Frequently Asked Questions

What is the primary difference between a Brush DC Motor and a Brushless DC Motor?

Brush DC Motors use commutation brushes which change the direction current flows periodically to maintain torque. Because of brush wear, a Brush DC Motor requires more maintenance and has shorter life than Brushless DC Motors. Instead of brushes, Brushless Motors use Hall Sensors which are placed at the back end of the motor. These Hall Sensors output high-low pulses when they detect a change in magnetic field. For this reason, Brushless DC Motors require the use of more complex circuitry found in Variable Speed Drives (VSD). Also, since Brushless DC Motors do not use brushes for commutation purposes, they are far more efficient, require very little maintenance, and have a longer life than Brush DC Motors.

Helpful Information

What are Brushless DC Motors?

Brushless DC Motors are also known as BLDC Motors; synchronous electric motors that are DC (Direct Current) powered. They are electronically commutated without brushes making them "Brushless." Brushless DC Motors consist of a fixed armature along with permanent magnets that rotate, Hall Sensors, stator windings, rotor magnet North and South, Hall Sensor magnets, an accessory shaft, and a driving end of the shaft.

Accessories

Anaheim Automation provides a variety of accessories for our Brushless DC Motors. These accessories include brakes, encoders, connectors, cables, and drivers. The Brushless DC Motors brake is a 24VDC system. These Brushless DC Motors brakes are perfect for any holding applications. Each brake that we offer is already available on any Brushless DC Motors, and already attached to the rear of the Brushless DC Motors. Our Brushless DC Motor brakes have a low voltage design for applications that are susceptible to brown out, weak battery, or long wiring runs. When electric power is applied to the Brushless DC Motor brake, the armature is drawn by the electromagnetic force in the magnet body assembly, which overcomes the spring action. By overcoming the spring action, the friction disc will rotate freely. When electrical power is interrupted, the electromagnetic force is removed, and the pressure spring mechanically forces the armature plate to clamp the friction disc between itself and the pressure plate. Brushless DC Motor cables can be provided with compatible connectors, by request, or each component can be ordered separately from Anaheim Automation.

Advantages and Disadvantages for Brushless DC Motors

Some of the advantages of Brushless DC Motors include, but are not limited to: higher speed ranges, high dynamic response, long operating life, better speed versus torque characteristics, noiseless operation, and high efficiency. Disadvantages for Brushless DC Motors may include high costs and additional system wiring, which may be required to power the electronic commutation circuitry.

Consumer Electronics

Although Brushless DC Motors may perform the same functions originally fulfilled by Brush DC Motors, cost and control complications prevent Brushless DC Motors from completely replacing brushed motors. However, Brushless DC Motors have monopolized many areas of the consumer electronics industry, and are used in many different applications, including computer hard drives and CD/DVD players. Brushless DC Motors are used to operate the small cooling fans that are located in electronic equipment as well. Cordless power tools also utilize BLDC Motors because the need for increased efficiency of the BLDC Motor allows for long periods of use before needing to recharge the battery. Furthermore, direct-drive turntables for analog audio disks use low-speed, low-power Brushless DC Motors. Electric and hybrid vehicles use high-power Brushless DC Motors that are essentially AC synchronous motors with permanent magnet rotors. Brushless DC Motors are used in Segway and Vectrix-Maxi-Scooters also. Electric bicycles sometimes build Brushless DC Motors into their wheel hubs, with the stator solidly fixed to the axle, and magnets attached to and rotating with the wheel. These electric bicycles have a standard bicycle transmission with pedals, sprockets, and chain that, if needed, can be pedaled along with or without the help of the Brushless DC Motors. In heating and ventilation, it has become a popular trend to switch from AC motors to BLDC Motors (EC) because of the dramatic reduction in power needed to run them. Although shaded-pole and permanent split capacitor motors were the primary fan motor of choice, many fans today are being run by BLDC Motors. Some use BLDC Motors simply to increase system efficiency as a whole. Certain HVAC systems – particularly those that feature load modulation and/or variable speed – use ECM Motors (Electronically Commutated BLDC Motors). In addition to being more efficient, BLDC Motors also have built-in microprocessors, which allows for better airflow control, programmability, and serial communication. The most popular motor choice for model aircraft today is BLDC Motors, which are available in a wide array of sizes, and have a favorable power-to-weight ratios. BLDC Motors have transformed the market of electric-powered model flight. The introduction of BLDC Motors has displaced the use of almost all brushed electric motors in model aircraft and helicopters. Modern batteries and BLDC Motors allow model airplanes to vertically ascend, versus gradually climb. The small fuel internal combustion engines that were used in the past provide stark contrast to silent and clean BLDC Motors. BLDC Motors have also proliferated among Radio Controlled (RC) cars, buggies, and trucks, where sensor-type BLDC Motors allow the position of the rotor magnet to be detected. Many BLDC Motors feature upgrades and replaceable parts like sintered neodymium-iron-boron (rare earth magnets), replaceable motor timing assemblies, and ceramic bearings. As a result, these BLDC Motors are quickly ascending to the top of the list as far as preferred motor types for electric on- and off-road RC racers. BLDC Motors are low-maintenance, highly reliable, and power-efficient, as most BLDC Motors have an efficiency rating of 80% or higher.

