Here derives the expression to obtain the instantaneous voltage across a charging capacitor as a function of time,that is V (t).Consider a capacitor connected in series with a resistor, to a constant DC supply through a switch S.C is the value of capacitance and R is the resistance value. The V is the Voltage of the DC source and v is the instantaneous voltage across the capacitor.When the switch S is closed, the current flows through the capacitor and it charges towards the voltage V from value 0.As the capacitor charges, the voltage across the capacitor increases and the current through the circuit gradually decrease. For an uncharged capacitor, the current through the circuit will be maximum at the instant of switching. And the charging currents reaches approximately equal to zero as the potential across the capacitor becomes equal to the Source voltage V.Capacitor charging equation derivation steps,Considering voltage law, the source voltage will be equal to the total voltage drop of the circuit.Therefore,Rearrange the equation to perform the integration function,RHS simplification,On integrating we get,As we are considering an uncharged capacitor (zero initial voltage), the value of constant K can be obtained by substituting the initial conditions of the time and voltage. At the instant of closing the switch, the initial condition of time is t=0 and voltage across the capacitor is v=0.Thus we get, logV=k for t=0 and v=0.Taking exponential on both sides,From the above expression, it is clear that the instantaneous voltage will be a result of factors such as capacitance, resistance in series with the capacitor, time and the applied voltage value.As the value of the constant RC increases, the value of exponential function also increases.That is the rateof voltagerise across the capacitor will be lesser with respect to time. That shows the charging time of the capacitor increase with the increase in the time constant RC.As the value of time t increases, the termreduces and it means the voltage across the capacitor is nearly reaching its saturation value.Charge q and charging current i of a capacitorThe expression for the voltage across a charging capacitor isderived as,= V(1- e -t/RC) equation (1).V source voltage instantaneous voltageC capacitanceR resistancet timeThe voltage of a charged capacitor, V = Q/C.Q Maximum chargeThe instantaneous voltage, v = q/C.q instantaneous chargeq/C =Q/C (1- e -t/RC)q = Q (1- e -t/RC)Charging currentFor a capacitor, the flow of the charging current decreases gradually to zero inan exponential decay function with respect to time.From the voltage law,= V(1- e -t/RC)= V V e -t/RCV = V e -t/RC equation(2)The source voltage, V = voltage drop across the resistor (IR) + voltage across the capacitor ( ).V = iR +V =iRSubstituteV =iR in the equation 2.Therefore,iR =V e -t/RCi = (V /R) e -t/RCAs V is the source voltage and R is the resistance, V/R will be the maximum value of current that can flow through the circuit.V/R =Imaxi = Imaxe -t/RCCapacitor Discharge Equation DerivationFor a discharging capacitor, the voltage across the capacitor v discharges towards 0.Applying Kirchhoffs voltage law,v is equal to the voltage drop across the resistor R.The current i through the resistor is rewritten as above and substituted in equation 1.By integrating and rearranging the above equation we get,Applying exponential function,The instantaneous voltage across a discharging capacitor is v=V e -t/RCInstantaneous charge, q = Q e -t/RCInstantaneous current, i = Imax e -t/RCFrom the above equations, it is clear that the voltage, current, and charge of a capacitor decay exponentially during the discharge. The discharge current has a negative sign because its direction is opposite to the charging current. The necessity of a starter in a DC motor is crucial because it controls high inrush currents, ensures smooth acceleration, protects against damage, enables automation, and enhances energy efficiency.DC motors are widely used in industrial and commercial applications due to their controllability, reliability, and efficiency. However, starting a DC motor without a starter can lead to several operational challenges and potential damages. This article describes the critical necessity of starters in DC motors, detailing their functions and protection.There is a necessity of starter in a DC motor for the following reasons.One of the primary reasons for using a starter with a DC motor is to manage the high inrush current that occurs during startup. When a DC motor is initially powered on, it draws a current several times higher than its rated operating current. This occurs because:Low Armature Resistance: At startup, the armature resistance is very low, leading to a surge in current. The resistance increases after running the motor because it increases with the increase in motor temperature.Absence of Back EMF: The motor has not yet started to generate back electromotive force (EMF), which normally opposes the supply voltage and limits current. The back EMF develops when the motor starts rotating and is zero when the motor is at a standstill.Mathematically, the armature current is expressed as,The above clearly shows that the DC motor draws a high starting current. To limit the starting high current, the starter adds resistance in the series of the armature resistance to limit the starting current.This high inrush current can cause several issues:Electrical Stress: Excessive current can lead to overheating and potential damage to the motor windings.Power Supply Fluctuations: A high initial current can cause voltage drops in the power supply network, affecting other connected devices.Increased Wear: The sudden torque can cause mechanical stress on the motor and associated machinery.Starters limit the inrush current by gradually increasing the current supplied to the motor, ensuring a smoother startup and reducing the risk of damage.Directly starting a DC motor can result in rapid acceleration, which may not be desirable for several reasons:Mechanical Stress: Sudden acceleration can cause mechanical shock to the motor and the load it drives, leading to wear and tear or mechanical failure.Safety Concerns: Rapid, uncontrolled acceleration in machinery can pose significant safety risks to operators and nearby personnel.Starters allow for controlled acceleration by incrementally increasing the voltage or current supplied to the motor. This controlled ramp-up ensures the motor reaches its operating speed gradually, minimizing mechanical stress and enhancing safety.Motor starters often come equipped with various protective features that safeguard the motor during both startup and normal operation:Overcurrent Protection: Starters can detect and limit excessive current, preventing overheating and potential damage.Under-Voltage Protection: If the supply voltage falls below a critical level, the starter can disconnect the motor to prevent damage from under-voltage conditions.Thermal Protection: Many starters include thermal overload protection, which disconnects the motor if it overheats.These protective mechanisms are crucial for maintaining the motors longevity and reliability, especially in demanding industrial environments.Motors are started and stopped frequently in many industrial applications, sometimes under varying conditions. Manual control of each operation can be impractical and inefficient. Starters enable:Automated Control: Starters can be programmed to start and stop motors based on predefined conditions, such as time schedules, temperature, or load demands.Remote Operation: Modern starters often allow for remote control, facilitating motor operation from a central control system or a remote location.This automation and remote control capability enhances operational efficiency, reduces the need for manual intervention, and improves overall process control.Modern electronic starter such as, thyristor drives for starting and speed control of the DC motor,, are designed to optimize energy usage. By precisely controlling the voltage and current supplied to the motor, these starters ensure that the motor operates at peak efficiency. This reduces energy consumption and lowers operational costs and environmental impact.The necessity of starters in DC motors is highlighted by their