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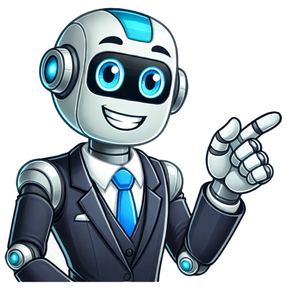

Voltage drop is the amount of voltage reduction that occurs in all components of the circuit caused by impedance when current flows through it. Therefore, the voltage at the receiving end of the circuit is always less than the voltage at the sending end of the voltage source. The voltage difference between both ends is called voltage drop (VD) or potential drop (PD).In an electrical system, different losses may occur to decrease the overall output and efficiency of that system. This article describes the effects of voltage drop (VD) in an electrical system.Voltage drop (VD) is the decrement in the electrical potential within a circuit or a conductor due to the resistance offered by the current passing through that circuit or conductor.Electrical current faces resistance in its pathway and increases the potential drop in the form of heat. This process is undesirable as this causes a loss of energy across sources of energy, conductors, and contacts.VD varies proportionally in load with the useful load power that must be converted into other useful energy. You can understand the concept from this example, one circuit (it may be a heater) has a resistance of 20 ohms but the conductor/wire that supplies the circuit’s current has 0.4 ohms resistance. It implies that there will be about 4% loss in the supply voltage because of connecting wires.In different countries, there is a different maximum limit of voltage drop (VD) in electrical loads to enhance and maintain the efficiency of an electrical system.   Voltage drop occurs due to different factors that contribute to the voltage loss in an electrical circuit. One of the main reasons for dropping voltage is the resistance or impedance of a conductor. The resistance restricts the flow of electrical current by offering hindrance in its way. Here the energy dissipates in heat form that eventually, drops the potential in a circuit.Here are some more factors that cause voltage drop:Current Magnitude: If the amount of current increases in a circuit, it will increase the VD in that circuit. This is given by Ohm’s law formula, i.e. V = IR.Material of Conductor: Different materials have different resistivity that affect the resistance in that material. Higher resistivity means higher resistance and eventually it will have a large VD. Temperature: Materials with a positive temperature coefficient have more voltage drop due to the higher temperature of the materialBy understanding the causes of potential drops, individuals should design/select the appropriate circuit or material that can offer less VD.There are different elements that cause a potential drop in a circuit. The resistor is a passive element that primarily introduced resistance in a circuit. The followings are the elements responsible for potential drop(PD).Resistor (DC Circuit)Capacitor (AC Circuit)Inductor (AC Circuit)The current faces opposition while passing through a conductor. Ohm’s law and Kirchhoff’s law state to provide the amount of voltage reduction. According to Kirchhoff’s law, the reduction in voltage across all components is equal to the supply voltage. The voltage drop will appear in the form of heat.Similarly, in the case of an AC circuit, current face reactance (another type of current opposing parameter). The combination of reactance and resistance is called impedance (Z). For AC current circuit, Ohm’s law becomes as,Where V is the VD, I is the circuit current, and Z is the impedance of the AC circuit.The energy is dissipated in the form of heat caused by VD in the source’s internal resistance, across contacts, conductors, and components.The VD in a circuit can be calculated using Ohm’s law. The formula for calculating the voltage drop in a DC circuit is;Where,I – Current flowing in the circuitR= Resistance of the circuitAccording to this formula, the VD is directly proportional to the current passing through a resistor and its resistance.To calculate voltage drop in an AC circuit, we can use the following formula,Where,I – Current flowing in the circuitZ= Impedance of the circuitThe power factor of the AC circuit plays a very important role in voltage drop in the AC circuit. The poor power factor causes more voltage drop in the circuit because it causes an increase in line current.The voltage drop (Line to neutral) in the AC circuit is;The voltage drop formula (Line-Line) in an AC circuit is given by;Electrical systems face opposition in the current flowing passage due to resistance. Significance of voltage drop lies in its effects on the