What is maximum power transfer?In DC circuits this theorem state that the source can transfer maximum power when the total resistance viewed from the load is equal to the value of the resistance of that load.Applications of Maximum Power Transfer In communication system, maximum power transfer is always sought. For example in public address system, the circuit is adjusted for maximum power transfer by making load resistance (speaker) equal to the source resistance (amplifier). When source and load have the same resistance, they are said to be matched.In car engines, the power delivered to the starter motor of the car will depend upon the effective resistance of the motor and the internal resistance of the battery. If the two resistances are equal, maximum power will be transferred to the motor to turn to the engine.Proof of Maximum Power Transfer At this point the simple circuit is can be a resemblance of a Thevinin's Circuit diagram where the internal resistance Ri similar to the Thevenin's resistance Rth while the supply voltage E in this circuit is similar to the open circuit voltage looking across the load RL. Therefore in this case we can analyze the above diagram by means of a simple circuit analysis, thus.... Maximized the resulting equation: Mathematically it is proven that at this point we say that the internal resistance (Rth) is equal to the load resistance (RL) .Sample Problem:In the given circuit find the following:The value of the load resistance RL to have maximum power transfer.Solution:Solve for the Rth and RL:1. To have maximum power it is required that Rth = RL. Therefore the load resistanceRL= 73.3 ohmsApplication of Maximum Power Transfer Reviewed by Editorial Staff on Friday, March 06, 2015 Rating: 5 Maximum Power Transfer Theorem states that A resistive load, being connected to a DC network, receives maximum power when the load resistance is equal to the internal resistance known as (Thevenins equivalent resistance) of the source network as seen from the load terminals. The Maximum Power Transfer theorem is used to find the load resistance for which there would be the maximum amount of power transfer from the source to the load. The maximum power transfer theorem is applied to both the DC and AC circuit. The only difference is that in the AC circuit the resistance is substituted by the impedance.The maximum power transfer theorem finds their applications in communication systems which receive low strength signal. It is also used in speaker for transferring the maximum power from an amplifier to the speaker.Content Explanation of Maximum Power Transfer TheoremA variable resistance RL is connected to a DC source network as shown in the circuit diagram in figure A below and the figure B represents the Thevenins voltage VTH and Thevenins resistance RTH of the source network.The aim of the Maximum Power Transfer theorem is to determine the value of load resistance RL, such that it receives maximum power from the DC source.Considering figure B the value of current will be calculated by the equation shown below While the power delivered to the resistive load is given by the equationPutting the value of I from the equation (1) in the equation (2) we will getPL can be maximized by varying RL and hence, maximum power can be delivered when (dPL/dRL) = 0However,But as we know, (dPL/dRL) = 0Therefore,Which givesHence, it is proved that power transfer from a DC source network to a resistive network is maximum when the internal resistance of the DC source network is equal to the load resistance.Again, with RTH = RL, the system is perfectly matched to the load and the source, thus, the power transfer becomes maximum, and this amount of power Pmax can be obtained by the equation shown below:Equation (3) gives the power which is consumed by the load. The power transfer by the source will also be the same as the power consumed by the load, i.e. equation (3), as the load power and the source power being the same.Thus, the total power supplied is given by the equationDuring Maximum Power Transfer the efficiency becomes:The concept of Maximum Power Transfer theorem is that by making the source resistance equal to the load resistance, which has wide application in communication circuits where the magnitude of power transfer is sufficiently small. To achieve maximum power transfer, the source and the load resistance are matched and with this, efficiency becomes 50% with the flow of maximum power from the source to the load.In the Electrical Power Transmission system, the load resistance being sufficiently greater than the source resistance, it is difficult to achieve the condition of maximum power transfer.In power system emphasis is given to keep the voltage drops and the line losses to a minimum value and hence the operation of the power system, operating with bulk power transmission capability, becomes uneconomical if it is operating with only 50% efficiency just for achieving maximum power transfer.Hence, in the electrical power transmission system, the criterion of maximum power transfer is very rarely used.Steps for Solving Network Using Maximum Power Transfer TheoremFollowing steps are used to solve the problem by Maximum Power Transfer theoremStep 1 Remove the load resistance of the circuit.Step 2 Find the Thevenins resistance (RTH) of the source network looking through the open-circuited load terminals.Step 3 As per the maximum power transfer theorem, this RTH is the load resistance of the network, i.e., RL = RTH that allows maximum power transfer.Step 4 Maximum Power Transfer is calculated by the equation shown belowThis is all about Maximum Power Transfer Theorem. From civilian power distribution to circuit boards, maximum power transfer is an important point to consider during design. Whether you are designing a power delivery network or an AC circuit, youll need to choose the right source and load impedances to transfer maximum power throughout your circuits.Anytime someone brings up a theorem, most people let their eyes glaze over as the mathematical derivations start to flow. Thankfully, the maximum power transfer theorem (also known as Jacobis law) in circuit analysis is deceptively simple and is easily applied in circuit design.What is the Maximum Power Transfer Theorem?When designing a DC circuit, especially a power delivery network, you need to ensure that you are delivering maximum power throughout the circuit. The actual power delivered will be a function of the source voltage, the output resistance from the power supply or driving DC component, and the resistance of the load. With the right combination of load resistance and output resistance, you can ensure that your power receives the maximum intended power.According to Thevenins theorem, the circuitry in a DC driver can be reduced to an equivalent voltage source and a series resistor. This output series resistance, along with the resistance of the load, will determine the output current that reaches the load, as well as the power delivered to the load. The power that reaches the load can be determined through a simple application of Ohms law, either by hand or with a circuit simulation. A circuit diagram that contains the Thevenin equivalent and the load resistor is shown in the figure below:Equivalent circuit and power dissipation across a load resistorThe maximum power transfer theorem states that the power delivered to the load resistor is maximized when the load resistance is equal to the series resistance. This