ability to manage high inrush currents, provide controlled acceleration, protect the motor from various operational hazards, and facilitate automation and energy efficiency. Starters are essential for ensuring the safe, reliable, and efficient operation of DC motors in various applications. Understanding the specific requirements of your motor and application is key to selecting the appropriate starter, ultimately enhancing the performance and longevity of your DC motor system. A starter is a device used in motors to start and accelerate. The function of a starter is to limit the starting current. At the time of starting the current flows through the motor is very high. The starter limits this current to a safe value.Motorsbelow 1 HP (0.746 Watts) are directly connected to the power supply withoutstarterbecause their armature resistance is very high and they have the ability to afford and safely pass the higher current because of the high internal resistance. So the armature windings are safe and wont be damaged from the high starting current while starting an electrical motor.In the case of large motors, they have a very low armature resistance. If we connect these types of motors directly to the power supply (mostly 3-phase supply), then the higher amount of current will start to flow and it will destroy the armature winding due to low resistance at the initial starting stage while the motor is not running at normal position. The motor will not start to run at this stage because there is no back E.M.F in the motor. The back E.M.F of the motor is reached at full rate when the motor is running at full speed and rated load. So this is the exact reason thats why we connect a starter with a motor in series. A starter in series with the motor (i.e.resistance) reduces the high starting current as the armature needs low current due to rating at the initial stage and then runs at normal speed.But this is not the end of the story. After starting the motor at low current, the starter resistance is reduced by turning the manual starter handle (the process can be automatic in case of automatic starter). This way, the rated current will start to flow through armature windings and the motor armature starts to rotate at full speed. What is the Necessity of a Starter in AC and DC Motors? When the DC motor is standstill, the speed of the rotor is zero. The back EMF is defined as; Where,P = Number of poles = Flux per poleZ = Number of conductorsA = Number of parallel pathsN = Speed of rotorNow, lets consider the speed of the rotor is zero. Hence, from the above equation, the back EMF of the DC motor is zero. The current flows through the armature are defined as; Here, in standstill condition, the back EMF is zero. So, the armature current is;Where,V = Supply voltageRa = Armature resistanceThe value of armature resistance is very small. Generally, it is less than one ohm. Therefore, in this condition, a very large current flows through the DC motor, and this current is sufficient to damage brushes, commutators, and windings.For example, consider a DC motor having an armature resistance of 0.8 ohms and is directly connected to the 240 V DC supply. Now find the armature current from the above equation.Ia = V Ra = 240 0.8 = 300 ASo, this current is 10-15 times of full load current. The armature winding is not designed to sustain this amount of current. Therefore, we need to reduce this current at a safe level and for that, a starter is connected in series with the armature winding. When the motor is in running condition, the applied voltage (V) is opposed by the back EMF (Eb). Hence, the difference between both quantities is small. From the equation of armature current (eq-1), the value of armature current is small and under safe value during the running condition.But in starting condition, the heavy inrush current may cause the following drawbacks;It causes heavy sparking at the commutators.It will damage the armature winding by temperature rise or by mechanical force set up by electromagnetic action.It will damage the rotating parts of the motor due to high starting torque and large acceleration.Therefore, in starting period of the motor (5 to 10 sec), it is necessary to reduce the current to a safe level. Now, to reduce the starting current, we need to connect a high resistance in series with the armature winding. The extra resistance added to the motor must be removed gradually when the motor is in running condition and develops back emf.When the motor reaches the rated speed, the additional resistance must be removed from the circuit. Otherwise, this resistance causes additional loss of energy and reduces the efficiency of the motor. Also, this additional resistance reduces the operating speed of the motor.For example, we consider the simplest form of starter for DC shunt and compound wound motor. Variable resistance is connected in series with the armature winding as shown in the figure below.At the time of starting the motor, the arm of the rheostat is placed at full resistance. Therefore, the entire resistance is connected in series with the armature winding. When the motor starts running, it develops back EMF that opposes the supply voltage. As the speed of a motor increases, move the arm towards the lower resistance. And when the motor reaches near the rated speed, the arm is placed at zero resistance. Therefore, in running conditions, there is no resistance added to the circuit. In the above concept, it must include a few protective devices like no-volt release and over-load release. There are commonly two types of starters used for DC shunt and compound wound motor; Three-point starter and Four-point starter.When the application needed a wide range of speed by shunt field motor, a four-point starter is used. And when no- (little) speed control is required, a three-point starter is used. Similarly, DOL and star-delta starter are used to run and operate the AC motors.Related Posts: What happens if we dont connect a Starter with a Motor?Lets see the following example.We know that the armature current can be found by the following formula.Ia = V Eb / Ra .. (I = V / R, Ohms Law)Where, Ia = Armature currentV = Supply voltageEb = Back E.M.F Ra = Armature resistanceRelated Post:Main Difference between Contactor and StarterSuppose A 5 HP (3.73 kilowatt) motor with 400 Volts having armature resistance of 0.25 ohms resistance and the normal full load current is 50 amperes. if we connect the motor directly to the power supply without starter, the result (of amount of flow of current) will be as follows:Putting the values in the equation given above.Ia = 400V 0V / 0.25Ia = 1600 AAh! This high current will destroy the armature winding because it is 32 times higher than the normal full load current of the motor. 1600 A / 50 A = 32 Amps.So that is the reason why we need to install a starter with a motor. Related Posts: In this topic, you study Starting of DC Motor and Starters for DC Motors.The armature current of a dc motor is given by the relation\[{{\text{I}}_{\text{a}}}=\frac{\text{V }{{\text{E}}_{\text{b}}}}{{{\text{R}}_{\text{a}}}}\]In the running condition, back emf (Eb) being nearly equal to the voltage applied across the armature (V), armature current is very small. But when the motor is at rest at the beginning, the armature conductors do not cut any flux lines.Hence,\[{{\text{E}}_{\text{b}}}=0\]Thus,\[{{\text{I}}_{\text{a}}}=\frac{\text{V}}{{{\text{R}}_{\text{a}}}}\]As the resistance of the armature is normally very small. Therefore, if the motor is switched directly across the supply, the starting armature current will be excessively high in the absence of the back emf This excessive current blows out the fuses and prior to that may damage the armature. The large voltage drop caused by this current in the line also affects the performance of the other equipments connected to the same line. It is, therefore, absolutely necessary to limit this current. This is achieved by connecting a variable resistance called the starting resistor in series with the armature at starting (Fig. 1). As the speed and the back emf increase, the starting resistor is gradually cut off from the armature circuit. The complete starting resistor assembly is called a starter. In addition to a starting resistor which