. Figure 6: Parameters contributing to motor performance The trend lines on these graphs can help you understand how to optimize your motor's performance and operating conditions, whether you're aiming for maximum flight time for your transport drone or maximum power for your racing drone. In the left-most graph, the horizontal lines represent heat losses, which are dependent only on torque and current, not RPM. The lower torque and current your motor operates at, the lower the heat losses. The graph in the middle shows the maximum power curve originating from the origin. If the motor does not operate along this line, it is operating at less than full power potential. A max power condition is ideal for winning a race, but not for increasing flight time or endurance. Finally, the right-most graph shows the maximum efficiency curve. A motor operating on this line will use it's battery more efficiently than anywhere else on the graph, thus increasing the flight time and endurance. The locations on the graph where you choose to operate depends greatly on the type of operations you are performing. The objectives of your flight should guide your design process and help you make decisions on which components to use. When modifying the operating range of your motor, you will be looking at changing either your motor size, propeller size or both. In other words, you will be trying to optimize the load of the motor for its size. An easy way to tell if a motor isn't efficient is to measure its temperature. A motor heating up too much is probably overloaded, AKA it is too small for its load. Furthermore, a motor not warming at all is probably too heavy or too big for its load, thus inefficient in that setup. Your needs will help you determine if you should start by modifying your motor or propeller size first. Conclusion When evaluating the performance of a motor, using both theoretical and experimental methods will give you the best understanding of your device. The difference between theoretical and experimental results comes from incorporating theoretical assumptions in your calculations, and also from imperfections in your measuring devices. For example, the ESC isn't perfect and might sometimes activate at the wrong time. Bearing friction is also not taken into account and the measuring instrument's precision comes with an expected error. The theoretical model is a good tool to understand intuitively how a change will affect the motor performance. To confirm your assumptions and optimize your system, you need to perform actual measurements in a systematic way. Motor performance can be improved in several ways and the best way to determine them is to compare theory with test results to get a better understanding of your whole system. We have several tools that can help you test your motor's performance: The challenges explained throughout this article highlight the need for both approaches to achieve a well-rounded understanding of the components you're working with and a respect for their limitations. Having several reiterations of a design is very normal as the drone building process operates as a loop: Assume – Build – Test – Repeat. For a practical extension on how to apply these concepts to your drone design, we recommend reading another one of our articles on How to Increase a Drone's Flight Time and Lift Capacity. If you have any questions about the contents of this article or the tools we used, don't hesitate to leave us a comment and we will be sure to respond. If there are any concepts you would like us to cover that we haven't already, just leave us a note below. 15 Oct 2024 Tags: Calculations Concepts User questions bldc motor power calculation Popularity: BLDC Motor Power Calculation This calculator provides the calculation of power of a BLDC motor for electrical engineering applications. Explanation Calculation Example: The power of a BLDC motor is calculated using the formula $P = V \cdot I \cdot \eta / 100$, where V is the voltage applied to the motor, I is the current drawn by the motor, and η is the efficiency of the motor. Q: What is the significance of motor efficiency in BLDC motor applications? A: Motor efficiency is a crucial factor in BLDC motor applications as it directly impacts the power consumption and operating costs. A higher efficiency motor consumes less power for the same output, leading to energy savings and reduced operating expenses. Q: How does the voltage applied to a BLDC motor affect its power output? A: The voltage applied to a BLDC motor has a direct impact on its power output. By increasing the voltage, the motor's speed and torque can be increased, resulting in a higher power output. However, it's important to consider the motor's specifications and limitations to avoid over-volting and potential damage. Variables Symbol Name Unit V Voltage V I Current A Efficiency % Calculation Expression Power Calculation: The power of the motor is given by $P = V \cdot I \cdot \eta / 100$ Calculator Calculated values Considering these as variable values: V=12.0, η=90.0, I=10.0, the calculated value(s) are given in table below Derived Variable Value Power Calculation (P10.8) Similar Calculators Explore Calculator Apps The Engineering ToolBox provides a wide range of free tools, calculators, and information resources aimed at engineers and designers. It offers detailed technical data and calculations for various fields such as fluid mechanics, material properties, HVAC systems, electrical engineering, and more. The site includes resources for common engineering tasks, such as calculating physical properties (e.g., density, viscosity, thermal conductivity), converting units, and designing systems like heating and water distribution. With sections on everything from acoustics to hydraulics, it serves as a comprehensive tool for both students and professionals in technical and engineering disciplines. 