can be calculated by taking the derivative of the power equation with respect to the load resistance and calculating the critical point. If you graph the power equation in the above image as a function of the load resistance, youll see that the power delivered to the load is maximized when the load and series resistors are equal.Power delivered to the load resistorIn this configuration, the Thevenin equivalent and the load resistor form a voltage divider, and the voltage dropped across the load will be half the value of the source voltage in the driver. Increasing the load resistor increases the voltage drop but decreases the total current, while decreasing the load resistor decreases the voltage drop and increases the total current.Maximum Power Transfer with AC and Digital SignalsWhile the maximum power transfer theorem is normally discussed in terms of DC circuits, it also applies to circuits carrying AC signals. Instead of working with a load and series resistance, you consider the load and series impedance at a given frequency. When working with an AC driver or a driver that outputs digital signals, you also want to ensure maximum power transfer to the circuit from the source, followed by maximum power delivery to the load.This requires considering the impedance of the source and load. If the source and load are included, an application of Ohms law yields the following equation for the instantaneous power transfer in terms of the resistance and reactance values of the sources and loads:Instantaneous power in an AC circuitHere, one finds that the maximum power transfer occurs when the source and load impedances are complex conjugates of each other. In other words, the instantaneous power is maximum when the source and load resistances are equal, and when the source and load reactances are equal with opposite sign.Note that the reactance of the load will induce a phase shift in the current, which will affect the instantaneous power. You can still calculate the average power over an oscillation period by taking an integral. Note that the load reactance will still induce a phase shift in the current, even if the maximum power transfer condition is met.The Maximum Power Transfer Theorem and Transmission LinesWith AC signals and with high speed digital signals, there is another element to consider. When the length of the conductor between the source and load is long enough, the propagation delay for signals along a trace can be longer than the signal rise time. A rule of thumb is that transmission line effects need to be considered when the propagation delay along a trace is greater than 50% of the rise/fall time of the DC signal being sent through the trace. With analog signal, the trace will act as a transmission line when the propagation delay is greater than one-quarter of the oscillation period of the AC signal.When an AC driver is in series with a transmission line and a load, the drivers source impedance and the load impedance should match the impedance of the transmission line. Normally, transmission lines are only matched at the load end to prevent signal reflection back along the transmission line. This will prevent a step-like response in the voltage across the transmission line under multiple reflections and ringing, which in turn prevents inadvertent switching of a digital IC at the load end. With AC signals, this is important for preventing standing waves from forming on the trace, which will cause the transmission line from acting like a transmitting antenna.When the load end is impedance matched to the transmission line, matching at the source end is usually ignored. Remember that the source driver and the transmission line form their own voltage divider. If the source impedance is matched to the transmission line impedance, then maximum power will be delivered to the transmission line, but the voltage will be half the value of the driving voltage.In order for the driving voltage to equal the actual voltage dropped across the transmission line, the output impedance of the driver should be very low. In effect, the series combination of the source impedance and transmission line impedance will form their own Thevenin equivalent circuit, and the load impedance should be matched to this combined impedance value.Maximum Power Transfer versus Maximum Power EfficiencyWhen working in, especially, AC power distribution schemas, the goal of high power efficiency is important for a low generator impedance to load impedance ratio. Unfortunately, maximum efficiency is not particularly tied to the maximum power transfer theorem. You will still need to design for efficiency as MPTT does not guarantee maximum efficiency, or even high efficiency.Furthermore, MPTT does not ensure low noise ratios either. If youre looking to learn more about noise floors, Id highly suggest reading about them here.Applications such as RF amplifiers are looking for low noise, low output impedances, and a moderate speaker load impedance. When looking at the maximum power transfer theorem and applying it to an RF amplifier, youll often find a mismatch between amplifier input impedance and the used antenna.Working with the right PCB layout and design software can help your DC and AC networks to satisfy the maximum power transfer theorem. Allegro PCB Designer and Cadences full suite of design tools are designed with the tools you need to ensure power delivery throughout your DC networks and AC circuits.If youre looking to learn more about how Cadence has the solution for you, talk to us and our team of experts. In any electric and electronic circuit, the power supply is used to provide electrical energy to the load wherever it is changed into functional work. Basically, the whole power supply will not there at load because of the heating effect as well as other restrictions within the circuit. So, there exists a certain difference between drawing and delivering powers. The size of the load will affect the sum of power delivered from the source of power supply, any change within the load resistance can result to modify within power transfer toward the load. So, the maximum power transfer theorem or MPTT ensures the condition to deliver the maximum power toward the load.In any electronic or electrical applications, the sum of power obtained through a load is an essential parameter. For instance, the load in DC circuits can be represented through a resistor with resistance RL ohms. In the same way in AC circuits, we can indicate it through a complex load with impedance ZL ohms. This article discusses an overview of MPPT (Maximum Power Transfer Theorem).What is the Maximum Power Transfer Theorem?The Maximum Power Transfer Theorem can be defined as, a resistive load is connected to a DC-network, when the load resistance (RL) is equivalent to the internal resistance then it receives the highest power is known as Thevenins equivalent resistance of the source network. The theorem defines how to select the load resistance (RL) when the source resistance is given once. It is a general misunderstanding for applying the theorem in the reverse situation.It doesnt mean that how to select the source resistance for a specific load resistance (RL). Actually, the source resistance that makes the best use of power transfer is constantly zero, apart from the value of load resistance. This theorem can be expanded to AC circuits that comprise reactance and defines that the highest power transmission happens when the load impedance (ZL) must be equivalent to the ZTH (complex conjugate of corresponding circuit impedance).Maximum Power Transfer TheoremMaximum Power Transfer Theorem Solved Problems1). Find the load resistance RL that enables the circuit (left of the terminals a and b) to deliver maximum power toward the load. Also, find the maximum power delivered to the load.Maximum Power Transfer Theorem ExampleSolution:In order to apply the maximum power transfer theorem, we need to find Thevenins equivalent circuit.