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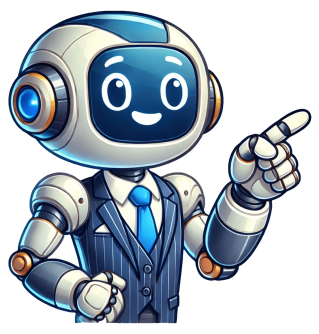

The disadvantage of the one wattmeter method is that it cannot be used for three-phase systems that carry unbalanced loads. Also, in three wattmeter method for star-connected load, it is difficult to get a neutral point to connect voltage coils, and the current coils are inserted in a closed delta for delta connected load. These drawbacks can be overcome by the Two Wattmeter method. The two wattmeter method of three-phase power measurement is given from Blondel's theorem. Blondel's Theorem for 3-Phase Power Measurement : Blondel's theorem tells about the number of wattmeters required to measure three-phase power. It states that, in order to measure power in a network with n number of lines. The total number of wattmeters required is equal to n, and total power is the sum of all the wattmeters readings. It is in such condition that, if current coils of each wattmeter are connected in each line and corresponding voltage coils are connected such that, one end to their respective line and other ends of all the voltage coils are connected together forming a common point. Suppose, if the common point is to be taken on any one of the lines. Then the other end of the voltage coils is connected to that common line (i.e., common point). In such conditions, the power can be measured by (n-1) wattmeters. Thus for measuring 3-phase power, only 2 wattmeters are required, this is called Two Wattmeter Method. Measurement of Power by Two Wattmeter Method : This method is employed for the power measurement of a 3-phase 3-wire unbalanced or balanced system. The current coils are connected in series with the two lines. One end of each voltage coil is connected to the line in which current coils are placed and the other ends of two voltage coils are brought out and are connected to the third line. The connection diagram for the two wattmeter method of measuring the three-phase power of star and delta connected loads is shown below. Measurement of Power by Two Wattmeter Method in Star Connection : Let the phase voltages and line currents of the phases R, Y, and B be (VR & IR), (VY & IY), and (VB & IB). Let W1 and W2 be the power measured by wattmeters 1 and 2 respectively. From the above figure, the power measurement by wattmeter 1 is,W1 = (VR - VY) IR = VR IR - VY IR Power measurement by wattmeter 2 is,W2 = (VB - VY) IB = VB IB - VY IB At neutral point N, we have, Therefore, total power i.e., sum of both the wattmeter readings is, Hence, the sum of both the wattmeter readings gives the total power consumed by the load. Measurement of Power by Two Wattmeter Method in Delta Connection : Let the phase voltages and line currents of the phases R, Y, and B be (VR & IR), (VY & IY), and (VB & IB). Let W1 and W2 be the power measured by wattmeters 1 and 2 respectively. From the above figure, the power measurement by wattmeter 1 is,W1 = VR (IR - IB) = VR IR - VR IB Power measurement by wattmeter 2 is,W2 = -VY (IB - IY) = -VY IB - VY IY Here, VY is taken as negative because it is being measured from phase B to Y while VY is from Y to B. Applying KVL to the delta connected load, we get, Therefore, total power i.e., sum of both the wattmeter readings is, In this case also, the sum of both the wattmeter readings gives the total power consumed by the load. Hence, at any instant regardless of the power factor, the sum of two wattmeter readings gives total instantaneous power in a three-phase unbalanced load. Sign Up Now &Daily Live Classes3000+ TestsStudy Material & PDFQuizzes With Detailed Analytics+ More BenefitsGet Free Access Now Two Wattmeter Method of power measurement can be used for both the balanced or unbalanced loads of 3 Φ 4 wires or 3 Φ 3 wire systems. In this method two wattmeters are connected as shown in Fig. 1. The current coils are connected in series with the load and the pressure coils are connected across the line voltage. The total power consumed by the load is the algebraic sum of both wattmeters reading keeping in view the value of power factor of the load i.e. p = W1 + W2 In this method, the current coil of the two wattmeters are connected in any of the two lines and the potential coil of both wattmeters are connected with the left third line, in which no wattmeter is connected. Star Connected Load The Fig. 1. shows arrangement of wattmeter for a 3-phase star connected load. Fig. 1. Two Wattmeter Method for Star Connected Load. Let v1, v2, v3 are the instantaneous voltages and i1, i2, and i3 are the instantaneous value of currents. As, these are the instantaneous values therefore, instantaneous power will be equal to the sum of their products i.e., instantaneous power p = v1 i1 + v2 i2 + v3 i3 . . .