Medical Applications

As costs have decreased, Brushless DC Motors have become especially popular within the medical equipment industry for their long-lasting design. Used in medical equipment, Brushless DC Motors have a life expectancy of 10,000 hours, versus the 2,000-5,000 hour lifespan of a typical brushed motor. Brushless DC Motors also have a top speed that is not limited by a large number of poles. Because they are efficient, reliable, and compact, Brushless DC Motors can be used in a variety of ways. Brushless DC Motors are essentially synchronous, electric motors that are powered by a DC power source. An electric commutation circuit replaces the standard commutator and brush assembly found in the Brushed DC motor. Brushless DC Motors and Brushed DC motors are essentially opposites. While the windings of Brushed DC motors rotate around the rotating shaft or armature, the Brushless DC Motors have windings that are attached to the motor housing. The magnets of the Brushed DC Motors attach to the motor housing, while Brushless DC Motors magnets are affixed to the rotor. Commutation is the process of reversing the polarity of the phase currents in the windings of the motor at an exact time that will produce continuous rotational torque. If commutation did not occur, the magnets and magnetic fields would lock the rotating shaft in place by aligning themselves. The appropriate reversal time is crucial; the Brushless DC Motor shaft must continue spinning, and it does so as a result of the changing polarity of the windings. The primary way Brushless DC Motors and Brushed DC Motors differ is in their methods of commutation. Brushed DC motors use brushes and a commutator that acts as an electromechanical switch to connect the windings in the proper polarity. In Brushless DC Motors, electronic switches take the place of the mechanical switch, controlling the timing of the polarity-reversal by an electrical circuit. Usually, Brushless DC Controllers sense rotor position and control the electronic drive of Brushless DC Motors by using Hall-effect devices (HFD). However, because of the ability to monitor motor back-EMF, HFD can be eliminated to create a sensorless Brushless DC Motor drive. These motors are far less expensive, and are a primary reason they appeal in medical equipment design.

Sleep Apnea can also be treated with the help of Brushless DC Motors. Treatment for the disorder requires the use of Positive Airway Pressure (PAP) respirators. The PAP respirator is attached to a special breathing mask that the patient must wear while sleeping. Within the respirator is a blower fan that pressurizes the air mask, according to the patient’s breathing pattern. As the patient inhales, the blower fan speeds up, allowing more air to reach the lungs, and when the patient exhales, the blower fan slows down to reduce the amount of air the patient breathes out. Brushless DC Motors never need to operate underneath the minimum threshold speed of the drive, so they are the perfect power source for blower fans. Furthermore, there is no risk for any sudden changes in load. Low noise level standards force hospital equipment to be as quiet as possible, thus making Brushless DC Motors a prime candidate due to how silent they are in operation. Due to the absence of commutators and brushes, Brushless DC Motors can operate accurately at high speeds, yet maintain extremely low noise levels. Therefore, they can be used both in hospitals, and in patients’ homes.