performance, efficiency, and safety of electrical components and systems.The following factors should be considered.Power Loss: Potential drop causes loss in power of a system. Energy will be converted into waste in the form of heat. It can lead to the use of more conductors to compensate for the voltage drop. This can also cause cost increases.Design of Electrical System: VD must be considered to design electrical circuits, equipment, or panels. The conductor and wire must be selected to minimize the voltage drop.Performance: Excessive potential drop may cause the poor performance of equipment. The following steps can be taken to measure the potential drop in the circuit.Measure the source voltage. Let it be V1Measure the voltage across the load. Let it be V2.Find the difference between V1 and V2.The difference between V1 and V2 is the voltage drop in the circuit.VD in the above example is;Thus, the voltage drop in the connecting wires is 4 Volts.The potential drop in the circuit depends on the current and the resistance of the circuit. It is possible to reduce the VD by either decreasing the circuit resistance or by decreasing the load current. The load current of the equipment is fixed and in this case, the voltage drop can be reduced by reducing the circuit resistance. The following steps can be taken to reduce the potential drop in the circuit.By selecting the Thicker Wires- The resistance of the wire is inversely proportional to the cross-section area. If you select a thicker wire, the resistance of the wire will be less and it leads to lower circuit resistance. This approach of reducing VD is suitable for AC and DC circuits.By Improving the Power Factor of AC Circuit- The line current increase if the power factor of the load is low. The reactive current drawn by the load causes more voltage drop because of increased line current. Installing a capacitor bank across the load can improve the power factor. The capacitive reactive current drawn by the capacitor nullifies the inductive reactive current and eventually, the line current reduces, resulting in the reduction in voltage drop.Electrical systems face potential drop due to opposition faced in the flow of current. This behavior decreases the system’s efficiency. VD occurs due to resistance in a circuit or conductor. The potential drop can be more or less depending on the resistivity and type of material of a conductor. We should select materials that offer less voltage drop to achieve maximum efficiency it. Numerical Example (1): Consider a 10 ohms resistor in a circuit and 2 amperes current is flowing through it. Calculate VD across the resistor.Solution:Given, R = 10 ohms, I = 3AUsing the voltage drop formula,Numerical Example (2): Consider a 100-meter-long copper wire with a cross-sectional area of 2 square millimeters. If 5 amperes of current passes through it, calculate its potential drop. Use resistivity of 1.68 x 10-8 ohm-meter for copper.Solution:Give data is,Length (L) = 100 metersCross-sectional area (A) = 2 square millimeters= 2 x 10-6 square metersCurrent (I) = 5 amperesResistivity (ρ) = 1.68 x 10-8 ohm-meterIn order to calculate the resistance (R), we use the formulaPutting the values, we get,Now using the voltage drop formula, Decrease in electric potential along the flow of current in a circuit Not to be confused with Voltage droop. In electronics, voltage drop is the decrease of electric potential along the path of a current flowing in a circuit. Voltage drops in the internal resistance of the source, across conductors, across contacts, and across connectors are undesirable because some of the energy supplied is dissipated. The voltage drop across the load is proportional to the power available to be converted in that load to some other useful form of energy. For example, an electric space heater may have a resistance of 10 ohms, and the wires that supply it may have a resistance of 0.2 ohms, about 2% of the total circuit resistance. This means that approximately 2% of the supplied voltage is lost in the wire itself. An excessive voltage drop may result in the unsatisfactory performance of the space heater and the overheating of the wires and connections. National and local electrical codes may set guidelines for the maximum voltage drop allowed in electrical wiring to ensure efficiency of distribution and proper operation of electrical equipment. The maximum permitted voltage drop varies from one country to another.