(i) It can be proved, that the total power will be the algebraic sum of the readings of the two wattmeters. If readings of the wattmeters are W1 and W2, the total power = W1 + W2. Proof: Since all the three phases meet at a star point, according to the Kirchoff's currents law (KCL), the algebraic sum of the currents will be zero. i.e., i1 + i2 + i3 = 0 or i3 = – (i1 + i2) . . .(ii) Substituting this value in expression (i). The Instantaneous total power will be p = v1 i1 + v2 i2 + v3 (i1 + i2) = v1 i1 + v2 i2 – v3 i1 – v3 i2 p = i1 (v1 – v3) + i2 (v2 – v3) . . .(iii) As i1 is the instantaneous current flowing through the current coil of wattmeter w1 and (v1 – v3) is the potential difference acting across its potential coil hence, i1 (v1 – v3) = W1 Similarly, i2 is the instantaneous current flowing through the current coil of wattmeter W2 and (v2 – v3) is the potential difference acting across its potential coil hence. i2 (v2 – v3) = W2 Hence, total instantaneous power, p = W1 + W2 Delta Connected Load The Fig. 2 shows wattmeters connections for 3-phase delta connected load. Fig. 2. Two Wattmeter Method for Delta Connected Load In delta, as the three phases form a closed ioop and according to the Kircloiff voltage law (KVL) v1 + v2 + v3 = 0 or v1 = – (v2 + v3) The Instantaneous total power will be p = v1 i1 + v2 i2 + v3 i3 . . .(iv) Substituting in eq. (iv) v1 = – (v2 + v3) we get p = – (v1 – v3) i1 + v2 i2 + v3 i3 p = – v3 (i1 – i3) + v1 (i2 – i1) . . .(v) As – v3 is the instantaneous potential difference across potential coil of wattmeter W2 and (i1 – i3) is the instantaneous current flowing through its current coil hence. – v3 (i2 – i3) = W1 Similarly, v1 is the instantaneous potential difference across the potential coil of wattmeter W2 and (i2 – i1) is the instantaneous current flowing through its current coil hence, v1 (i2 – i1) = W2 Hence, total instantaneous power [(From eq. (v)] p = W1 + W2 Result: Hence, the algebraic sum of two wattmeters' readùigs give the total power of the circuit irrespective that it is star or delta connected or it is balanced or unbalanced. Depending upon the power factor, the readings of the wattmeters are affected. There are the following different cases. (i) When power factor is unity. In this case both the wattmeters will give positive readings and equal also. (ii) When Power factor ≥ 0.5. Both wattmeters will read positive but different readings. In case if the power factor is 0.5, only one wattmeter will give reading and total power will be equal the this reading. (iii) When power factor < 0.5. In this case the one wattmeter will read in opposite direction, change the connection of the current coil of this wattmeter and get positive reading. This article explains the measurement of three-phase power in star connected or delta connecter load using the wattmeter methods.The power in a three phase load can be measured by following methods:Three wattmeter methodTwo wattmeter methodOne wattmeter methodThe name of these methods indicates the number of wattmeters used in the measurement of the three-phase power.What is a Wattmeter?A wattmeter is an equipment used to measure power in a circuit. It consists of two types of coils. They are:A Current Coil that possesses a low resistance.A Pressure or Potential Coil that possesses a high resistance.The current coil is connected in series with the line carrying current. The pressure coil is connected across the two points whose potential difference is to be measured. Refer the figure for the connections of a wattmeter.Connection of a WattmeterA wattmeter shows a reading which proportional to the product of three values. They areCurrent (I) through its current coil.Potential difference (V) across its pressure coil.Cosine of the angle between voltage and current (Cosϕ).P = VICos(ϕ)A comparison between the methods of measuring power in a three-phase circuit is shown in the table below.Three Wattmeter MethodUsed for measurement of 3 phase, 4 wire circuits. Both balanced and unbalanced loads.One Wattmeter MethodUsed in Balanced 3 phase, 3 wire load circuit.Two Wattmeter MethodUsed in both balanced and unbalanced 3 phase, 3 wire circuitsNow we will explain the measurement three-phase power measurement using three wattmeter method.Three wattmeter method is used to measure power in 3 phase, 4-wire circuits. However, this