22 Sep 2024 Tags: Electrical Engineering Electric Drives Electric Drives BLDC Motor Calculator Popularity: BLDC Motor Calculator This calculator provides the calculation of current, torque, and power for BLDC motors. Explanation Calculation Example: BLDC (Brushless Direct Current) motors are widely used in various applications due to their high efficiency, reliability, and low maintenance requirements. This calculator provides the calculation of current, torque, and power for BLDC motors based on the given battery voltage, motor constant, and desired motor speed. Q: What are the advantages of using BLDC motors? A: BLDC motors offer several advantages over traditional brushed DC motors, including higher efficiency, longer lifespan, lower maintenance requirements, and higher power density. Q: How does the motor constant affect the performance of a BLDC motor? A: The motor constant (Kv) is a crucial parameter that determines the relationship between the motor's electrical and mechanical characteristics. A higher Kv value indicates a higher motor speed for a given voltage. Variables Symbol Name Unit V Battery Voltage V Kv Motor Constant rpm/V N Motor Speed rpm Calculation Expression Current Function: The current flowing through the motor is given by $I = V / R$. Torque Function: The torque produced by the motor is given by $T = Kv \cdot I$. Power Function: The power consumed by the motor is given by $P = V \cdot I$. Calculator Calculated values Considering these as variable values: V=12.0, Kv=200.0, N=3000.0, the calculated value(s) are given in table below Derived Variable Value Current Function 12.0/R Power Function (P12.0) Torque Function (T200.0) Similar Calculators Explore Calculator Apps BLDC Motor Calculator AI supported calculators Gear Design in 3D & Learning A BLDC (Brushless DC) motor is a type of electric motor commonly used in a variety of applications due to its efficiency and reliability. One of the key metrics for evaluating the performance of a BLDC motor is its power output. The power output is determined by various factors, including the motor constant (Kv), the operating current, and the no-load current (I₀). The BLDC motor power calculator allows users to compute the motor's power based on these inputs. The formula for calculating the power output of a BLDC motor is: $BLDC \text{ Power} = (Kv \times (I - I_0)) \times [(30 / \pi) \times (V / Kv)] \times (I - I_0)$ Where: Kv is the motor constant (RPM per volt), I is the motor's operating current (in Amps), I₀ is the no-load current (in Amps). This formula helps determine the actual power output based on the differences between the operating current and no-load current. To use the BLDC motor power calculator: Enter the motor constant (Kv): This is typically provided by the motor manufacturer and represents the motor's efficiency at converting electrical energy into mechanical motion. Enter the motor's operating current (I): This is the current the motor draws when operating under load. Enter the no-load current (I₀): This is the current the motor draws when not under load. Click on the "Calculate" button to compute the BLDC motor power output. Let's consider the following values: Kv = 200 RPM/V I = 10 Amps I₀ = 1 Amp Using the formula: $BLDC \text{ Power} = (200 \times (10 - 1)) \times [(30 / \pi) \times (12 / 200)] \times (10 - 1)$ $BLDC \text{ Power} = (200 \times 9) \times [(30 / \pi) \times 0.06] \times 9$ $BLDC \text{ Power} = 1800 \times [0.045 \times 9]$ $BLDC \text{ Power} = 1800 \times 0.405 = 729 \text{ Watts}$ Thus, the power output of the BLDC motor is 729 Watts. What is the significance of Kv in the formula? Kv represents the motor constant in RPM per volt and determines how fast the motor will spin for a given input voltage. What does the motor's current (I) refer to? The motor's current (I) refers to the amount of electrical current the motor draws during operation under load. What is the no-load current (I₀)? The no-load current (I₀) is the current the motor consumes when it is not performing any mechanical work (i.e., running without a load). Why is it important to calculate BLDC motor power? Calculating the motor power helps assess the efficiency of the motor, determine suitable power supplies, and predict performance under various operating conditions. Can this formula be applied to any BLDC motor? Yes, this formula applies to all BLDC motors, provided the Kv, I, and I₀ values are available. What units are used in the BLDC power calculation? The result is given in watts (W), which is the standard unit of power. How does the no-load current affect the motor power? A higher no-load current will reduce the power output because the difference between the load current and no-load current becomes smaller. What happens if the current I is less than I₀? If the operating current (I) is less than the no-load current (I₀), the motor will not function properly under load, and the power calculation may not be valid. Can the calculator handle high Kv values? Yes, the calculator can handle high Kv values, but keep in mind that very high Kv motors generally produce higher speeds and lower torque. How does the value of Kv affect motor efficiency? Motors with higher Kv values tend to spin faster but provide less torque for the same current. The balance between Kv, I, and I₀ is important for optimal efficiency. What does the result in watts mean for my motor? The result represents the motor's actual power output, which can be used to gauge its performance and match it with the required specifications for a given task. Can this formula be used for motors other than BLDC? This formula is specifically designed for BLDC motors. Other motor types will have different performance metrics and formulas. What is the impact of increasing the motor's Kv value? Increasing Kv increases the motor's speed but decreases the available torque for the same input current. How does the BLDC motor power relate to the torque? While power is related to speed, torque is a different measurement. However, both are essential for determining a motor's overall performance. What other factors affect BLDC motor power output? Other factors like motor efficiency, load conditions, and supply voltage can also influence the motor's power output. Can I use the BLDC power result to choose a suitable power supply? Yes, the power output helps in selecting an appropriate power supply that can handle the motor's demands. Is the BLDC power calculator accurate for all applications? The calculator provides an estimate. For high-precision applications, additional