[1] In electronic design and power transmission, various techniques are employed to compensate for the effect of voltage drop on long circuits or where voltage levels must be accurately maintained. The simplest way to reduce voltage drop is to increase the diameter of the conductor between the source and the load, which lowers the overall resistance. In power distribution systems, a given amount of power can be transmitted with less voltage drop if a higher voltage is used. More sophisticated techniques use active elements to compensate for excessive voltage drop. Ohm's law can be used to determine the DC voltage drop by multiplying current times resistance: V = I R. Also, Kirchhoff's circuit laws state that in any DC circuit, the sum of the voltage drops across each component of the circuit is equal to the supply voltage. Consider a direct-current circuit with a nine-volt DC source; three resistors of 67 ohms, 100 ohms, and 470 ohms; and a light bulb—all connected in series. The DC source, the conductors (wires), the resistors, and the light bulb (the load) all have resistance; all use and dissipate supplied energy to some degree. Their physical characteristics determine how much energy. For example, the DC resistance of a conductor depends upon the conductor's length, cross-sectional area, type of material, and temperature. If the voltage between the DC source and the first resistor (67 ohms) is measured, the voltage potential at the first resistor will be slightly less than nine volts. The current passes through the conductor (wire) from the DC source to the first resistor; as this occurs, some of the supplied energy is "lost" (unavailable to the load), due to the resistance of the conductor. Voltage drop exists in both the supply and return wires of a circuit. If the voltage drop across each resistor is measured, the measurement will be a significant number. That represents the energy used by the resistor. The larger the resistor, the more energy used by that resistor, and the bigger the voltage drop across that resistor. AC voltages additionally have a second kind of opposition to current flow: reactance. The sum of resistance and reactance is called impedance. Electrical impedance is commonly represented by the variable Z and measured in ohms at a specific frequency. Electrical impedance is computed as the vector sum of electrical resistance, capacitive reactance, and inductive reactance. The amount of impedance in an alternating-current circuit depends on the frequency of the alternating current and the magnetic permeability of electrical conductors and electrically isolated elements (including surrounding elements), which varies with their size and spacing. Analogous to Ohm's law for direct-current circuits, electrical impedance may be expressed by the formula E = I Z. So, the voltage drop in an AC circuit is the product of the current and the impedance of the circuit. Main articles: Diode and Light-emitting diode P–n junctions in diodes and transistors experience a characteristic voltage drop when forward-biased (see Diode § Forward threshold voltage for various semiconductors for a list of values). The energy is dissipated through photons, which for the case of light-emitting diodes are emitted and visible. Electronics portal Brownout (electricity) Capacitive dropper Electric power distribution Electrical resistivity and conductivity Ground loop (electricity) Kirchhoff's voltage law Mesh analysis Power cable Voltage divider Voltage droop ^ "Voltage drop - maximum, determination, calculation of voltage drop". Archived from the original on 2010-03-06. Retrieved 2010-03-06. 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Assuming there was no solar to account for, the transformer in your neighbourhood may be set to pump out voltage at 250 volts. See also What is a force kids definition?Does voltage drop over distance? Any length or size of wires will have some resistance, and running a current through this dc resistance will cause the voltage to drop. As the length of the cable increases, so does its resistance and reactance increase in proportion. How do you increase voltage drop? Decreasing Temperature of Conductor. In regards to the flow of power, high temperatures of conductors will resist the flow and will cause the voltage drop percentage to rise. Decreasing the Length of Conductor. Increasing Quantity/Size of the Conductors. Reducing the Power Load. What is voltage drop in parallel circuit? In the parallel circuit diagram, the voltage drop across a resistor in a parallel circuit is the same across all resistors in each branch of the parallel circuit. 