limits the starting current, the (l.c. motor starter usually contains some protective devices. These devices provide protection to the motor in case the field circuit becomes open or the applied voltage becomes too low or load exceeds its predetermined value. The starter also ensures that the starting resistance is automatically reconnected into the armature circuit every time the motor stops.Fig. 1: Starting of DC MotorStarting of DC MotorAll dc motors except very small motors need starters. Small fractional-kilowatt dc motors normally do not require starters because of the following reasonsIn comparison with large motors, they have high armature resistance. This helps in limiting the starting current.Being small with low moment of inertia, they pick-up speed very quickly and thereby fastly develop the back emfDisturbance caused due to their momentary starting current to the other equipments connected to the lines is minimum.Various types of manually operated face-plate starters are commonly used for startingdc motors. All these starters have a face-plate fitted with a rotary type of switch connectedto a group of current limiting resistors. Push-button type automatic starters are also availablenow-a-days. These starters use electromagnetic contactors and time-delay relays forautomatically cutting out the starting resistors from the armature circuit in a predeterminedtime sequence or when the armature current drops to a preset value.Shunt Motor Starters Following two varieties of manually operated face-plate type starters are in common usefor starting dc shunt motors.Three-point starter,Four-point starter. While starting a DC motor huge amount of current canbe driven to the windings due to the absence of the back emf. The current may rise about4-6 times higher than the rated load current of the winding wire. So,it can damage the winding of the motor at the starting itself. To prevent such high current rush, startersare used in DC motors.Actually, a starter consists ofa variable series resistance which is added to the armature of the motor. It is used in order to reduce the starting voltage across the winding.When the motor speeds up the starter resistance decrease gradually. And it will disconnect completely when the armature attains enough speed to generate the back emf (that is the normal speed). At a full speed, the starter has no effect on the armature circuit of the motor. Then the contacts of the motor terminals will be directly connected. In a DC motor, when the armature rotates under the influence of the driving torque, the armature conductors move through the magnetic field, and therefore an EMF is induced in them by the generator action. This induced EMF in the armature conductors acts in opposite direction to the applied voltage $\mathit{V_{s}}$ and is known as the back EMF or counter EMF.The magnitude of the back EMF is given by,$$\mathrm{\mathit{E_{b}}\:=\:\frac{\mathit{NP\phi Z}}{\mathrm{60}\mathit{A}}\:\cdot \cdot \cdot (1)}$$The back EMF $\mathit{E_{b}}$ is always less than the applied voltage $\mathit{V_{s}}$. However, this difference is small when the DC motor is running under normal conditions.In DC motors, the back EMF $\mathit{E_{b}}$ induced in the armature opposes the applied voltage, thus the applied voltage has to overcome this EMF $\mathit{E_{b}}$ to force a current $\mathit{I_{a}}$ in the armature circuit for motor action. The required power to overcome this opposition is given by,$$\mathrm{\mathit{P_{m}}\:=\:\mathit{E_{b}I_{a}}\:\cdot \cdot \cdot (2)}$$The power $\mathit{P_{m}}$ is one which actually converted into mechanical power. For this reason, the power $\mathit{P_{m}}$ is also called as electrical equivalent of mechanical power developed.Consider a shunt DC motor whose electrical equivalent circuit is shown in Figure-1.When a DC voltage $\mathit{V_{s}}$ is applied across terminals of the motor, the field electromagnets are excited and armature conductors are supplied with current. Hence, a driving torque acts on the armature which begins to rotate. When the armature rotates, a back EMF is induced in the armature conductors that opposes the applied voltage $\mathit{V_{s}}$. This applied voltage has to force a current through the armature conductors against the back EMF.The voltage equation of the dc motor can be expressed as,$$\mathrm{\mathit{V_{s}}\:=\:E_{b}+I_{a}R_{a}\:\cdot \cdot \cdot (3)}$$Where,$\mathit{R_{a}}$ is the resistance of the armature circuit.Then, the armature current of the DC motor is given by,$$\mathrm{\mathit{I_{a}}\:=\:\frac{\mathit{V_{s}-E_{b}}}{\mathit{R_{a}}}\:\cdot \cdot \cdot (4)}$$Since the applied voltage $\mathit{V_{s}}$ and armature resistance $\mathit{R_{a}}$ are usually fixed for a given motor, then the value of $\mathit{E_{b}}$ will determine the current drawn by the DC motor. If the speed of the DC motor is high, then the value of back EMF is large and hence the motor will draw less armature current and vice-versa.Significance of Back EMF in DC MotorThe back EMF in a DC motor makes it a self-regulating machine, which means it makes the motor to draw a sufficient amount of armature current to develop the torque required by the mechanical load.Now, from Equation-4, we may explain the importance of back EMF in the DC motor as Case 1 Motor running on no loadIn this case, the dc motor requires a small torque to overcome the frictional and windage losses. Thus, the armature current $\mathit{I_{a}}$ drawn by the motor is small and the back EMF is nearly equal to the supply voltage.Case 2 Motor load is changed suddenlyIn this case, when load is suddenly attached to the motor shaft, the armature slows down. Consequently, the speed at which the armature conductors move through the magnetic field is decreased and hence the back EMF decreases. This decreased back EMF allows a larger current to pass through the armature conductors, and larger armature current means high driving torque. Hence, it is clear that the driving torque increases as the motor speed decreases. The reduction in motor speed stops when the armature current is sufficient to produce the increased torque required by the mechanical load.Consider another situation, where the load on the motor is decreased. In this case, the driving torque is momentarily more than the requirement so that the armature is accelerated. The increase in the armature speed increases the back EMF, and causes the armature current to decrease. Once the armature current is just sufficient to produce the reduced driving torque required by the load, the motor will stop accelerating.This discussion clears that the back EMF in a dc motor automatically regulates the flow of armature current to meet the load requirements. Posted: May 20, 2021 What is a DC (Direct Current) Motor? A DC motor is any class of rotary electrical motors that converts direct current electrical energy into mechanical energy.The history of DC motors goes as far back as the 19th century. In 1832, a British scientist, William Sturgeon, created the first DC motor that had the ability to power machinery.Sturgeons initial development was further expanded upon by an American scientist, Thomas Davenport. Davenport is known for creating the first working DC motor, which he patented in 1837. However, Davenport ran into some issues with the cost of battery power while the motors were running. This made the motors ineffective to stand up over time.After the initial invention, created by Davenport, many other inventors began developing concepts. In 1834, Moritz von Jacobi, a Russian engineer, invented the first rotating DC motor. Jacobis motor became well known for its power, which would later set a world record. Jacobi went on to create an even more powerful motor, thus breaking his own record for power in 1838. The invention of this motor, by Jacobi, went on to further inspire others to expand and produce more DC motors of the same power.Antonio Pacinotti made a breakthrough in 1864 with the development of the ring armature. This piece has become crucial in the design of the DC motor; the ring armature carries the current through the grouped coils.Even with all of the developments throughout the 19th century, possibly the most important came in 1886. An inventor named Julian Sprague invented a DC motor that was capable of