Applications
Brushless DC Motors are utilized in a variety of applications in many different industries. For example, some of many applications are CNC, Aerospace, Semiconductor, Packaging Equipment, Automotive, Instrumentation, Appliances, Medical, and Consumer.

Basic Types
All Brushless DC Motors are permanent magnet motors. There are also two basic types labeled as a Trapezoidal Motor and the other as a Sine Wave Motor. The Trapezoidal Motor is said to be a DC servo motor and the Sine Wave Motor has close resemblance to an AC synchronous motor.

Construction

The Stator: The stator of a Brushless DC Motor consists of stacked steel laminations with windings positioned in slots that are cut into the laminations. The stator of a Brushless DC Motor is equivalent to that of an AC motor, but the windings are different. There are three stator windings in each Brushless DC Motor wired in either a Delta or star configuration. In each of these windings, there are multiple coils that are constructed to connect together to form a winding. Anaheim Automation typically has six coils per Brushless DC Motor which are made into a three-phase winding. There is usually an even number of polls. There are two main types of stator windings: sinusoidal and trapezoidal. The difference in the stator windings is identified in the interconnection of the coils of the stator windings, which result in a different type of back-EMF. The trapezoidal variant delivers its back-EMF in a trapezoidal shape. A sinusoidal variation gives the Brushless DC Motor a back-EMF that matches the current. Sinusoidal Brushless DC Motors have smoother output torque than trapezoidal Brushless DC Motors.

The Rotor: The rotor is made up of permanent magnets, and normally has between two and eight poles. The magnets are bonded onto the rotor core in alternating north and south pole fields. Permanent magnet rotors are generally constructed with ferrite magnets. If a higher power density is needed in an application, rare earth magnets are generally being used. Higher power density means that Brushless DC Motors can put out much more torque per unit volume, which is helpful to manufacturers who are continuously pushed to provide smaller and smaller packages. The ferrite magnets are less expensive, but the flux density is lower than that of the rare earth magnets. The price of rare earth magnets is also coming down. Rare earth magnet types include Neodymium (Nd) Samarium Cobalt (SmCo) The alloy of Neodymium, Ferrite, and Boron (NdFeB)

Cost

Brushless DC Motors vary in price. They can be anywhere from twenty dollars or less to several hundred dollars, possibly more. It just depends on the size and capabilities of the Brushless DC Motors themselves.