(a) Vthderivation of the circuit: open-circuit voltageopen-circuit voltageConstraints: V1=100, V2 20=Vx, and V3=VthAt node 2:At node 3:(1)*2 + (2)*3 > Vth=120 [V](b) Rthderivation (by Test Voltage Method): After deactivation & test voltage application, we have:After deactivation & test voltage applicationConstraints: V3=VTand V2=VxAt node 2:At node 3 (KCL):From (1) and (2):(c) Maximum Power Transfer: now the circuit is reduced to:Result CircuitTo obtain maximum power transfer, then, RL=3=Rth. Finally, the maximum power transferred to RLis:2). Determine the maximum power that can be delivered to the variable resistor R.Maximum Power Transfer Theorem Example 2Solution:(a) Vth: Open circuit voltageVth_ Open circuit voltageFrom the circuit, Vab=Vth=40-10=30 [V](b) Rth: Lets apply Input Resistance Method:Rth_ Lets apply Input Resistance MethodThen Rab= (10//20) + (25//5) = 6.67+4.16=10.83 =Rth.(c) Thevenin circuit:Thevenin circuitMPTT FormulaThe Maximum Power Transfer Theorem Formula is explained below. If we consider the (efficiency) as the fraction of power dissolved through the load R to power extended with the source, VTH, then it is simple to compute the efficiency of maximum power transfer as = (Pmax/P) X 100 = 50%Where; the maximum power (Pmax)Pmax = V2TH RTH / (RTH + RTH)2 = V2TH / 4RTHAnd the power supplied (P) isP = 2 V2TH / 4RTH = V2TH / 2RTHThe is only 50% when the highest power transfer is attained, although reaches 100% as the RL (load resistance) reaches infinity, while the whole power stage tends to zero.Maximum Power Transfer Theorem for AC CircuitsIn an AC circuit, the MPTT provides the conditions of impedance to transfer the highest power toward a load. This theorem states that in an active AC circuit, a source through internal impedance like ZS is included which is connected to a load like ZL. So, the maximum power transfer mainly happens from source to load once the load impedance is equivalent to the compound conjugate of ZS or source impedance.As inactive arrangement, the highest power is transmitted to the load while the impedance of the load is equivalent to the complex conjugate of a corresponding impedance of a given set-up as observed from the terminals of the load.Maximum Power Transfer Theorem For A.C CircuitsThe above circuit is an equivalent circuit to Thevenins. When the above circuit is considered across the terminals of the load, then the flow of current will be given asI = VTH/ ZTH+ ZLWhere ZL=RL+ jXLZTH= RTH+ jXTHTherefore,I = VTH/ (RL+ jXL+ RTH+ jXTH)= VTH/ ((RL+ RTH) + j(XL+ XTH))The power circulated to the load,PL= I2RLPL= V2THRL/ ((RL+ RTH)2+ (XL+ XTH)2) (1)For highest power the above equation derivative should be zero, later than simplification we can get the following.XL+ XTH= 0XL= XTHSubstitute the XL value in the above equation 1, and then we can get the following.PL= V2THRL/ ((RL+ RTH) 2Again for the highest power transfer, the above equation derivation must be equivalent to zero, after solving this we can getRL+ RTH= 2 RLRL= RTHTherefore, the highest power will be transmitted from the source to load, if RL (load resistor) = RTH & XL = XTH in an AC circuit. This means that the load impedance (ZL)must be equivalent to the ZTH(complex conjugate of corresponding circuit impedance)ZL= ZTHThis maximum power transmitted (Pmax)= V2TH/ 4 RLor V2TH/ 4 RTHMaximum Power Transfer Theorem for DC CircuitsThe MPTT is used in DC circuits which defines the statement of highest power transfer from an active network toward an exterior load resistance. It defines that in an active, linear, bilateral DC n/w, the highest power will be delivered from the power source to the electric load once the exterior load resistance equivalents to the power sources internal resistance.The development of MPTT can be done through reference to a voltage source or practical current. If the power source is an independent voltage source or practical, then its inside series resistance should equal load resistance to transmit the highest power.An independent current source or practical, parallel internal resistance must be equal by the load resistance. The internal source series resistance in the DC circuit changes the power transmitted to the load and thus the highest current transmitted from the power source toward the electric load is restricted.MPTT ProofThe maximum power transfer theorem-proof is, in some applications, the purpose of a circuit is to provide maximum power to a load. Some examples:Stereo amplifiersRadio transmittersCommunications equipmentIf the entire circuit is replaced by its Thevenin equivalent circuit, except the load, as shown below, the power absorbed by the load is:Maximum Power Transfer Theorem ProofPL = i2 RL = (Vth/Rth + RL)2 x RL = V2th RL/ (Rth + RL)2As VTHand RTHare fixed for a given circuit, the load power is a function of the load resistance RL.By differentiating PLwith respect to RLand set the result equal to zero, we have the following maximum power transfer theorem; Maximum power occurs when RLis equal to RTH.When the maximum power transfer condition is met, i.e., RL=RTH, the maximum power transferred is:Differentiating PL with respect to RLPL = V2th RL / [Rth + RL]2 = V2th Rth/ [Rth + RL]2 = V2th/ 4 RthSteps for Solving Network using Maximum Power Transfer TheoremBelow steps are used to solve the problem by Maximum Power Transfer TheoremStep 1: Remove the load resistance of the circuit.Step 2: Find the Thevenins resistance (RTH) of the source network looking through the open-circuited load terminals.Step 3: As per the maximum power transfer theorem, RTHis the load resistance of the network, i.e., RL= RTHthat allows maximum power transfer.Step 4: Maximum Power Transfer is calculated by the below equation(Pmax)= V2TH/ 4 RTHMaximum Power Transfer Theorem Example Problems with SolutionsFind the RL value for the below circuit that the power is highest as well, find the highest power through RL using the theorem of maximum power transfer.Finding RL valueSolution:According to this theorem, when power is highest via the load, then resistance is similar to the equal resistance between the two ends of the RL after eliminating it.So, for load resistance (RL) discovery, we have to discover the equivalent resistance:So,Now, for discovering the highest power through RL-load resistance, we have to discover the voltage value between the VOCcircuits.For the above circuit, apply the mesh analysis. We can get:Apply KVL for loop-1:6-6I1-8I1+8I2=0-14I1+8I2=-6 (1)Apply KVL for loop-2:-8I2-5I2-12I2+8I1=08I1-25I2=0 (2)By solving the above two equations, we getI1= 0.524 AI2= 0.167 ANow, from the circuit Vo.cisVA-5I2- VB= 0Vo.c/ VAB= 5I2= 5X0.167 = 0.835vHence, the maximum power through the load resistance (RL) is;P max = VOC2 / 4RL = (0.835 x 0.835)/ 4 x 3.77 = 0.046 wattDiscover thehighest powerthat can be transmitted to the RL-load resistor of the below circuit.Maximum Power to RLSolutionApply Thevenins theorem to the above circuit,Here, Thevenins voltage(Vth)= (200/3) and Thevenins