maintaining a constant speed under variable loads. Spragues invention would lead to the commercial use of the DC motor. This would include early variations of the electric elevator and electric trolleys. These developments led to high demand of the motors, for both commercial & residential usage. Today, DC motors are widely used in many industries, such as healthcare, food service and many industrial settings. The use of DC motors has made industry work far more efficient, with machines able to function with a dependable source of power and speed. DC motors have made many other industries far easier to function in their day to day faculties, by taking a lot of manual power off of humans or animals, and replacing it with motorized equipment. Many of us wouldnt know how to function in our everyday lives without DC motors. From dishwashers, to blenders, to medical equipment at the doctors office, many of us dont know just how ingrained DC motors are in our everyday life. We help provide the motors that you need for the equipment that you use or manufacture.If you are having any issues with your machinery or your current DC motor provider, please contact our experts today at Motor Specialty! A DC motor requires a starter for various crucial reasons:1). To control the initial inrush current: When a DC motor is started, there is no back electromotive force (EMF) as the rotor is stationary. This absence of back EMF results in a high initial current, known as inrush current, which can be damaging to the motors components and power supply due to excessive voltage drops.2). To protect the motor: The high inrush current can lead to overheating, potentially damaging the motors insulation and shortening its lifespan. A starter helps in gradually increasing the current, safeguarding the motor from thermal stress.3). To ensure smooth acceleration: A starter enables the motor to smoothly increase its speed, preventing mechanical stress on both the motor and the connected load. This controlled acceleration contributes to a longer lifespan for the equipment.4). To maintain system stability: In a complex system with multiple motors and electrical devices, starting a DC motor without a starter can cause instability in the power supply, resulting in voltage sags and affecting other equipment.5). To comply with safety standards: Many safety regulations mandate the use of starters to limit inrush current and protect the motor and electrical system from damage.Various types of starters are available for DC motors , such asResistor starters,Autotransformer starters, andElectronic starters,each serving the purpose of controlling the motors initial current and ensuring its safe operation.There are various types of starting methods for DC motors, which include:1). Resistor StartersIncorporate resistors in the armature circuit to restrict the initial current flow.These resistors are progressively bypassed as the motor accelerates.2). Autotransformer StartersEmploy an autotransformer to decrease the initial voltage supplied to the motor, thus limiting the initial current.3). Electronic StartersMake use of power electronics to regulate the voltage and current delivered to the motor, enabling precise management of the starting sequence.The utilization of a starter guarantees that the DC motor commences operation safely, functions effectively, and has an extended operational lifespan.You can also follow us on AutomationForum.co, Facebook and Linkedin to receive daily Instrumentation updates.You can also follow us on ForumElectrical.com, Facebook and Linkedin to receive daily Electrical updates. Basic operational voltage equation of a DC motor is given asE = Eb + IaRa and hence, Ia = (E - Eb) / RaNow, when the motor is at rest, obviously, the back emf Eb = 0. Hence, armature current at the moment of starting can be given as Ia = E / Ra. In practical DC machines, armature resistance is basically very low, generally about 0.5 . Therefore, a large current flows through the armature during starting. This current is large enough to damage the armature circuit.Due to this excessive starting current -the fuses may blow out and the armature winding and/or commutator brush arrangement may get damaged.very high starting torque will be produced (as torque is directly proportional to the armature current), and this high starting torque may cause huge centrifugal force which may throw off the armature winding.other loads connected to the same source may experience a dip in the terminal voltage.A large DC motor will pick up speed rather slowly due to its large rotor inertia. Hence, building up the back emf slowly causing the level of high starting current maintained for quite some time. This may cause severe damage. To avoid this, a suitable DC motor starter must be used. Very small dc motors, however, may be started directly by connecting them to the supply with the help of a contactor or a switch. It does not result in any harm because they gather speed quickly due to small rotor inertia. In this case, the large starting current will die down quickly because of the fast rise in the back emf. To avoid the above dangers while starting a DC motor, it is necessary to limit the starting current. So, a DC motor is started by using a starter. There are various types of dc motor starters, such as 3 point starter, 4 point starter, no-load release coil starter, thyristor controller starter etc.The basic concept behind every DC motor starter is adding external resistance to the armature winding during starting.From the followings, 3 point starters and 4 point starters are used for starting shunt wound motors and compound wound motors. The internal wiring of a 3 point starter is as shown in the figure.When the connected dc motor is to be started, the lever is turned gradually to the right. When the lever touches point 1, the field winding gets directly connected across the supply, and the armature winding gets connected with resistances R1 to R5 in series. During starting, full resistance is added in series with thearmature winding. Then, as the lever is moved further, the resistance is gradually is cut out from the armature circuit. Now, as the lever reaches to position 6, all the resistance is cut out from the armature circuit and armature gets directly connected across the supply. The electromagnet 'E' (no voltage coil) holds the lever at this position. This electromagnet releases the lever when there is no (or low) supply voltage.It can be seen that, when the arm is moved from the position 1 to the last position, the starter resistance gets added in series with the field winding. But, as the value of starter resistance is very small as compared to the shunt resistance, the decrease in shunt field current may be negligible. However, to overcome this drawback a brass or copper arc may be employed within a 3 point starter which makes aconnection between the moving arm and the field winding, as shown in the figure of 4 point starter below.When the motor is overloaded beyond a predefined value, 'overcurrent release electromagnet' D gets activated, which short-circuits electromagnet E and, hence, releases the lever and the motor is turned off. The main difference between a 3 point starter and a 4 point starter is that the no voltage coil (electromagnet E) is not connected in series with the field coil. The field winding gets directly connected to the supply, as the lever moves touching the brass arc (the arc below the resistance studs). The no voltage coil (or Hold-on coil) is connected with a current limiting resistance Rh. This arrangement ensures that any change of current in the shunt field does not affect the current through hold-on coil at all. This means, electromagnetic pull of the hold-on coil will always be sufficient so that the spring does not unnecessarily restore the lever to the off position. A 4 point starter is used where field current is to be adjusted by means of a field rheostat for the purpose of operating the motor above rated speed by reducing the field current. Construction of DC series motor starters is very basic as shown in the figure. The start arm is simply moved towards right to start the motor. Thus, maximum resistance is connected in series with the armature during starting and then gradually decreased as the