Customization

Anaheim Automation was founded in 1966 as a manufacturer of turnkey motion control systems. Our focus on R&D has insured the continued introduction of advanced Brushless DC Motor Drivers and Controllers. Today, Anaheim Automation ranks highly among the leading manufacturers and distributors of motion control products, thanks to our reputation for selling quality products at competitive prices, and our Brushless DC product line is no exception. Anaheim Automation offers a wide variety of standard Brushless DC Motors, Gearmotors, Drivers/Controllers, and even Brushless Motors with Integrated Speed Controllers. Occasionally, OEM customers with mid- to large-quantity requirements may purchase custom Brushless DC Motors modified to meet their exact design requirements. Sometimes the customization is as simple as shaft modification, brake, oil seal for an IP65 rating, mounting dimensions, wire colors, or label. Other times, a customer might require that a Brushless DC Motors meet ideal specifications such as speed, torque, and/or voltage. Buyers appreciate the simplicity afforded by Anaheim Automation's 'one-stop shop' philosophy and the cost savings of our standard Brushless DC Products line, while engineers value the creativity, system efficiency, and customization options that Anaheim Automation allows. Anaheim Automation's standard Brushless DC Motor product line is known for its rugged construction, excellent performance, and cost-effectiveness. A considerable size of its sales growth has resulted from committed engineering, friendly customer service and professional application assistance, often surpassing the customer's expectations for fulfilling their custom requirements. While a good portion of Anaheim Automation's Brushless DC Motors sales consist of custom, special, or private-labeled items, we take pride in stocking standard offerings in Anaheim, California, USA. To make customization of a Brushless DC Motors affordable, a minimum quantity and/or a Non-Recurring Engineering (NRE) fee is required. Contact the factory for details, should you require a custom Brushless DC Motor in your design. All sales for customized or modified Brushless DC Motors are Non-Cancelable, Non-Returnable, and a NCNR Agreement must be signed by the customer per each request. All sales are made according to Anaheim Automation's standardized Terms and Conditions, in lieu of any other expressed or implied terms, including but not limited to any implied warranties. Anaheim Automation's Brushless DC Motor customers are diverse: companies running or designing automated machinery or functions that involve food, cosmetics or medical packaging; labeling or tamper-evident requirements; assembly; conveyor; material handling; robotics; special filming and projection effects; medical diagnostics; inspection and security devices; pump flow control; metal fabrication (CNC machinery); and equipment upgrades. Many OEM customers request that we private-label their Brushless DC Motors, so that their customers stay loyal to them for servicing, replacements and repairs. PLEASE NOTE: Technical support for our Brushless DC Motors – as well as other Brushless DC Products and all products manufactured or distributed by Anaheim Automation – is offered at no charge. This assistance is provided to help the customer in choosing

Anaheim Automation products for specific applications. However, any application, selection, or quotation recommendation given by Anaheim Automation's staff, its distributors, or representatives, for a Brushless DC Motor or any other product, is made as a suggestion, meant only to assist the customer in his/her selection. In all cases, determination of fitness of any product in a certain system design is solely the customer's responsibility. While every effort is made to offer dependable advice regarding Brushless DC Motors, as well as other motion control products, and to produce technical data and illustrations accurately, such advice and documents are for reference only, and subject to change without notice.

Environmental Considerations

The following environmental and safety considerations must be observed during all phases of operation, service, and repair of a Brushless DC Motor system. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the Brushless DC Motor and Controller. Please note that even well-built Brushless DC Motor products, operated and installed improperly, can be hazardous. The user must exercise precaution with respect to the load and operating environment. The customer is ultimately responsible for the proper selection, installation, and operation of the Brushless DC Motor system. The atmosphere in which a Brushless DC Motor is used must be conducive to good general practices of electrical/electronic equipment. Do not operate the Brushless DC Motor in the presence of flammable gases, dust, oil, vapor or moisture. For outdoor use, the Brushless DC Motor and controller must be protected from the elements by an adequate cover, while still providing adequate air flow and cooling. Moisture may cause an electrical shock hazard and/or induce system breakdown. Due consideration should be given to the avoidance of liquids and vapors of any kind. Contact the factory should your application require specific IP ratings. It is wise to install the Brushless DC Motor and Controller in an environment which is free from condensation, electrical noise, vibration and shock. Additionally, it is preferable to work with the Brushless DC Motor and Controller system in a non-static protective environment. Exposed circuitry should always be properly guarded and/or enclosed to prevent unauthorized human contact with live circuitry. No work should be performed while power is applied. Do not plug in or unplug the connectors when power is ON. Wait for at least 5 minutes before doing inspection work on the Brushless DC Motors system after turning power OFF, because even after the power is turned off, there will still be some electrical energy remaining in the capacitors of the internal circuit of the Brushless DC Motor Controller. Plan the installation of the Brushless DC Motors and controller in a system design that is free from debris, such as metal debris from cutting, drilling, tapping, and welding, or any other foreign material that could come in contact with circuitry. Failure to prevent debris from entering the Brushless DC Motor system can result in damage and/or shock.