resistance(Rth)=(40/3)Substitute the fraction of the circuit, which is left-side of terminals A & B of the given circuit with the Thevenins equivalent circuit. The secondary circuit diagram is shown below.We can find the maximum power that will be delivered to the load resistor, RLby using the following formula.PL, Max = V2TH/ 4 RTHSubstituteVTh = (200/3)VandRTh = (40/3)in the above formula.PL, Max = (200/3)2/ 4(40/3) = 250/3 wattsTherefore, the maximum power that will be delivered to the load resistor RL of the given circuit is 250/3 W.Advantages and DisadvantagesThe advantages and disadvantages of the maximum power transfer theorem include the following.The main benefit of the maximum power transfer theorem is, it can analyze the performance at any pointThe main drawback of the maximum power transfer theorem is, it is not used in the networks like nonlinear as well as unilateral.The limitation of the maximum power transfer theorem is it not applicable in power systems, due to its 50% efficiency. So the main concern of this is efficiency.This theorem can be applied to communication lines instead of power lines because if we applied to power lines, then practical problems will occur like the following.In power lines, receiving end voltage constancy is a significant condition, so this theorem ignores this feature.Due to less efficiency, this cannot be accepted within power lines.Applications of Maximum Power Transfer TheoremThe theorem of maximum power transfer can be applicable in many ways to determine the load resistances value that receives the maximum power from the supply and the maximum power under the state of the highest power transfer. Below are a few applications of the Maximum power transfer theorem:This theorem is always sought in a communication system. For instance, in a community address system, the circuit is attuned for the highest power transfer with making the speaker (load resistance) equivalent to the amplifier (source resistance). When the load and source have matched then it has equal resistance.In automobile engines, the power transmitted to the motor starter of the automobile will depend on the effective resistance of the motor & the batterys inner resistance. When the two resistances are equivalent, then the highest power will be transmitted to the motor to activate the engine.The maximum power transfer theorem can be applied in the complex network as followsIt is used in ac and dc networks.For maximum power transfer in the public address system, the circuit can be altered by making RL (load resistance) like speaker equivalent toward the source resistance like an amplifier. Once both the source as well as load includes the equivalent resistance, then they are matched.This theorem is used wherever all the autonomous voltage sources are deactivated & the same impedance is simply considered, then a maximum quantity of power can be transmitted.In radio communications, it is used where the power amplifier broadcasts the highest amount of signal toward the antenna if load impedance within the circuit is equivalent to the impedance of the source.In audio systems, it is used where the need to be delivered toward the speaker. The amplifier changes the highest quantity of voice once the load impedance is equivalent to the source impedance.In a resistive network, a resistive load will abstract maximum power once the load resistance is equivalent to the resistance observed through the load because it looks back toward the network.In fact, the resistance can be accessed toward the network output terminals. Actually, this resistance is Thevenin equivalent resistance which is described in Thevenins theorem if we consider the complete network like a voltage source. Likewise, if we consider the network like a current source, then this resistance will be called Norton equivalent resistance which can be described in the Norton theorem.It is used in all kinds of circuits where the circuits are designed based on the efficiency principle which will reduce by 50%. However, consumers use this MPTT in areas wherever power is restricted such as mobile receivers & audio speakers.This less efficiency can be bearable for the sake of the highest power to be delivered toward the load used in the network. In power systems, the voltage drops & power losses within the generators, as well as the transmission systems, are set aside like small.Here, the load impedance is higher several times as compared to the internal impedance of the sourceTherefore, power circuits work below the conditions of optimal matching. For instance, in power transmission wherever the highest efficiency matters, so we design systems based on the highest voltage. But it is not possible to resist heat dissipation because of 50% loss, as the power delivered is a hundred MW.This is all about the maximum power theorem. From the above information, finally, we can conclude that this theorem is used often to assure that the highest power can be transmitted from a source of power to a load. Here is a question for you, what is the advantage of the maximum power transfer theorem? In any electric and electronic circuit, the power supply is used to provide electrical energy to the load wherever it is changed into functional work. Basically, the whole power supply will not there at load because of the heating effect as well as other restrictions within the circuit. So, there exists a certain difference between drawing and delivering powers. The size of the load will affect the sum of power delivered from the source of power supply, any change within the load resistance can result to modify within power transfer toward the load. So, the maximum power transfer theorem or MPTT ensures the condition to deliver the maximum power toward the load.In any electronic or electrical applications, the sum of power obtained through a load is an essential parameter. For instance, the load in DC circuits can be represented through a resistor with resistance RL ohms. In the same way in AC circuits, we can indicate it through a complex load with impedance ZL ohms. 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Some examples:Stereo amplifiersRadio transmittersCommunications equipmentIf the entire circuit is replaced by its Thevenin equivalent circuit, except the load, as shown below, the power absorbed by the load is:Maximum Power Transfer Theorem ProofPL = i2 RL = (Vth/Rth + RL)2 x RL = V2th RL/ (Rth + RL)2As VTHand RTHare fixed for a given circuit, the load power is a function of the load resistance RL.By differentiating PLwith respect to RLand set the result equal to zero, we have the following maximum power transfer theorem; Maximum power occurs when RLis equal to RTH.When the maximum power transfer condition is met, i.e., RL=RTH, the maximum power transferred is:Differentiating PL with respect to RLPL = V2th RL / [Rth + RL]2 = V2th Rth/ [Rth + RL]2 = V2th/ 4 RthSteps for Solving Network using Maximum Power Transfer TheoremBelow steps are used to solve the problem by Maximum Power Transfer TheoremStep 1: Remove the load resistance of the circuit.Step 2: Find the Thevenins resistance (RTH) of the source network looking through the open-circuited load terminals.Step 3: As per the maximum power transfer theorem, RTHis the load resistance of the network, i.e., RL= RTHthat allows maximum power transfer.Step 4: Maximum Power Transfer is calculated by the below equation(Pmax)= V2TH/ 4 RTHMaximum Power Transfer Theorem Example Problems with SolutionsFind