start arm moves towards right. This starter is sometimes also called as a 2 point starter.The no load release coil holds the start arm to the run position and leaves it when the voltage is lost.Found this helpful? Share it with your network: 4-Channel ReDriver Boosts Signal Quality for High-Speed PCIe 5.0, SAS4, and CXL Interfaces June 17, 2025 High-Speed 4-Channel ReDriver Supports PCIe 6.0, 64GT/s, PAM4 in Latest Computing and Communication Systems June 11, 2025 6.5GHz Double-Pole-Triple-Throw Mux/DeMux with OVT for USB 2.0 and MHL Switching in Portable Applications May 6, 2025 A starter is a device to start and accelerate a motor. A controller is a device to start the motor, control and reverse the speed of the DC motor and stop the motor. While starting the DC motor, it draws the heavy current which damages the motor. The starter reduces the heavy currentand protects the system from damage.Need of Starters for DC MotorsThe dc motor has no back emf. At the starting of the motor, the armature current is controlled by the resistance of the circuit. The resistance of the armature is low, and when the full voltage is applied at the standstill condition of the motor, the armature current becomes very high which damage the parts of the motor.Because of the high armature current, the additional resistance is placed in the armature circuit at starting. The starting resistance of the machine is cut out of the circuit when the machine gains its speeds. The armature current of a motor is given by:Thus, Ia depends upon E and Ra, if V is kept constant. When the motor is first switched ON, the armature is stationary. Hence, the back EMF Eb is also zero. The initial starting armature current Ias is given by the equation shown below:Since, the armature resistance of a motor is very small, generally less than one ohm. Therefore, the starting armature current Ias would be very large. For example if a motor with the armature resistance of 0.5 ohms is connected directly to a 230 V supply, then by putting the values in the equation (2) we will get, This large current would damage the brushes, commutator and windings.As the motor speed increases, the back EMF increases and the difference (V E) go on decreasing. This results in a gradual decrease of armature current until the motor attains its stable speed and the corresponding back EMF. Under this condition, the armature current reaches its desired value. Thus, it is found that the back EMF helps the armature resistance in limiting the current through the armature.Since at the time of starting the DC Motor, the starting current is very large. At the time of starting of all DC Motors, except for very small motors, an extra resistance must be connected in series with the armature. This extra resistance is added so that a safe value of the motor is maintained and to limit the starting current until the motor has attained its stable speed.The series resistance is divided into sections which are cut out one by one, as the speed of the motor rises and the back EMF builds up. The extra resistance is cut out when the speed of the motor builds up to its normal value. Direct current flows only in one direction, which means it has a constant polarity across its terminals. Where an Alternating current periodically changes its direction of the current, that is an alternating polarity at the terminals.A rectifier is a circuit that converts AC to DC and this conversion process is called rectification. In simple words, a rectifier converts the bi-directional flow of current to a unidirectional flow, which maintains a constant polarity across the load. It can be done by either blocking the reverse flow of current or by redirecting the reverse flow to one direction.Half Wave rectifier theoryA half wave rectifier clips the negative half cycles and allows only the positive half cycles to flow through the load. Thus it utilizes only the one-half cycle of the input signal.During the positive half cycle (A- Positive & B- Negative) of the signal, the diode will be forward biased and conducts the current through the load resistance. And on negative half cycle (A- Negative & B- Positive), the diode will be reverse biased and prevents the current to flow in the opposite direction. So the polarity of the output terminals keeps unchanged and obtains a unidirectional current through the load.Half Wave Rectifier equations and valuesAverage voltage, Vaverage= Vm/ | Average Current, Iaverage= Im/Rms Voltage, Vrms = Vm/2 | Rms Current, Irms = Im/2Ripple factor = 1.21Maximum efficiency =40.6%Transformer utilization factor (TUF) = 0.287Form factor = 1.57peak factor = 2Full Wave rectifier theoryIt converts the complete cycles of the AC signal to DC. Both positive and negative half cycles of the AC signal is converted to a unidirectional flow of current.Full wave center tap rectifier circuitA center tapped full wave rectifierworks only with a center tap transformer or with a similar common potential point across the terminals. The center tap act as a common zero potential terminal in both half cycles.On the positive half cycle (A- Positive & B- Negative), the diode D1 is forward biased and diode D2 is in reverse biased. Hence the current flow through D1 and the load resistance, from terminal A to center tap.On the negative half cycle (A- Negative & B- Positive), the diode D2 is forward biased and diode D1 is reverse biased. Current flows through D2 and load resistance, from the B terminal to the center tap of the transformer.The biasing of diodes changes alternately with respect to change in the polarity of terminals.In the center tap rectifier, the output DC voltage will be half of the total output voltage of the secondary winding. Because the load is always on half of the secondary winding.Full Wave Bridge Rectifier circuitThe bridge rectifier consists of 4 diodes in a bridge circuit configuration. From a center tap rectifier, the bridge rectifier has a difference only in the circuit arrangement. The efficiency, ripple factor, average value, RMS value all are same except the transformer utilisation factor(TUF). Because in a center tap rectifier the transformer winding should consider separately.The bridge rectifier has an advantage over the center tap, that is it works without a center tapped transformer or a common ground.On the positive half cycle, (A- Positive & B- Negative) diode D2 & D3 are in forward biased. D1 & D4 are in reverse biased, thus the conduction path forms through diode D2, load resistance, and diode D3.Similarly, on the negative half cycle (A- Negative & B- Positive) diode D4 & D1 is in forward biased. Diode D3 & D2 are in reverse biased. Current flows through D4, load resistance and D1.The biasing of the diodes alternates in each half cycle and creates a same polarity across the load. Hence, in both half cycles the load resistance has the same direction of the current.Full wave Rectifier equations and valuesAverage voltage, Vaverage= 2Vm/ | Average Current, Iaverage= 2Im/RMS Voltage, Vrms = Vm/2 | RMS Current, Irms = Im/2Center tap rectifier, Transformer utilization factor (TUF) = 0.693Bridge rectifier, Transformer utilization factor (TUF) = 0.812Ripple factor = 0.482Maximum efficiency =81.2%Form factor = 1.11peak factor = 2Average value of rectifierThe arithmetic average of all the instantaneous values of a signal is called as its average value.Average value = area under curve / baseAverage value of sine waveThe average of a sinusoidal wave form can be calculated as,Average value = Area of a unit cycle/ base length of a unit cycleDerivation to mathematically find the resultant average value for a unit cycle of a sine wave,V = Vmsint, Vm Maximum Voltage or peak voltage, V Instantaneous voltage.The average value of a function f(x) on an interval [a, b] = (1/b-a) abf(x) dx.The area under the curve is the Integral of function f(x) in the interval from a to b. And the base length is the difference between the limits banda.For a unit cycle of a sine wave, the area of the region has obtained by integrating the sine wave equation and the base length from the difference of limits 0 and 2.Hence the average voltage, Vavg = Vm/2 02sint dt | Vm/2 is a constant value.= Vm/2 (0sint dt + 2sint dt) = Vm/2 [cost]0+ Vm/2 [cost]0.