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In a linear circuit of fixed resistance, if we increase the voltage, the current goes up, and similarly, if we decrease the voltage, the current goes down. Why does voltage drop but not current? This is due to the gap in between the switch. So the applied energy is not converted to current even though the resistance is still there. Hence voltage will be there, where you applied it. Voltage applied to a series circuit is equal to the sum of the individual voltage drops. The voltage drop across a resistor in a series circuit is directly proportional to the size of the resistor. If the circuit is broken at any point, no current will flow. In a simple definition, the Voltage drop in an electrical or electronic circuit is the lowering or decreasing of electric potential along with the path of the flow of electric current in that circuit. There is no practical electrical or electronic circuit where voltage drop does not occur. In all the closed electrical or electronic circuits, a voltage drop occurs.Here is the list of places where voltage drop occurs,Internal Resistance of the Power SourceAcross current-carrying conductorsAcross electrical contactsAcross electrical or electronic componentsAcross the electrical loadAcross connectorsResistance and the flow of current, both are the main responsible factors for voltage drop.An ideal power source has no internal resistance but a practical power source has internal resistance. So, when a load is connected to the power source current starts flowing from the power source to the load through the internal resistance. So, as the current flows through the internal resistance, it also creates a voltage drop.Generally, all the wires or electrical conductors have internal resistance depending upon the properties of the manufacturing material. So when those conductors conduct current, a voltage drop will occur due to their internal resistance.Voltage drop occurs in an electrical contact due to the contact resistance. This contact resistance depends upon the size of contacts, area of the contact point, properties of contact material, strength or tightness of the contact, etc.Almost all the electrical or electronic components have an internal resistance that is constant. So, due to that, a constant voltage drop occurs when they are connected in a circuit. Also, resistance property changes in some components due to the nature of the flowing current, frequency, etc. So, for those variable voltage drops occurs.Electrical loads are those that actually consume electrical power. An electrical load only makes a higher voltage drop. This depends upon the internal resistance of the load and the current consumed by the load.Read Also: [Main] Difference between Cell and Battery ExplainedThe formula for voltage drop is very simple. If you don't know the internal resistance of the circuit then the voltage drop can be calculated by subtracting the receiving end voltage from the sending end voltage.So, the voltage drop Vd = Vs-VrLet's understand with a circuit example.No, if we calculate the voltage drop,Read Also: [Main] Difference Between Voltage and EMF Explained1. Voltage Drop causes to decrease or reduction in the voltage from the actual source voltage to load voltage.2. Voltage drop causes to decrease in the flow of electric current also.3. Voltage drop produces power loss in the circuit, or it wastes electrical energy.4. Voltage drop can step down both AC and DC voltage.5. Voltage drop makes the circuit less efficient.Read Also: Resistance Reactance Difference, Effects, Example, Application1. Rheostat works on the principle of voltage drop. It steps down voltage by dropping the voltage.2. Old or conventional electrical fan regulator also works on the principle of voltage drop. It varies voltage across the ceiling fan coil and the flow of current by varying the voltage drop in its variable resistor.3. Transformerless power supply with series capacitor also works on the principle of voltage drop but here the voltage drop happens due to the capacitive reactance, not resistance.Read Also: Thank you for visiting the website. keep visiting for more updates. Voltage drop is the reduction in electrical potential (voltage) as electric current flows through a conductor, such as a wire or cable, due to the inherent resistance or impedance of the conductor. It is a natural phenomenon that occurs in all electrical circuits.To calculate the voltage drop specifically for a cable in an electrical circuit, you can use the following formula:Vd = (I * L * R * 2) / (1000 * K)Where:Vd is the voltage drop (in volts).I: is the current in amperes (A) flowing through the cable.L is the length of the cable in feet (ft).R is the resistance of the cable material in ohms per 1000 feet (Ω/1000 ft).K is the circular mils (CM) or circular mil area (CMA) of the cable’s cross-sectional area.This formula is commonly used to calculate voltage drop in cables. Here’s how you can use it:Determine the current (I) flowing through the cable, which is the load current or the current drawn by the connected devices.Measure the length of the cable (L) in feet. If you’re working with meters, you can convert them to feet (1 meter ≈ 3.28084 feet).Find the resistance of the cable material (R) in ohms per 1000 feet. This value is typically provided in cable specifications or reference materials. It depends on the type and size of the cable.Calculate the circular mils (CM) or circular mil area (CMA) of the cable’s cross-sectional area. This involves knowing the cable’s diameter and the specific cross-sectional shape (e.g., round, flat).Plug the values into the formula to calculate the voltage drop (Vd).Remember to consider the units consistently. The formula assumes that the length is in feet, the resistance is in ohms per 1000 feet, and the current is in amperes. The result will be in volts.Let’s go through an example of how to calculate the voltage drop for a cable using the formula I provided earlier:Suppose you have a 120-volt electrical circuit, and you want to calculate the voltage drop for a 100-foot length of 12-gauge copper wire (which has a resistance of approximately 1.588 ohms per 1000 feet) carrying a current of 10 amperes.Current (I): The current flowing through the cable is 10 amperes (I = 10 A).Length of Cable (L): The cable length is 100 feet (L = 100 ft).Resistance of the Cable (R): For 12-gauge copper wire, the resistance is approximately 1.588 ohms per 1000 feet. So, for 100 feet, the resistance is (1.588 Ω / 1000 ft) * 100 ft = 0.1588 ohms.Circular Mil Area (CMA): The circular mil area depends on the cable’s specific cross-sectional shape and size. Let’s assume a round cable with a CMA of 6530 circular mils.Now, we can calculate the voltage drop (Vd):Vd = (I * L * R * 2) / (1000 * K) Vd = (10 A * 100 ft * 0.1588 ohms * 2) / (1000 * 6530 circular mils)Let’s calculate this step by step:10 A * 100 ft = 1000 A*ft0.1588 ohms * 2 = 0.3176 ohms(1000 A*ft * 0.3176 ohms) / (1000 * 6530 circular mils) = 0.0486 voltsSo, the voltage drop for this 100-foot length of 12-gauge copper wire carrying a 10-ampere current is approximately 0.0486 volts or about 48.6 millivolts.Cable voltage drop occurs due to several factors, primarily associated with the electrical and physical properties of the cable and the system it operates in. Here’s a detailed explanation of the causes:Material: Conductors like copper and aluminum have inherent electrical resistance. Copper has lower resistance compared to aluminum, making it a better choice for reducing voltage drop.Length of Cable: Longer cables have more resistance because the electrons encounter more obstacles as they travel through the conductor.Cross-sectional Area: Smaller cable diameters (thinner cables) have higher resistance, which leads to greater voltage drop. Increasing the cross-sectional area reduces resistance.Load Current: Higher current causes a larger voltage drop because the voltage drop (VVV) is directly proportional to the current (III) and resistance (RRR) of the cable, as given by Ohm’s Law: V=I·RV = I \cdot RV=I·RInductive Reactance: In AC systems, the cable’s inductance contributes to voltage drop. This becomes significant in long cables or when high-frequency currents are involved.Capacitive Reactance: While typically less significant, capacitive reactance can play a role, especially in cables with high capacitance or long lengths.Higher temperatures increase the resistance of the conductor. As current flows through the cable, it generates heat, which in turn raises the resistance and exacerbates voltage drop.Low power factor loads (e.g., inductive loads like motors) cause more voltage drop because the apparent power increases. This increases the current flowing through the cable, contributing to additional drop. Read my detailed article Power Factor Correction: Questions and AnswersPoor connections or joints add extra resistance, leading to localized voltage drops. Proper installation and maintenance are crucial to minimize this.Uneven or unbalanced loads in three-phase systems can result in higher current in one phase, causing more voltage drop in that phase.Excessive voltage drop can lead to:Reduced efficiency.Overheating of cables.Poor performance of connected equipment.Potential equipment damage.Excessive voltage drop can have serious consequences for both the performance and safety of an