First Use of Brushless DC Motors

It is said that Brushless DC Motors have been in commercial use since 1962, although the first Brushless DC Motors appeared during the 1800s. This was made possible by the conversion of electrical energy into mechanical energy by electromagnetic means, which was demonstrated by British scientist Michael Farady in 1821. A Hungarian physicist named Nyos Jedlik began experimenting with devices he called electromagnetic self-rotors in 1827. At the time, they were only used for instructional purposes. In 1828, he demonstrated the first device to contain the three main components of practical direct current motors; the rotor, the commutator, and the stator. The magnetic fields of both the revolving and stationary components were produced solely by currents flowing through their windings, and the DC motors did not contain permanent magnets in those times. In 1832, William Sturgeon, also a British scientist, invented the first commutator-type direct current electric motor capable of turning machinery. Americans Thomas and Emily Davenport built a commutator-type direct current electric motor intended for commercial use following Sturgeon′s work, and patented their design in 1837. The DC motors were used for a printing press and powered machine tools. They are said to have run up to 600 revolutions per minute (RPM). These Brushless DC Motors were commercially unsuccessful due to the high costs of the primary battery power, and the lack of a commercial market for Brushless DC Motors at that time. Modern Brushless DC Motors were invented in 1873, when Belgian electrical engineer Zénobe Gramme discovered by accident that his Gramme dynamo was reversible. This discovery developed into the Gramme Machine, the first electric motor powerful enough to be successful in industry. In 1886, Frank Julian Sprauge invented the first practical Brushless DC Motor – a non-sparking motor capable of maintaining constant speed under variable loads.

Housing

Brushless DC Motor types are manufactured with the housing-less design where the laminations are exposed and coated with a paint to prevent rusting from occurring. Some Brushless DC Motor types are housed in an extrusion or aluminum or steel cylindrical housing and the laminations of the stator are placed and secured in that housing.

How Do Brushless DC Motors Work?
Brushless DC Motors have an electronic commutation system – no brushes and no mechanical commutators. This allows the Brushless DC Motors to operate at higher speeds. There can be a different amount of poles on the stator for each motor.

How are Brushless DC Motors controlled?
Most Brushless DC Motors need a controller/driver to run. There are many different types of controllers/drivers that are manufactured around the world for different applications. Many come with different options and can be custom made. Most are referred to as Electronic Speed Controllers (ESC). In a Brushless Controller/Driver, either a Hall Effect Sensor or the Back-EMF (Electromotive Force) is used to run the motor. The Hall Effect uses three Hall sensors within the motor to help detect the position of the rotor. This method is primarily used in speed detection, positioning, current sensing, and proximity switching. The magnetic field changes in response to the transducer that varies its output voltage. A feedback is created by directly returning a voltage since the sensor operates as an analogue transducer. The distance between the Hall plate and a known magnetic field can be determined with a group of sensors – in this case, three – and the relative position of the magnet can be deduced. A Hall sensor can act as an on/off switch in a digital mode when combined with circuitry. The Back-EMF, also known as the Counter-Electromotive Force is caused by a changing electromagnetic field. In Brushless DC Motors, the back-EMF is a voltage that occurs where there is motion between the external magnetic field and the armature of the motor. In other words, the voltage is developed in an inductor by an alternating current or pulsating current. At every moment, the polarity of the voltage is the reverse of the input voltage. This method is commonly used to measure the motor′s position and speed indirectly.

Hall Sensor Feedback
In a Brushless DC Motor, two coils are energized at the same time with equal and opposite polarities, causing the rotor to move as one coil pushes the rotor away from it, and the other pulls the rotor toward it. In order to correctly energize each successive winding in proper sequence, a motor controller needs to know the rotor position. In most designs, the rotor position is detected by the Hall sensors embedded in the back end cap of the Brushless DC Motor’s housing. Brushless DC Motors utilize three Hall sensors, which can be spaced either 120° or 60° electrical degrees apart to read the magnetic field of the rotor. Hall sensors detect either the rotor magnet or external

magnet placed in the back of the shaft, and they send a signal indicating whether a North or South Pole passes the sensors. Using each signal from the sensors, the Brushless DC Motor controller can easily maintain the Brushless DC Motor's velocity. Each Hall sensor is typically mounted on a PC board and fastened to the back end cap on the non-driving end of the Brushless DC Motor.