= Vm/2 [- cos + cos0] + Vm/2 [- cos2 + cos]Therefore, Vavg = Vm/2 [1+1] + Vm/2 [-1-1] = 2Vm/2 2Vm/2 = 0The average value of a sinusoidal alternating quantity for a complete cycle will be equal to zero. Because, the positive and negative half cycle is equal in magnitude and thus the total value cancels out on summation.Average value of Half wave rectifierNegative half cycles are absent in the output wave form of a half wave rectifier. So, in order to find the average value of the rectifier, the area under the positive half cycle has divided by the total base length.The area under the positive half cycle is the integral of sinusoidal wave equation from the limits 0 to . The total base length is the difference of limits of a complete cycle (2 0 = 2), which includes the base length of both the positive and negative cycles.The average output voltage of a half wave rectifier can be derived as,Average voltage, VDC= Vm/2 0sint dt= Vm/2 [cost]0 = Vm/2 [- cos + cos0]= Vm/2 [1+1] = 2Vm/2= Vm/The average voltage equation for a half wave rectifier is VDC = Vm/.Average value of Full wave rectifierIn a full wave rectifier, the negative polarity of the wave will be converted to positive polarity. So the average value can be found by taking the average of one positive half cycle.Derivation for average voltage of a full wave rectifier,The average voltage, VDC= Vm/ 0sint dt= Vm/ [cost]0 = Vm/ [- cos + cos0]= Vm/ [1+1] = 2Vm/Average voltage equation for a full wave rectifier is VDC = 2Vm/.So during calculations, the average voltage can be obtained by substitutingthe value of maximum voltage in the equation for VDC.RMS value of rectifierRMS (Root mean square) value is the square root of the mean value of the squared values.The RMS value of an alternating current is the equivalent DC valueof an alternating or varying electrical quantity. RMS value of an AC current produces the same amount of heat when an equal value of DC current flows through the same resistance.RMS value of a signal = Area under the curve squared / base length.For a function f(x) the RMS value for an interval [a, b] = (1/b-a) abf2(x) dx.RMS value of a sine waveRMS Value = Area of half cycle squared / half cycle base lengthThe RMS value of a sine wave can be calculated by just taking the half cycle region only. Because the area of positive half cycle squared and negative half cycle squared have the same values. So the derivation will be same as it for a full wave rectifier.So the RMS Voltage of a sine wave, VRMS = Vm/ 2, Vm Maximum voltage or peak voltage.RMS value of Half wave rectifierIn a half wave rectifier, the negative half cycle will be removed from the output. So, the total base length(2) should be taken from the interval 0 to 2.The RMS voltage, VRMS = Vm2/2 0sin2t dt= Vm2/2 0(1 cos2t) / 2) dt = Vm2/4 [t sin2t / 2]0= Vm2/4 [(sin) / 2 (0 (sin0) / 2)] = Vm2/4 ( ) = Vm2/ 4Therefore the RMS voltage, VRMS = Vm/ 2RMS value of Full wave rectifierThe RMS voltage, VRMS = Vm2/ 0sin2t dt= Vm2/ 0(1 cos2t) / 2) dt = Vm2/2 [t sin2t / 2]0= Vm2/2 [(sin) / 2 (0 (sin0) / 2)] = Vm2/2 ( ) = Vm2/ 2RMS voltage, VRMS= Vm/ 2Peak factor of rectifierThe peak factor is defined as the ratio of the maximum value to the RMS value of an alternating quantity.Peak factor = Peak value / RMS valueRMS voltage of a half wave rectifier, VRMS = Vm/2. Where Vmis the Maximum or peak voltage.Then the Peak factor of half wave rectifiercan be calculated as,Vm / VRMS = Vm / (Vm / 2) = 2 Vm / Vm = 2Similarly, For a full wave rectifier, the RMS voltage VRMS = Vm / 2Therefore, the Peak factor value of full wave rectifier = Vm / Vm/ 2= Vm 2 / Vm = 2 = 1.414Form factor of rectifierThe ratio of RMS value to the average value of an alternating quantity is known as its form factor.Form factor = RMS value / Average valueRMS voltage of a half wave rectifier, VRMS = Vm / 2 and Average Voltage VAVG= Vm/, Vmis the peak voltage.Form factor of half wave rectifier = VRMS/ VAVG=(Vm /2) / (Vm /)= Vm / 2 Vm = 1.57For a full wave rectifier, the RMS voltage VRMS = Vm / 2 and the average Voltage,VAVG = 2 Vm/ Form factor value of full wave rectifier = (Vm / 2) / (2Vm /)= Vm / 22 Vm = 1.11Ripple factor of rectifierThe ratio of theRMS value (root mean square) of the AC componentto the DC component of the output is defined as the Ripple factor and is denoted by .Ripple factor, = VAC/VDC |VDC is the average value of the DC output.VRMS= VDC2 + VAC2 or IRMS = IDC2 + IAC2VAC= VRMS2 VDC2Therefore the ripple factor equation is, = (VRMS2 VDC2)/ VDC2= (VRMS/ VDC)2 1To calculate the ripple factor of a half wave and full wave rectifier, just substitute the RMS and Average value of the respective rectifier in the above equation.Ripple factor of Half wave rectifierRMS Voltage of a half wave rectifier, VRMS = Vm / 2 | Vm is the peak voltage.Average Voltage of a halfwave rectifier, VAVG = Vm/ Ripple factor, = ([(Vm/ 2) / (Vm /)]2 -1) = (/ 2)2 1 = 1.21Ripple factor of Full wave rectifierRMS Voltage of a full wave rectifier, VRMS = Vm / 2Average Voltage of a full wave rectifier, VAVG = 2 Vm/ r = ([(Vm/ 2) / (2 Vm /)]2 1) = (/ (2 2))2 1 = 0.48Efficiency of rectifierThe ratio of DC output power to the AC input power of a rectifier is called as its efficiency. It is denoted by .Rectifier efficiency, = DC output power/input AC power = PDC / PACEfficiency of Half wave rectifierIRMS = Im / 2 , PAC=IRMS2 (rf + RL) = (Im / 2)2(rf + RL)Vmis the peak Current |PDC=IAVG2 RL= (Im /)2RLFor a half wave rectifier, the Efficiency =PDC / PAC= ((Im /)2RL) / ((Im / 2)2(rf + RL))= 4 RL / 2(rf + RL) = 0.405 RL / (rf + RL)Therfore the maximum efficiecy = 40.5%Efficiency of Full wave rectifierSimilarly for a full wave rectifier,IRMS = Im / 2 , PAC= (Im / 2)2(rf + RL)PDC= (2 Im /)2RLFor a half wave rectifier, the Efficiency =PDC / PAC= ((2 Im /)2RL) / ((Im / 2)2(rf + RL))= 8 RL / 2(rf + RL) = 0.810 RL / (rf + RL)Maximum efficiecy = 81.0%Hence we can see that, the efficiency of a full wave rectifier is double than that of a half wave rectifier. AC to DCRectifier circuitFilter circuitVoltage regulator circuit Coding Ground For Developers Code, Edit, Run and Share Ignite your coding potential on Coding Ground - an immersive online platform for hands-on learning, collaboration, and skill development. Java Compiler Python Compiler C++ Compiler HTML Editor DC Motor Starter is an additional external device which is required to be connected along with a dc motor, in order to start the motor in a safe manner. That means starting a dc motor without a starter is not safe for the motor. So we should understand the need of starter (Fig. 1). Fig. 1:DC Motor with Starter Need of a DC Motor StarterWe know that for a dc shunt motor,\[\text{V = }{{\text{E}}_{\text{b}}}\text{+ }{{\text{I}}_{\text{a}}}{{\text{R}}_{\text{a}}}\]And for a dc series motor,\[\text{V = }{{\text{E}}_{\text{b}}}\text{+ }{{\text{I}}_{\text{a}}}\left({{\text{R}}_{\text{a}}}\text{+ }{{\text{R}}_{\text{s}}} \right)\]Hence the expression for Ia are as follows:For dc shunt motor,\[\]\[{{\text{I}}_{\text{a}}}=\text{ }\frac{\text{V }{{\text{E}}_{\text{b}}}}{{{\text{R}}_{\text{a}}}}\]For dc shunt motor,\[{{\text{I}}_{\text{a}}}=\text{ }\frac{\text{V }{{\text{E}}_{\text{b}}}}{\left({{\text{R}}_{\text{a}}}\text{+ }{{\text{R}}_{\text{s}}} \right)}\]At the time of starting the motor, speed N = 0 and hence the back emf Eb = 0. Hence the armature current at the time of starting is given by,For a dc shunt motor,\[{{\text{I}}_{\text{a (starting)}}}=\text{ }\frac{\text{V}}{{{\text{R}}_{\text{a}}}}\]For a dc series motor,\[{{\text{I}}_{\text{a (starting)}}}=\text{ }\frac{\text{V}}{\left({{\text{R}}_{\text{a}}}\text{+ }{{\text{R}}_{\text{s}}} \right)}\] -.