method can also be used in 3 phase, 3 wire delta connected load, where power consumed by each load is required to be determined separately.The figure below shows the three wattmeter connection of 3 phase, 4 wire star connected load.Three Wattmeter MethodAs indicated in the figure, the three wattmeters are connected in each of the three phases to measure three-phase power usage of the load whether star or delta connected.The current coil of each wattmeter carries the current of one phase only and the pressure coil measures the phase voltage of the phase. Hence, each wattmeter measures the power in a single phase. The total power in the load is given by the algebraic sum of the readings of the three wattmeters.P = W1 + W2 + W3where , W1 = V1*I1 , W2 = V2*I2, W3 = V3*I3While using three wattmeter method following difficulty is met with:In the case of 3 phase, 3 wire star connected load, it is difficult to get a neutral point which is required for connection. In special cases, when this method is necessary to use, an 'artificial star' can be formed.In case of delta connected circuits, the difficulty in using this method is due to fact that the phase coils are required to be broken for inserting current coils of wattmeters.To measure power it is not necessary to use three wattmeter, even two wattmeters can be used for the purpose.Except for 3 phase, 4 wire unbalanced load, three-phase power are measured using only Two Wattmeter Method.The next method we are going to discuss is the one wattmeter method.In this method of three-phase power measurment, the current coil is connected in any one line and the pressure coil is connected alternatively between this and the other two lines. The connection diagram is shown in the figure below.One Wattmeter MethodSo we will get two readings for a balanced load. The two readings so obtained, correspond to those obtained by the normal two wattmeter method.A balanced load is a load that draws the same current from each phase of the three-phase system, while an unbalanced load has at least one of those currents different from the rest.In balanced 3-wire, 3-phase load circuit the power in each phase is equal. Therefore, the total power of the circuit can be determined by multiplying the power measured in any one phase by three.Total power in balanced load = 3 x Power per Phase= 3 x Wattmeter readingThis method is not of as much universal application as the two wattmeter method because it is restricted to fairly balance loads only. Even a slight degree of unbalance in the loading produce a large error in the measurement.However, it may be conveniently applied, for instance, when it is desired to find the power input to a factory motor in order to check the load up on the motor.As the name indicates, in this method two wattmeters are used to measure three-phase power. This is the most popular method among the three.This method is generally used for the measurement of power in 3 phase, 3-wire load circuits. It can be used to measure power in star/delta connected load in balanced or unbalanced condition.Remember a balanced load is a load that draws the same current from each phase of the three-phase system, while an unbalanced load has at least one of those currents different from the rest.In two wattmeter method, the current coils of the two wattmeters are inserted in any two lines and pressure coil of each wattmeter is joined to the third line. Refer the figure below for better understanding.Two Wattmeter MethodThe figure above shows the two wattmeter connection of star connected load. Similarly, delta connected loads are also used. Two wattmeter method can be used irrespective of balanced or unbalanced load.The algebraic sum of two wattmeter reading gives the total power in the 3-phase, 3 wire star-connected or delta connected load circuits whether the load is balanced or unbalanced.P = W1 + W2 WORKED EXAMPLES THREE PHASE POWER MEASUREMENT By 2 wattmeter method Case (a): Balanced star connected loads.COM Example 13 Determine the power and power factor if the two wattmeters read (i) 1000 w each, both positive (ii) 1000 w each of opposite sign. Solution: Case (i): W1 = 1000 watts W2 = 1000 watts This power factor may be lead or lag. As the load is not specified, (inductive or capacitive) we can not identify the nature of power factor. Example 14 The power input to a 2000 V, 50 HZ, 36 motor running on full load at an efficiency of 90% is measured by two wattmeters which indicate 300KW and 100KW respectively. Calculate i) Input, ii) Power factor, iii) Line