the RL value for the below circuit that the power is highest as well, find the highest power through RL using the theorem of maximum power transfer.Finding RL valueSolution:According to this theorem, when power is highest via the load, then resistance is similar to the equal resistance between the two ends of the RL after eliminating it.So, for load resistance (RL) discovery, we have to discover the equivalent resistance:So,Now, for discovering the highest power through RL-load resistance, we have to discover the voltage value between the VOCcircuits.For the above circuit, apply the mesh analysis. We can get:Apply KVL for loop-1:6-6I1-8I1+8I2=0-14I1+8I2=-6 (1)Apply KVL for loop-2:-8I2-5I2-12I2+8I1=08I1-25I2=0 (2)By solving the above two equations, we getI1= 0.524 AI2= 0.167 ANow, from the circuit Vo.cisVA-5I2- VB= 0Vo.c/ VAB= 5I2= 5X0.167 = 0.835vHence, the maximum power through the load resistance (RL) is;P max = VOC2 / 4RL = (0.835 x 0.835)/ 4 x 3.77 = 0.046 wattDiscover thehighest powerthat can be transmitted to the RL-load resistor of the below circuit.Maximum Power to RLSolutionApply Thevenins theorem to the above circuit,Here, Thevenins voltage(Vth)= (200/3) and Thevenins resistance(Rth)=(40/3)Substitute the fraction of the circuit, which is left-side of terminals A & B of the given circuit with the Thevenins equivalent circuit. The secondary circuit diagram is shown below.We can find the maximum power that will be delivered to the load resistor, RLby using the following formula.PL, Max = V2TH/ 4 RTHSubstituteVTh = (200/3)VandRTh = (40/3)in the above formula.PL, Max = (200/3)2/ 4(40/3) = 250/3 wattsTherefore, the maximum power that will be delivered to the load resistor RL of the given circuit is 250/3 W.Advantages and DisadvantagesThe advantages and disadvantages of the maximum power transfer theorem include the following.The main benefit of the maximum power transfer theorem is, it can analyze the performance at any pointThe main drawback of the maximum power transfer theorem is, it is not used in the networks like nonlinear as well as unilateral.The limitation of the maximum power transfer theorem is it not applicable in power systems, due to its 50% efficiency. So the main concern of this is efficiency.This theorem can be applied to communication lines instead of power lines because if we applied to power lines, then practical problems will occur like the following.In power lines, receiving end voltage constancy is a significant condition, so this theorem ignores this feature.Due to less efficiency, this cannot be accepted within power lines.Applications of Maximum Power Transfer TheoremThe theorem of maximum power transfer can be applicable in many ways to determine the load resistances value that receives the maximum power from the supply and the maximum power under the state of the highest power transfer. Below are a few applications of the Maximum power transfer theorem:This theorem is always sought in a communication system. For instance, in a community address system, the circuit is attuned for the highest power transfer with making the speaker (load resistance) equivalent to the amplifier (source resistance). When the load and source have matched then it has equal resistance.In automobile engines, the power transmitted to the motor starter of the automobile will depend on the effective resistance of the motor & the batterys inner resistance. When the two resistances are equivalent, then the highest power will be transmitted to the motor to activate the engine.The maximum power transfer theorem can be applied in the complex network as followsIt is used in ac and dc networks.For maximum power transfer in the public address system, the circuit can be altered by making RL (load resistance) like speaker equivalent toward the source resistance like an amplifier. Once both the source as well as load includes the equivalent resistance, then they are matched.This theorem is used wherever all the autonomous voltage sources are deactivated & the same impedance is simply considered, then a maximum quantity of power can be transmitted.In radio communications, it is used where the power amplifier broadcasts the highest amount of signal toward the antenna if load impedance within the circuit is equivalent to the impedance of the source.In audio systems, it is used where the need to be delivered toward the speaker. The amplifier changes the highest quantity of voice once the load impedance is equivalent to the source impedance.In a resistive network, a resistive load will abstract maximum power once the load resistance is equivalent to the resistance observed through the load because it looks back toward the network.In fact, the resistance can be accessed toward the network output terminals. Actually, this resistance is Thevenin equivalent resistance which is described in Thevenins theorem if we consider the complete network like a voltage source. Likewise, if we consider the network like a current source, then this resistance will be called Norton equivalent resistance which can be described in the Norton theorem.It is used in all kinds of circuits where the circuits are designed based on the efficiency principle which will reduce by 50%. However, consumers use this MPTT in areas wherever power is restricted such as mobile receivers & audio speakers.This less efficiency can be bearable for the sake of the highest power to be delivered toward the load used in the network. In power systems, the voltage drops & power losses within the generators, as well as the transmission systems, are set aside like small.Here, the load impedance is higher several times as compared to the internal impedance of the sourceTherefore, power circuits work below the conditions of optimal matching. For instance, in power transmission wherever the highest efficiency matters, so we design systems based on the highest voltage. But it is not possible to resist heat dissipation because of 50% loss, as the power delivered is a hundred MW.This is all about the maximum power theorem. From the above information, finally, we can conclude that this theorem is used often to assure that the highest power can be transmitted from a source of power to a load. Here is a question for you, what is the advantage of the maximum power transfer theorem? Definition: An optical fiber is a thin flexible strand made up of glass(silica) or plastic that is used for transmitting optical (light) signals. Usually, the diameter of the optical fiber is more as compared to human hair. More specifically, we can say that it is a waveguide that has the ability to transmit electromagnetic waves Optical Fiber Read More Definition: Step index fiber is a type of optical fibers that holds its classification on the basis of refractive index. Step index fiber is that optical waveguide, that has a constant refractive index within the core and another constant refractive index within the cladding. The refractive index of the core is somewhat more as compared Step Index Fiber Read More Definition: An optical component that permits the propagation of the light signal in one direction only and completely blocking the other direction is known as Optical Isolator. Faraday effect is the basis of working of this device. Basically, when a light ray is allowed to pass through the fiber then there are some chances that Optical Isolator Read More Definition: Optical Modulation is the process by which a light wave is modulated (modified) according to a high-frequency