- dc series motorSince the values of Ra and Rs are small, the starting currents will extremely large if the rated voltage V is applied to the motor at the time of starting. The starting current of the motor can be 15 to 20 times higher than the lull load current. Such a high starting current has the following undesirable effects.Effects of high starting currentDue to very high starting current, the supply voltage will fluctuate. The fluctuations in supply voltage affects the other equipments operating on the same supply. Due to excessive current, the insulation of the armature winding may get damaged. The fuses will blow, circuit breakers will trip. For dc series motors the torque is\[\text{T}\propto \text{I}_{\text{a}}^{\text{2}}\]So an excessively large starting torque is produced. This can put a heavy mechanical stress on the winding and shaft of the motor resulting in mechanical damage to the motor. So in order to avoid all these effects we have to keep the starting current of the motor below the safe limits. This is so in order to avoid all these effects we have to keep the starting current of the motor below the safe limits. This is achieved by using a starter.Working Principle of DC Motor StarterDC Motor Starter is basically a resistance which is connected in series with the armature winding only at the time of starting the motor. Its job is to limit the starting current of the motor. The starter or starter resistance will remain in the circuit of the motor only at the time of starting and will go out of circuit or becomes ineffective when the motor speed reaches its desired value. The starter principle is illustrated in Fig. 1. At the time of starting. the starter is in the start position as shown in Fig. 2. So the full starter resistance appears in series with the armature. This will reduce the armature current of the motor at the instant of starting. The starter resistance is then gradually cutoff by moving it towards run position. The motor will speed up, back emf will be developed and it will regulate the armature current. The starter is not necessary then. So the starter is pushed to the Run position as shown in Fig. 3 under the normal operating condition. The value of starter resistance is zero in this position and it does not affect the normal operation.Fig. 2: At the time of startingFig. 3: Under normal operating conditionTypes of DC Motor StarterThere are two types of starters used for the DC shunt motors:Three point starter.Four point starter.In addition to this a two point starter is used for DC seriesmotor starting. A starter is an essential component required to start a DC motor. The primary function of the starter is to provide an initial boost of electrical energy to the motor's armature, enabling it to overcome the initial inertia and begin rotation. Without a starter, the motor would not start and could potentially damage the electrical circuit. To understand why a starter is necessary, it is essential to understand the working principle of a DC motor. A DC motor operates on the principle of Fleming's Left-hand rule, which states that when a conductor carrying current is placed in a magnetic field, it experiences a force perpendicular to both the direction of current and magnetic field. This force causes the conductor to rotate, which, in turn, drives the motor's shaft. However, to start the motor, an initial torque must be applied to overcome the motor's static friction and start the rotational motion. This initial torque is generated by an external force, such as a starter, which provides the required electrical energy to the motor's armature. The starter, typically a DC series motor, is connected in series with the motor's armature, and its magnetic field is used to provide the initial torque. When the starter is energized, the magnetic field generated by the starter interacts with the magnetic field of the motor's armature. This interaction generates a torque that causes the armature to rotate. As the armature begins to rotate, the magnetic field generated by the armature increases, which, in turn, increases the torque provided by the starter. Once the motor reaches its rated speed, the starter is switched off, and the motor continues to run under its own power. The need for a starter is particularly crucial in high-power applications, such as industrial machinery, where the starting current drawn by the motor can be several times higher than the motor's rated current. This high starting current can cause significant damage to the motor and electrical circuit if not controlled properly. The starter serves as a current limiter, limiting the initial current drawn by the motor to a safe level. In addition to providing an initial boost of electrical energy, the starter also serves other essential functions, such as protection against overloading and under-voltage. The starter contains protection devices, such as overload relays and under-voltage relays, which protect the motor from damage due to overloading or low voltage. In conclusion, a starter is an essential component required to start a DC motor. It provides an initial boost of electrical energy to the motor's armature, enabling it to overcome the initial inertia and begin rotation. The starter also serves as a current limiter, protecting the motor and electrical circuit from damage due to high starting currents. In high-power applications, the need for a starter is particularly crucial as it prevents damage to the motor and electrical circuit and ensures reliable operation of the system. Starters are used to protect DC motors from damage that can be caused by very high current and torque during startup. They do this by providing externalresistance to the motor, which is connected in series to the motors armature winding and restricts the current to an acceptable level.To see why DC motors experience high startup current, we can examine the voltage equation of a DC motor:Image credit: circuitglobe.comWhere:E = supply voltageEb = back EMFIa = armature currentRa = armature resistanceBack EMF is directly proportional to the motors speed, so at startup, when motor speed is zero, back EMF is also zero. Therefore, removing the Eb term and rearranging the voltage equation, we can see that, at startup, armature current is inversely proportional to armature resistance.For the best motor performance, armature resistance in DC motors is kept very low (typically less than 1 ohm).To see how significantly this affects the starting current, we can assume that armature resistance (Ra) is 0.4 ohm and supply voltage (E) is 220 V. This gives a starting current (Ia) of 550 amps, whichcan be more than tentimes the rated current, and high enough to damage the internal motor circuit.Not only canthe high startup current result inpotential motor circuit damage, it can also produce dangerously high torque, which can cause the rotor to literally break apart. From the DC motortorque equation, we can see that torque is directly proportional to current:Where:T = torqueka= torque constant = motor flux To combat these problems, a motor starter adds external resistance (Rs) to the armature winding, which reduces the armature current:But this resistance doesnt need to be present through the motors full operating speed range. As motor speed increases, back EMF develops, which counters the supply voltage and also has the effect of reducing armature current:As the back EMF reaches its maximum, the starter progressively decreases the external resistance, Rs, to zero. Types of DC motor startersShunt wound and compound wound DC motors typically use either a 3 point or 4 point starter. The name comes from the number of terminals that connect to the motor, with 3 point starters having three terminals: the armature terminal, which is connected to the motor armature winding; the line terminal, which is connected to the positive supply pole; and the field terminal, which is connected to the field winding.Four point starters are virtually identical to 3 point starters, but they have an additional terminal, labeled the N terminal, which links the supply to the no voltage coil of the starter. This protects against unnecessary tripping when the motor is run above its normal speed. Series wound motors typically use 4 point starters.A 4 point starter is essentially the same as a 3 point starter, with the addition of a fourth terminal, labeled N.Image credit: electrical4u.comThree point and 4 point starters are manually controlledby an operator, whoadjusts theresistance thats delivered to the motor through a simple lever or handle. But electronic starters are also available, using a micro controller and thyristors to regulatethe resistance delivered to the motor. A more recent development are starters that use voltage chopping, rather than resistance, to limit the startup current. Chopping the frequency of the input voltage varies itsratio of on-time versus off-time. Thisallows the average voltage to be controlled, so that armature current