Encoder Feedback
For low-speed products, it is recommended to use an encoder for the feedback rather than the Hall sensors. The number of counts per revolution for the Hall sensor can only be as large as the number of polls times the number of Hall sensors. When operating a Brushless DC Motor, a Brushless DC Controller can utilize the higher count to its advantage. The Brushless DC Controller can use the additional information, with more counts per revolution at its disposal, for more precise control of the velocity. The higher the resolution on the encoder, the more finely the controller can drive the Brushless DC Motors. Though the encoder is more expensive than the Hall sensor, you enjoy more precise control with the encoder at a lower cost, when evaluated against comparable technologies such as AC motors, Servo motors, or Synchronous motors.

How to Select Brushless DC Motors
When selecting a Brushless DC Motor, there are a few questions to bear in mind: What is the application? What are the specifications? What is the budget? What controller/driver should be used? The type of application will need to be determined for your Brushless DC Motors. You will then need to determine all specifications, which may include factors that are definitively known, as well as any possible variables. For example, do you need a specific frame size, weight, power, speed, length, etc.? Once you have answered those questions, you will need to take the controller/driver into consideration. This goes hand in hand with the selection of the motor. Keep in mind there are many different motors and driver/controllers to choose from, therefore it is wise to do detailed research.

Modern day uses of Brushless DC Motors
Brushless DC Motors continue to rise in popularity for many different applications. Although, Brushless DC Motors may cost a little more than Brushed DC Motors, they have far more advantages than disadvantages. Many industries have turned to Brushless motors for their applications. For specific Industries, please check the "In what Industries are Brushless DC Motors Used?" section.

Mounting
The following information is designed as a overall guideline for the installation and mounting of Brushless DC Motor systems. WARNING - Dangerous voltages capable of causing injury or death may be present in Brushless DC Motor systems. Use extreme caution when handling, testing, and adjusting during installation, set-up, and operation. It is very important that the wiring of Brushless DC Motors and Controllers be taken into consideration upon installation and mounting. Subpanels installed inside the enclosure for mounting Brushless DC Motor system components must be flat, rigid surfaces that will be free from shock, vibration, moisture, oil, vapors, or dust. Remember that Brushless DC Motors and Controllers will produce heat during work; therefore, heat dissipation should be taken into consideration in designing the system layout. To be sure not to exceed the maximum ambient temperature rating, size the enclosure. It is suggested that the Brushless DC Controllers be mounted in such a position as to provide adequate airflow. The Brushless DC Motor needs to be mounted in a stable fashion, secured tightly. NOTE: There must be a minimum of 10mm in between the Brushless DC Controller and any other device mounted in the system/electric panel or cabinet. NOTE: in order to comply with CE and UL standards, Brushless DC Motor systems must be grounded in a grounded conducive enclosure offering protection as defined in standard EN 60529 (IEC 529) to IP55, such that they are not accessible to the operator or unskilled person. As with any active part in a system, Brushless DC Motors should be kept out of the reach of the operator. A NEMA 4X enclosure surpasses those requirements providing protection to IP66. To improve the bond between the power rail and the subpanel, construct your subpanel out of zinc-plated (paint-free) steel. Additionally, it is strongly suggested that the Brushless DC Controller be protected against electrical noise interferences. Noise from signal wires can cause mechanical vibration and malfunctions.

Physical Properties of Brushless DC Motors
Brushless DC Motors have 3 stationary phase windings or coils, which are known as the stator. A rotating armature called the rotor is located inside. Brushless DC Motors can be constructed in many different physical configurations. One configuration is known as the "Inrunner" type, in which the permanent magnets are a part of the rotor, and three stator windings surround the rotor. Another configuration is the "Outrunner" type, where the radial-relationship between the coils and magnets is reversed. The stator coils form the core of the motor, while permanent magnets spin within an overhanging rotor surrounding the core.