electrical signal that contains information. These modified light waves are then transmitted either by a transparent medium or through an optical fiber cable. More specifically, we can say that it is the process by which an electrical Optical Modulation Read More Definition: Optical Line Terminal or optical line termination is a device that basically acts as a part of a passive optical network (PON). It is present in the central office of the network and manages the transmission and reception of information across the overall network. Optical line terminal is abbreviated as OLT. OLT do so Optical Line Terminal (OLT) Read More Both semiconductors and superconductors are the two categories of materials that offer conductivity. However, the level of conductivity offered by the two crucially differentiates the two. The significant difference between semiconductors and superconductors is that in the case of semiconductors, the conductivity ranges between conductor and insulator. As against superconductors are the materials whose level Difference Between Semiconductors and Superconductors Read More Shunt and series voltage regulators are the two classifications of linear voltage regulators. The crucial difference between shunt and series voltage regulator is that in the shunt voltage regulator, the control element is in parallel connection with the load. On the contrary, in the series voltage regulator, the control element is serially connected to the Difference Between Shunt and Series Voltage Regulator Read More Symmetric and Asymmetric multiprocessing are the two major classifications of multiprocessing as both include the use of multiple processors for system operation. The significant difference between symmetric and asymmetric multiprocessors lies in the way multiple processors are utilized by the system or we can say, the way multiple processors operate within the system. In symmetric Difference Between Symmetric and Asymmetric Multiprocessing Read More Definition: The electromagnetic flow meter is a device used for measuring the flow of the liquid when it passes through the pipeline. Or we can say that the electromagnetic flowmeter use for measuring the flow rate of the electrically conducting fluid. The electrically conductive liquid means the liquid allows the current to pass through it. Electromagnetic Flow Meter Read More Both charge and mass are the properties of matter. The significant difference between charge and mass is that charge has a classification. As against, the mass has no further classification. Charge mainly exists in two types positive and negative but mass can never be negative, it is always positive. A charge is a component that Difference Between Charge and Mass Read More In this article, we will study about Maximum Power Transfer Theorem. The Maximum Power is transferred in the circuit when the load impedance is matched with the source impedance. This theorem helps in increasing the efficiency and performance of the circuit. It is very helpful in circuit design. In this article, we will learn more about Maximum Power Transfer Theorem, We will see the Maximum Power Transfer Formula, Maximum Power Transfer Theorem Proof, Efficiency of Maximum Power Transfer and at last we Will go through Some Examples. What is the Maximum Power Transfer Theorem?The statement of Maximum Power Transfer Theorem is as follows: It states that the maximum power is developed in a load when the load resistance equals the Thevenin resistance of the source to which it is connected. Condition for Maximum Power TransferTo achieve power transfer in a circuit, the resistance or impedance of the load must match with the source impedance. This means the load and source should have properties for efficient energy utilization and maximum power delivery. Resistive Circuit Maximum Power Transfer FormulaAccording to the image of resistive circuit shown above, maximum transfer of power takes place when: R_{s} = R_{L} When this condition is matched, Pmax will be: P_{max (deliveredToLoad)} = \frac{V_{s}^2}{4R_{s}}=\frac{V_{th}^2}{4R_{th}} Maximum Power Transfer Theorem Proof Let us consider a circuit, where a practical voltage source is connected to a load resistance (RL). The circuit is given below: Practical Voltage Source Connected to a Load Resistor Step 1: Calculating the power delivered to the load The power delivered to the load RL is: P_{L} = i^2_{L}*R_{L} i_{L} = \frac{v_{s}}{R_{s}+R_{L}} P_{L} = \frac{v_{s}^2*R_{L}}{(R_{s}+R_{L})^2} Step 2: Differentiating to find the maximum power To find the value of RL that absorbs maximum power from the given practical source, we differentiate with respect to RL and equating it with 0. \frac{dP_{L}}{dR_{L}} = \frac{(R_{s}+R_{L})^2v_{s}^2 - v_{s}^2R_{L}(2)(R_{s}+R_{L})}{(R_{s}+R_{L})^4} On equating it to zero we will get: 2R_{L}(R_{s} + R_{L}) = (R_{s} + R_{L})^2 -> R_{s}= R_{L} (condition for maximum delivery of the power) Note: An alternative way to look at the maximum power transfer theorem is possible in terms of the Thevenin equivalent resistance of a network. The modified circuit is given below: A network delivers maximum power to a load resistance RL when RL is equal to a the Thevenin equivalent resistance of the network i.e., RL = Rs = Rth Thevenin Equivalent Circuit Hence we have proven that according to the Maximum Power Transfer Theorem, when the 'load resistance' or 'Thevenin resistance' is equal to 'source resistance', maximum power is delivered. Hence the formula for Pmax is given as: P_{max (deliveredToLoad)} = \frac{V_{s}^2}{4R_{s}}=\frac{V_{th}^2}{4R_{th}} Efficiency of Maximum Power TransferThe Maximum Power Transfer Theorem ensures efficient power transfer and minimize wastage when applied correctly. It is useful in scenarios where maximizing power usage and minimizing waste is essential, such as audio amplifiers. Efficiency Calculation_{max} = \frac{P_{L,max}}{P_{s}} where, PL,max: Maximum amount of power transferred to loadPs: Power generated by the sourcePL,max = \frac{V_{th}^2}{4R_{th}} Calculating PsP_{s} = I^2R_{th}+I^2R_{L} According to the condition of maximum power transfer: RL = Rs = Rth P_{s} = 2I^2R_{th} And we know I= \frac{V_{th}}{R_{s}+R_{L}} = \frac{V_{th}}{2R_{th}} P_{s} = 2*(\frac{V_{th}}{2R_{th}})^2R_{th} P_{s} = (\frac{V_{th}^2}{2R_{th}}) Hence efficiency will be: _{max} = \frac{(\frac{V_{th}^2}{4R_{th}})}{(\frac{V_{th}^2}{2R_{th}})} _{max}= \frac{1}{2} = 50% Therefore, the efficiency of Maximum Power Transfer theorem is 50% Maximum Power Transfer Theorem for AC CircuitsIn AC circuits, the Maximum Power Transfer Theorem determines the conditions for transferring the maximum power from a source to a load. This theorem states that in an active AC circuit, where a source with internal impedance (denoted as ZS) is connected to a load (ZL), the highest power transfer occurs when the impedance of the load matches the complex conjugate of the source impedance. For a passive setup, maximum power is transferred to the load when the impedance of the load equals the complex conjugate of the corresponding impedance observed from the load's terminals. Now let us derive the condition for maximum power transfer in the AC circuits: AC Circuit Consider an equivalent circuit analogous to Thevenin's. When analyzing this circuit across the load terminals, the current flowing is given by: I = \frac{V_{th}}{(Z_{th} + Z_{L})} Where: ZL = RL + jXL (Load impedance)Zth = Rth + jXth (Thevenin impedance)Therefore, I = \frac{V_{th}}{(R_{L}+R_{th}) + j(X_{L}+X_{th})]} Magnitude of current is: I = \frac{V_{th}}{\sqrt{[(R_{L}+R_{th})^2 + (X_{L}+X_{th})^2]}} The power delivered to the load (PL) is given by: P_{L} = I^2R_{L} P_{L} = \frac{V_{th}^2 * R_{L}}{(R_{L} + R_{th})^2 + (X_{L} + X_{th})^2} -> (1) To maximize power transfer, we will differentiate the equation-1 and equate it to zero. After simplification we will find that: XL + XTH = 0 XL = -XTH (condition for maximum power transfer) Substituting the value of XL into equation (1), we obtain: P_{L} = \frac{V_{th}^2 * RL}{(R_{L} + R_{th})^2} For maximum power transfer, we will equate the above equation to zero: RL + Rth = 2RL RL = Rth Hence, in an AC circuit, the highest power transfer occurs when the load resistor (RL) equals the Thevenin resistance (Rth) and XL equals the negative of Xth. In other words, the load impedance (ZL) must be equal to the complex conjugate of the corresponding circuit impedance, i.e., if ZL = RL + jXL then Zth = Rth - jXL How to Solve Network using Maximum Power Transfer Theorem?Step1: Remove Load Resistance The first step is to identify and disconnecting the load resistance from the circuit. Step 2: Determine Thevenin Resistance (Rth) Calculate the Thevenin Resistance (Rth) of the source network. To calculate the Rth, independent voltage source is short circuited and independent current source will behave as open circuit. Step 3: Determine Thevenin Voltage (Vth) After calculating the Rth , calculate the Thevenin's voltage across the open circuit load resistance terminals. Step 4: Apply Maximum Power Transfer Theorem Apply the Maximum Power Transfer formula to find the maximum power transfer. It can be calculated using the above derived formula. Solved Example on Maximum Power Transfer TheoremQ.1 The circuit shown in figure is a model for the common-emitter bipolar junction transistor amplifier. Choose a load resistance so that maximum power is transferred to it. Circuit DiagramSolution Step 1: Find the Thevenin equivalent of the circuit To find the Rth, remove RL and short-circuit the independent sources. The final circuit diagram is shown below: Thevenin Equivalent circuitFrom the above circuit it is clear that v = 0. So the dependent current source will behave as an open circuit. Hence R_{th} = 1k\Omega In order to obtain maximum power delivered into the load, RL should be set to R_{th} = 1k\Omega Step 2: Find the Thevenin voltage of the circuit To find the Vth consider the circuit given below: Thevenin Voltage voc = 0.03v (1000) = 30v where the voltage v may be found from simple voltage division: v_{\Pi} = 2.5*10^{-3}*sin(440t)*(\frac{3864}{300+3864}) Vth = 69.6 sin(440t) mV Step 3: Calculate the Maximum Power Transfer P_{max} = \frac{V_{th}^2}{4R_{th}} Pmax = 1.211 sin2 (440t) W Advantages and Disadvantages of Maximum Power Transfer TheoremHere, some list of Advantages and Disadvantages of Maximum Power Transfer Theorem given below : AdvantagesIt ensures that the maximum available power from a source is efficiently delivered to the load.It helps in designing the circuits that minimize power wastage. it leads in making devices more energy-efficient.It prevent the overloading of components by matching load resistance with the source resistance which enhance circuit safety.It is very easy to apply which helps in quick estimation.Disadvantages It is not applicable in non-linear and unilateral networks.Matching resistances may not always be feasible in real-world applications due to component limitations.In cases where load resistance doesn't match, it can result in power loss, reducing circuit efficiency.The maximum efficiency up to which Maximum Power Transfer Theorem can reach is 50% and not is applicable for power systems. Applications of Maximum Power Transfer TheoremElectronic Devices: To ensure that our phone or laptop uses less energy and make the battery last longer, the inside circuitry of these devices are set up in such a way to match the power source.Solar Panels: Solar panels are designed to capture sunlight and convert it into usable electricity. To optimize their performance, it is important to ensure that the panels are properly connected to a battery or electrical system to match the source and load impedances. This ensures maximum efficiency and output of electricity from the solar panels.Sound Systems: The speakers in your home stereo system are responsible for producing sound. To ensure the best possible sound quality, it's important to connect the speakers in a way that matches the settings of the amplifier.Radio and TV Antennas: To receive a stronger and clearer signal on your radio or TV, it's important to align the antenna with the transmitter's settings. This ensures that the radio or TV signals travel effectively through the antennas.Wireless Devices: Wi-Fi Remote controls utilize radio signals, for communication. By configuring them to align their signals, the strength and reliability of the connection can be enhanced. ConclusionIn the above article, we gave seen that Maximum Power Transfer Theorem maximizes the power transfer at Thevenin's resistance of the circuit. It is applicable to both AC and DC circuits and the derivation is explained above. It finds its application in various fields like electronic devices, solar panels, wireless devices and many more. Skip to content April 2, 2024 By Ravi Teja In this tutorial, we will learn about Maximum Power Transfer Theorem (MPTT). It is one of the basic yet important laws that states the necessary condition for maximum power transfer (not to be confused with maximum efficiency). Maximum Power Transfer TheoremIn any electric circuit, the electrical energy from the power supply is delivered to the load where it is converted into a useful work. Practically, the entire supplied power will not be present at the load due to the heating effect and other constraints in the network. Therefore, there exists a certain difference between drawing and delivering powers.The size of the load always affects the amount of power transferred from the supply source, i.e., any change in the load resistance results a change in the power transferred to the load. Thus, the Maximum Power Transfer Theorem ensures the ideal condition to transfer the maximum power to the load. Let us see how.Maximum Power Transfer Theorem StatementThe Maximum Power Transfer Theorem states that in a linear, bilateral DC network, Maximum Power is delivered to the load when the load resistance is equal to the internal resistance of the source.If it is an independent voltage source, then its series resistance (internal resistance RS) or if it is independent current source, then its parallel resistance (internal resistance RS) must equal to the load resistance RL to deliver maximum power to the load.Proof of Maximum Power Transfer TheoremThe Maximum Power Transfer Theorem ensures the value of the load resistance, at which the maximum power is transferred to the load.Consider the below DC two terminal network (left side circuit). The condition for maximum power is determined by obtaining the expression of power absorbed by load using mesh or nodal current methods and then deriving the resulting expression with respect to load resistance RL.This is quite a complex procedure. But in the previous tutorials, we have seen that the complex part of the network can be replaced with a Thevenins equivalent as shown below.The original two terminal circuit is replaced with a Thevenins equivalent circuit across the variable load resistance. The current through the load for any value of load resistance isForm the above expression, the power delivered depends on the values of RTH and RL. However, as the Thevenins equivalent is a constant, the power delivered from this equivalent source to the load entirely depends on the load resistance RL. To find the exact value of RL, we apply differentiation to PL with respect to RL and equating it to zero as shown below:Therefore, this is the condition of matching the load where the maximum power transfer occurs when the load resistance is equal to the Thevenins resistance of the circuit. By substituting the RTH = RL in the previous equation, we get:The maximum power delivered to the load is,Total power transferred from source is:PT= 2 * IL2 RL .