is kept to an acceptable level while speed (and, thus, back EMF) is developed.Feature image credit: ABBBy David Birks, Applications Engineer, Diodes IncorporatedDC electric motors have been around for nearly two hundred years, with a steady series of refinements in that time. More recently, brushless DC motors have become increasingly popular but for many applications brushed DC motors are still the right choice. Brushed motors are lower cost and are simpler to drive, so they remain a popular option.In this article, well explain the basics of brushed DC motors, and then look at the circuitry required to drive them. Well also introduce brushless DC motors and their pros and cons.Brushed DC Motor BasicsGoing back to basics, the fundamental principle of an electric motor is, of course, that it converts electricity into motion. It does this through the interaction between magnets, one of which is typically created by passing a current through wire bound around a ferrite core. The current flowing through the wire generates the second magnetic field. This interacts with the primary magnetic field to create an opposing force that moves one part of the motor, usually causing it to rotate around an axle.Brushed DC motors consist of four key components; the stationary magnet (called a stator), the rotor, the commutator and the brushes (see Figure 1). The rotor consists of one or more windings of wire wrapped around a core made of a ferrous metal, usually iron, and connected to power with a metal brush. When we send current through the rotor windings, the field generated interacts with the stator's field and creates the force that turns the rotor. The stator can be a permanent magnet or electromagnet, depending on the requirements of any particular application.Thats all very well but if we just used regular wires to connect the rotor windings to the power supply, once the rotor has turned far enough its magnetic force would effectively reverse direction so the rotor would just move back and forth, instead of rotating in one direction.To fix this we use the commutator, which is a conductive copper sleeve around the axle of the rotor, physically and electrically divided into segments. As the commutator rotates it connects and disconnects these segments through the brushes, applying power to different pairs of segments. This causes the polarity of the magnetic field to reverse each time the motor rotates 180, resulting in smooth and continuous rotation. Figure 1: Two Pole Brushed MotorThe Alternative: Brushless DC MotorsAs its name suggests, a brushless DC motor has no brushes. Instead it uses transistors in the electronic control circuitry to apply and remove power to the rotor's wire, producing an alternating current from a DC supply to reverse the current on each half-cycle, achieving continuous rotation.Brushless DC motors are typically smoother and more efficient than brushed motors, have higher torque-to-power ratios and offer higher speeds with more precise control. With no wear on a brush or commutator, they need less maintenance and have a longer operational life. However, one of the main drawbacks of the brushless motor is cost: of the motor itself, and of the more complex drive circuitry thats needed.To provide continuous motion, the brushless motors controller reverses the direction, or phase, of the current each time the motor rotates 180 degrees, or another fixed amount such as 120 degrees for a 3-phase motor.Varying the control voltage may be achieved with analog components, or digitally using an FPGA or microcontroller. The control circuitry needs to be aware of the relative angular position of the motor, so it can activate the correct phase at the right time. This can be achieved with sensors, by using an optical encoder or Hall effect sensor, or without sensors by inferring the rotational angle from the back EMF generated by the magnetic field. In either case, an all-in-one motor driver is often used which integrates the required functions into a single chip.Drive Circuits for Brushed MotorsIn principle, as discussed above, a brushed motor does not require an external controller, as the change of magnetic field polarity is implemented through the brushes making and breaking the electrical pathway through the windings, achieving continuous rotation in one direction.For some applications, thats good enough. But if we want to be able to change the speed of the motor, or reverse the direction of rotation, we need a drive circuit. This can be as simple as just reversing the direction of current flow to make the motor turn the other way.To change speed we could alter the voltage, using a potential divider with speed being proportional to voltage. However, reducing the voltage in this way is inefficient, as a voltage divider does not reduce the total current flowing. To overcome this, pulse width modulation (PWM) is often used, which involves rapidly switching the current off and on to reduce the average voltage across the motor.Lets look at an example of a simple single-direction application, such as a toy. For this, we only need a single transistor and a flyback diode, which provides a route to dissipate the back EMF that could otherwise cause damage (see Figure 2).To enable the speed to be varied, we need a transistor that can deliver the required power and can be switched on and off by a control signal. An example of this is the DMTH4008LFDFWQ from Diodes Incorporated, a rugged MOSFET device that operates at up to 175C. The device offers high power density, with up to 40V and 11.6A being handled in a compact 2mm x 2mm package. Figure 2: Single Direction Brushed DC Motor ControlIf changing the motor's direction of rotation is required, it can be achieved using an H-bridge' circuit, so called because it uses four transistors to control the flow of current (see Figure 3). When the two transistors Q1 and Q4 are switched on, current flows through the motor (labelled BDC in Figure 3) from left to right, making it rotate. Switching Q1 and Q4 off, and turning Q2 and Q3 on, causes the current to flow from right to left through the motor, causing it to rotate in the opposite direction. Figure 3 also shows that we still need a flyback diode for each transistor, as in the single-transistor circuit discussed earlier. In practice, the body diode of the transistor provides this functionality. Figure 3: H-Bridge Gate ArrangementThere are now devices available that integrate all four transistors of the H-bridge into one package, such as the DMHC4035LSDQ. This forms an H-bridge that can switch up to 3A. It is provided in the SO-8 package and is qualified for automotive applications, based on the rigorous AEC-Q101 standard. This device can also be used to control a single-phase brushless motor.ConclusionBrushed DC motors may seem less glamorous than their brushless cousins but they deliver reliable, proven performance that needs less complicated drive circuitry keeping overall costs to a minimum.Choosing the right motor for any given application depends on the specific requirements of that application. Is precise control of the motors position required, with the smoothness of motion offered by brushless motors, or can a simpler, lower cost brushed alternative provide a better solution? Is it important to avoid wear and maintenance, which a brushless motor can deliver, or does the application's motor operate so rarely that deterioration of the brushes and commutator is a low priority?If the application does not justify the higher cost and complexity that come with the features offered by a brushless motor, then a brushed DC motor, coupled with the right drive circuit design, can still provide a very appealing solution. Your browser does not support the video tag. At Motor Specialty Inc. we design and manufacture custom universal, shunt wound, permanent magnet fractional & integral horsepower electric motors, gearmotors and armatures & fields up to 2 HP, 12 volts to 240 volts.We can design or modify existing models to your specifications with various mounting options available to meet your needs. Motor Specialty Inc. has been serving OEMs with quality motors for over 75 years. Company History - Elliot Snyder, Ridge Tool Co.

Why are starters needed in dc motors. Why are starters used in dc motors.