electrical system. Here’s a detailed breakdown of the points:1. Reduced Efficiency of Electrical SystemsEnergy Loss: Voltage drop causes energy to be wasted as heat in the conductor. This reduces the efficiency of the system because not all the electrical energy supplied is available for use by the load.Increased Operating Costs: Over time, this wasted energy can result in higher electricity bills, especially in systems that run continuously or under heavy loads.2. Malfunctioning or Inefficient Operation of EquipmentUnderperformance: Electrical equipment often requires a specific voltage to operate correctly. If the voltage drops too much:Motors may not start or may run inefficiently.Lights may dim or flicker.Electronic devices may fail to function properly or shut down.Shortened Lifespan: Prolonged operation at low voltage can strain equipment, causing premature wear and tear.For more information read my other article Boost Motor Efficiency with Voltage Drop Solutions3. Overheating of CablesIncreased Resistance Effects: Excessive voltage drop increases the current drawn to maintain power at the load. This higher current causes more heat to build up in the conductor, potentially leading to:Insulation breakdown.Fire hazards in extreme cases.Safety Risks: Overheated cables are a serious safety concern and can result in dangerous electrical fires if not addressed.4. Impact on Compliance with StandardsElectrical codes and standards typically specify acceptable voltage drop limits (e.g., 3% for lighting circuits, 5% for general power circuits). Exceeding these limits may result in non-compliance, which could:Void warranties for certain equipment.Lead to penalties or require costly system upgrades to meet compliance.Summary of Why It Matters:Voltage drop is more than just an engineering issue; it directly affects:System Reliability: Ensures consistent performance.Energy Efficiency: Reduces energy waste.Safety: Prevents overheating and potential fire risks.Cost-Effectiveness: Saves money in the long run by avoiding equipment damage and high energy bills.Understanding and managing voltage drop is essential for designing efficient, safe, and cost-effective electrical systems.Voltage drop must be kept within certain limits to ensure electrical systems operate efficiently, safely, and reliably. These limits vary depending on the application and the relevant electrical standards or regulations. Here’s a more detailed explanation:Performance: Electrical devices are designed to operate within a specific voltage range. Excessive voltage drop can lead to underperformance or damage to these devices.Energy Efficiency: High voltage drop means more energy is wasted as heat in the conductors, reducing overall system efficiency.Safety: Excessive voltage drop can lead to overheating of cables, increasing fire risks.While exact values depend on local standards and regulations, commonly accepted limits include:Lighting Circuits:Voltage drop should not exceed 3% of the supply voltage.Reason: Lighting circuits are sensitive to voltage fluctuations. Even small drops can cause lights to dim or flicker, which is undesirable and inefficient.Power Circuits (General Loads):Voltage drop should not exceed 5% of the supply voltage.Reason: Power circuits typically supply devices like motors, appliances, and general equipment that are more tolerant to voltage variation than lighting but still require a stable supply for optimal performance.To manage voltage drop effectively:Select the Right Cable Size:Use conductors with a larger cross-sectional area to reduce resistance.Larger cables cost more upfront but save energy and maintenance costs in the long run.Minimize Cable Length:Reduce the distance between the power source and the load. Shorter cables mean lower resistance and less voltage drop.Optimize Load Distribution:Balance loads across circuits to avoid overloading any single cable.Improve Power Factor (for AC Systems):Use power factor correction devices to reduce reactive power, which increases apparent current and voltage drop.Regular Maintenance:Check and tighten connections, as loose or corroded joints can increase resistance.Electrical Cables Most Common Tables “Cables Tables”And, my Electrical Calculations App “Fast Electrical Calculator”Looking to stay ahead of the game in the world of electrical engineering? Subscribe to my YouTube channel and gain access to exclusive content you won’t find anywhere else!(Amazon Affiliate Links to products I believe are high quality):Disclaimer: This contains affiliate links to Amazon products. I may earn a commission for purchases made through these links.