(2)Hence, the maximum power transfer theorem expresses the state at which maximum power is delivered to the load i.e., when the load resistance is equal to the Thevenins equivalent resistance of the circuit. Below figure shows a curve of power delivered to the load with respect to the load resistance.Note that the power delivered is zero when the load resistance is zero as there is no voltage drop across the load during this condition. Also, the power will be maximum, when the load resistance is equal to the internal resistance of the circuit (or Thevenins equivalent resistance). Again, the power is zero as the load resistance reaches to infinity as there is no current flow through the load.Power Transfer EfficiencyWe must remember that this theorem states only maximum power transfer but not for maximum efficiency. If the load resistance is smaller than source resistance, power dissipated at the load is reduced while most of the power is dissipated at the source, then the efficiency becomes lower.Consider the total power delivered from source equation (equation 2), in which the power is dissipated in the equivalent Thevenins resistance RTH by the voltage source VTH.Therefore, the efficiency under the condition of maximum power transfer is:Efficiency = Output / Input 100= IL2 RL / 2 IL2 RL 100= 50 %Hence, at the condition of maximum power transfer, the efficiency is 50%, that means only half of the generated power is delivered to the load and at other conditions, a small percentage of power is delivered to the load, as indicated in efficiency verses maximum power transfer the curves below.For some applications, it is desirable to transfer maximum power to the load than achieving high efficiency such as in amplifiers and communication circuits.On the other hand, it is desirable to achieve higher efficiency than maximized power transfer in case of power transmission systems, where a large load resistance (much larger value than internal source resistance) is placed across the load. Even though the efficiency is high the power delivered will be less in those cases.Maximum Power Transfer Theorem for AC CircuitsIn an active network, it can be stated that the maximum power is transferred to the load when the load impedance is equal to the complex conjugate of an equivalent impedance of a given network as viewed from the load terminals.Consider the above Thevenins equivalent circuit across the load terminals in which the current flowing through the circuit is given as: Therefore, I = VTH / (RL + jXL + RTH + jXTH)I = VTH / ((RL+ RTH) + j(XL + XTH))The power delivered to the load, PL = V2TH * RL / ((RL+ RTH)2 + (XL + XTH)2) (1)For maximum power the derivative of the above equation must be zero, after simplification we getPutting the above relation in equation 1, we getPL = V2TH RL / ((RL+ RTH)2 Again for maximum power transfer, derivation of above equation must be equal to zero and after simplification we get: Hence, the maximum power will transferred to the load from source, if RL = RTH and XL = XTH in an AC circuit. This means that the load impedance should be equal to the complex conjugate of equivalent impedance of the circuit, Where ZTH is the complex conjugate of the equivalent impedance of the circuit.This maximum power transferred, PMAX= V2TH / 4 RTH or V2TH/ 4 RLApplying Maximum Power Transfer Example to DC CircuitConsider the below circuit to which we determine the value of the load resistance that receives the maximum power from the supply source and the maximum power under the maximum power transfer condition.Disconnect the load resistance from the load terminals a and b. To represent the given circuit as Thevenins equivalent, we have to determine the Thevenins voltage VTHand Thevenins equivalent resistance RTH.The Thevenins voltage or voltage across the terminals ab is Vab = Va VbVa = V R2 / (R1 + R2)= 30 20 /(20 + 15)= 17.14 VVb = V R4/ (R3 + R4)= 30 5 /(10 + 5)= 10 VVab = 17.14 10= 7.14 VVTH = Vab = 7.14 VoltsCalculate the Thevenins equivalent resistance RTH by replacing sources with their internal resistances (here, let us assume that voltage source has zero internal resistance so it becomes a short circuit).Thevenins equivalent resistance or resistance across the terminals ab isRTH = Rab = [R1R2 / (R1 + R2)] + [R3R4 /(R3 + R4)]= [(15 20) / (15 + 20)] + [(10 5) / (10+ 5)]= 8.57 + 3.33RTH = 11.90 OhmsThe Thevenins equivalent circuit with above calculated values by reconnecting the load resistance is shown below.From the maximum power transfer theorem, RL value must equal to the RTHto deliver the maximum power to the load.Therefore, RL = RTH= 11.90 OhmsAnd the maximum power transferred under this condition is,PMAX= V2TH / 4 RTH= (7.14)2 / (4 11.90)= 50.97 / 47.6= 1.07 WattsApplying Maximum Power Transfer to AC circuitThe below AC network consists of load impedance ZL of which both reactive and resistive parts can be varied. Hence, we have to determine the load impedance value at which the maximum power delivered from the source and also the value of the maximum power.To find the value of load impedance, first, we find the Thevenins equivalent circuit across the load terminals. For finding Thevenins voltage, disconnect the load impedance as shown in below figure.By voltage divider rule,VTH = 200 [j6 / (4 + j6)]= 200 [690 / 7.2156.3]= 200 0.82533.7VTH = 16.533.7 VBy shorting the voltage source, we calculate the Thevenins equivalent impedance of the circuit as shown in figure.Therefore,ZTH = (4 j6) / (4 + j6)= (4 690) / (7.2156.3)= 3.3333.7 0r 2.77 + j1.85 OhmsHence, the Thevenins equivalent circuit across the load terminals is shown in below.Therefore to transfer the maximum power to the load, the value of the load impedance should beZL = ZTH= 2.77 j1.85 ohmsThe maximum power delivered, PMAX= V2TH / 4 RTH= (16.5)2/4(2.77)= 272.25 / 11.08= 24.5 WPractical Application of Maximum Power Transfer TheoremConsider the practical example of a speaker with an impedance of 8 ohms. It is driven by an audio amplifier with an internal impedance of 500 ohms. The Thevenins equivalent circuit is also shown in figure.According to the maximum power transfer theorem, the power is maximized at the load if the load impedance is 500 ohms (same as internal impedance). Or else internal resistance has to be changed to 8 ohms to achieve the Maximum Power Transfer condition. However, it is not possible to change either of them.So, it is an impedance mismatch condition and it can be overcome by using an impedance matching transformer with its impedance transformation ratio of 500:8.

Maximum power transfer theorem advantages and disadvantages. What is maximum power transfer theorem. Limitations of maximum power transfer theorem. Maximum power transfer theorem examples.