factors such as motor efficiency and environmental conditions may need to be considered. How often should the motor's power output be recalculated? It should be recalculated when the motor's load conditions or electrical inputs change. How does the BLDC motor power calculation differ in real-world use? In real-world use, the actual power output may vary due to factors like temperature, friction, and system losses. Can the power calculation help in designing motor control systems? Yes, understanding the motor's power output is crucial for designing motor controllers that match the motor's performance capabilities. The BLDC motor power calculator is a valuable tool for evaluating the power output of brushless DC motors based on key parameters such as Kv, operating current, and no-load current. By using this calculator, engineers and hobbyists can assess motor performance, optimize designs, and ensure that their motors are suitable for their specific applications. Understanding motor power is essential for selecting the right motor, power supply, and motor controller for any project. Brushless DC (BLDC) motors are a modern and efficient type of motor widely used in applications from small appliances to electric vehicles. The BLDC Motor Power Calculator is a practical tool designed to estimate the output power of a BLDC motor based on its input parameters and efficiency. This calculator is invaluable for engineers, technicians, and hobbyists who need to optimize motor performance for specific applications. Output Power (P) = Input Voltage (V) * Input Current (I) * Efficiency (η) Where: P = Output Power of the motor (in watts). V = Input Voltage to the motor (in volts). I = Input Current to the motor (in amperes). η = Efficiency of the motor (as a decimal, e.g., 0.85 for 85% efficiency). See also SRAM Chain Length Calculator Online Measure Input Voltage (V): Determine the voltage supplied to the motor, which is typically specified by the power source or battery. Measure Input Current (I): Use an ammeter to measure the current flowing into the motor during operation. Determine Motor Efficiency (η): Motor efficiency can be obtained from the motor specifications provided by the manufacturer or from experimental measurements. Calculate Output Power: Multiply the input voltage, input current, and efficiency to find the motor's output power. To assist users, a table is provided below with common voltage and current ranges, along with typical efficiency values for BLDC motors. See also Belt Frequency Calculator Input Voltage (V) Input Current (I) Typical Efficiency (η) 12V 1.5A 0.80 24V 2.0A 0.85P = 24V (times 2A times 0.85P = 24V times 2A times 0.85P = 40.8 watts) P = 40.8 (text{ watts}) F = 40.8 watts This example shows how the calculator can be used to estimate the power output of a BLDC motor, providing crucial data for system design and verification. See also Boiler Horsepower Calculator Online 1. What is the advantage of using a BLDC motor? BLDC motors are known for their high efficiency, reliability, and long operational life, making them ideal for applications requiring low maintenance and high performance. 2. How accurate is the BLDC Motor Power Calculator? The accuracy of the calculator depends on the precision of the input data. Accurate measurements of voltage, current, and efficiency ensure reliable results. 3. Can this calculator be used for any BLDC motor? Yes, the calculator is universal and can be used for any BLDC motor as long as the input parameters are known. Brushless DC (BLDC) motors have become the backbone of various modern industries. A BLDC motor design calculator is a vital tool in designing and understanding these motors. This article offers an in-depth guide on the calculator, its functionality, and its applications. A BLDC motor design calculator is an application that helps in the computation of essential parameters of BLDC motor design. It employs mathematical formulas to generate accurate data, assisting engineers and researchers in development processes. The calculator takes specific inputs like the number of turns in the winding, magnetic flux, and angular velocity. By applying a unique formula, it provides the back electromotive force (EMF) of the motor. This automation of calculations reduces errors and enhances efficiency. See also Change In Electric Potential Calculator The formula used in the calculator is: $EMF = (N \cdot \phi \cdot \omega) / 60$ Where: EMF is the back electromotive force in volts. N is the number of turns in the motor winding. φ is the magnetic flux in Weber. ω is the angular velocity of the motor in revolutions per minute (RPM). Consider a BLDC motor with 100 turns, 0.5 Weber magnetic flux, and 1500 RPM. Using the above formula, the back EMF would be 1250 volts. BLDC motor design calculators are utilized in various fields: From robotics to automation, industries rely on BLDC motors. Accurate design is essential for efficient performance. See also Displacement Power Factor Calculation Online BLDC motors are crucial in electric vehicles. The calculator aids in designing motors for optimal energy consumption in renewable energy systems. BLDC motors are used to generate power. Design calculators assist in creating efficient systems. What are the essential parameters in BLDC motor design? Essential parameters include the number of turns, magnetic flux, and angular velocity. Each plays a vital role in determining the motor's performance. How to ensure the accuracy of calculations? By using well-structured formulas and specialized design calculators, accuracy can be ensured. These tools are built with scientific principles that consider every variable. See also Attenuation Calculator Where to use the BLDC motor design calculator? It's used by engineers, researchers, and educators across various industries, including automotive, industrial automation, and renewable energy systems. BLDC motor design calculators are an indispensable tool in today's technological world. They bridge the gap between theoretical knowledge and practical implementation. By understanding their working, formula, and applications, professionals can harness the full potential of BLDC motors, contributing to innovation and efficiency.