Motor Life Cycle

The key dissimilarity between brushless motors, also known as Brushless DC Motors, and their predecessors is the process of commutation. Newer Brushless DC Motors are electrically commutated; this is accomplished with Hall elements, by counter EMF, or encoder feedback. Brushless DC Motors are very useful and cost-effective by their design and construction. However, there are some factors that can negatively affect the life expectancy of the Brushless DC Motor. Bearing failure and lack of lubrication are major factors when it comes to Brushless DC Motors failing. As a result, manufacturers now use industrial grade components so that some Brushless DC Motors now have the ability to last lifetimes in excess of 20,000 hours or more! Integrated into these Brushless DC Motors are permanently lubricated ball bearings that use special grease, thus eliminating the need for re-lubrication. IMPORTANT NOTE: Non-approved lubricants are not recommended for Brushless DC Motor components because they could potentially shorten the lifespan of the Brushless DC Motor. Temperature also plays a key role in the lifespan of Brushless DC Motors. In particular, it must be ensured that the motor casing allows the heat generated in the motor windings to be dispelled. Brushless DC Motors could face severe damage if their maximum heat specifications are exceeded. Brushless DC Motor performance has a direct correlation with the maximum possible rotor temperature, ambient temperature, and duty cycle. As temperature increases, the winding resistance increases, and magnetic forces decrease, ultimately causing Brushless DC Motors to perform less efficiently. When Brushless DC Motors run at high continuous loads, heat sinking and forced air-cooling can considerably lower operating temperatures. Therefore, it is highly recommended that all of these factors be taken into consideration when designing and installing motion control systems that include Brushless DC Motors.

In What Industries are Brushless DC Motors Used?

Brushless DC Motors are quickly growing in popularity and are being used in many industries. Some of these industries include: Instrumentation, Medical Appliances, Consumer Automotive, Industrial Automation Equipment, Aerospace, and Military

Wiring

The general information provided in the following paragraph is designed to be a guideline for wiring Anaheim Automation Brushless DC Motors. System faults and communication errors can result from routing power and signal wiring together on a machine or system. Radiated noise from nearby relays, transformers, and electronic devices can be inducted into the Brushless DC Motors sensor and encoder signals, input/output communications, and other sensitive low voltage signals. WARNING - When you reach dangerous voltages, your Brushless DC Motor system is capable of causing injury or death. Use extreme caution when testing, handling, adjusting, and wiring during tuning, set-up, installation, and operation. To refrain from mechanical vibration that can lead to failure and/or loss, don’t make extreme changes or adjustments to the Brushless DC Motors system parameters. Do not directly turn On/Off the power supply from the Brushless DC Controller when the Brushless DC Motor is wired. You will decrease the lifetime of the Brushless DC Motor systems by aging the internal components if you frequently switch the power On/Off. Strictly comply with the following rules: follow the Wiring Diagram with each Brushless DC Motor; route high-voltage power cables independently from low-voltage power cables; segregate input power wiring and Brushless DC Motor power cables from control wiring and Brushless DC Motor feedback cables as they leave the Brushless DC Motors controller, and maintain this separation throughout the wire run; use shielded cable for power wiring, and provide a grounded 360 degree clamp termination to the enclosure wall; enable room on the sub-panel for wire bends; make all cable routes as short as possible. NOTE: Factory-made cables are ideal for use in our Brushless DC Motors and Driver systems. These cables are purchased separately, and are designed to minimize EMI. These cables are suggested over customer-built cables to enhance system performance and to produce additional safety for the Brushless DC Motors system and the user. WARNING - To avoid the risk of electrical shock, perform all mounting and wiring of the Brushless DC Motors and controllers system prior to applying power. Once power is applied, connection terminals may have voltage present.