current, iv) H.P. output. Solution: W1 = 300 KW W2 = 100 KW i) Total input power = W1 + W2 = 400 KW = 400 × 103 W ii) The motor is assumed to be Induction motor. Hence the power factor is lagging in nature. Example 15 In a balanced 34 system, the power is measured by two-wattmeter method and the ratio of two wattmeter readings is 2: 1. Determine the power factor of the system. Solution: Data: W2 / W1 = 1/2 = r (say) We know that for lagging power factor, Example 16 A balanced delta connected load takes a line current of 15A when connected to a balanced 3 phase 400 V system. A wattmeter with its current coil in one line and potential coil between the two remaining lines read 2000 W. Describe the load impedance. Solution : For this type of connection, the wattmeter indicates reactive power. Hence the given power must be in VAR and not watts. Watt meter reading Example 17 Three identical coils each having a resistance of 202 and a reactance of 202 are connected in i) star ii) delta across 440 V, 3 phase supply. Calculate for each case, line current and reading in each of the wattmeters connected to measure power. Solution: All the electrical equipment and machines work on supplying electric power and dissipate large amounts of energy. The supplied power is usually measured in terms of watts using a device namely wattmeter. A wattmeter is also called as deflection meter which is mainly used in electrical labs. It not only measure power in terms of watts but also measures in terms of kilowatts and megawatts. The wattmeter usually consists of two coils "CC" current coil which is usually connected in series with load current and a voltage/ pressure / potential coil "PC", this coil is usually connected across the load circuit. The electrical power can be represented in three forms they are real power, reactive power, and apparent power. The following article describes the two wattmeter method at balanced load condition. What is Two Wattmeter Method? A three-phase two-watt meter measures the current and voltage from any of the 2 supply lines of 3 phase corresponding to the 3rd supply line of 3 phase. The 3 phase 2 wattmeter is said to be at a balanced load condition if the current in every phase lag at an angle "φ" with phase voltage. Construction of Two Wattmeter Method The 3-phase power of a 3-phase circuit can be measured using 3 ways they are, 3 Wattmeter Method 2 Wattmeter Method 1 Wattmeter Method. The main concept of 2 Wattmeter with 3 phase voltage is to balance the 3 phase load by satisfying the condition of current lagging at an angle 'φ' with the voltage phase. The schematic diagram of 3 phase 2 wattmeter is shown below Circuit Diagram It consists of 2 wattmeters like W1 and W2, where each wattmeter has a current coil 'CC' and a pressure coil 'PC'. Here, one end of wattmeter 'W1' is connected to 'R' terminal whereas one end of wattmeter' W2′ is connected to' Y' terminal. The circuit also consists of 3 inductors 'Z' which are constructed in a star topology. The 2 ends of inductors are connected to 2 terminals of a wattmeter whereas the third terminal of the inductor is connected to B. Derivation of Two Wattmeter Method Two Wattmeter is used to determine two main parameters they are, Power factor Reactive power. Consider the load used as an inductive load which is represented by following the phasor diagram as shown below. Phasor Diagram The voltages VRN, VYN, and VBN are electrically 1200 in phase with one other, we can observe that the current phase lags at the "φ0 " angle with voltage phase. The current in wattmeter W1 is represented as W1 = IR …….. (1) where IR is current The potential difference across the wattmeter W1 coil is given as W1 = ~ VRB = [~ VRN – ~ VBN] ……… (2) Where VRN and VBN are voltages The phase difference between the voltage 'VYB' and current 'IY ' is given as (300 + φ) Hence the power measured by wattmeter is given as W2 = VYB IY cos (300 + φ) ………….. (3) At balanced load condition, IR = IY = IB = IL and …………. (4) VRY = VYB = VBR = VL ………… (5) Therefore we obtain wattmeter readings as W1 = VL IL cos(300 – φ) and ……………. (6) W2 = VL IL cos (300 + φ) …………….. (7) Total Power Derivation The total wattmeter reading is given as W1 + W2 = VL IL cos(300 – φ) + VL IL cos (300 + φ) ………….. (8) = VL IL [cos(300 – φ) + cos (300 + φ)] = VL IL [cos 300 cos φ + sin 300 sin φ + cos 300 cos φ – sin 300 sin φ] = VL IL [2 cos 300 cos φ] = VL IL [(2 √3 / 2) cos 300 cos φ] = √3 [VL IL cos φ] ……… (9) W1 + W2 =P ….. (10) Where 'P' is the total observed power in a 3-phase balanced load condition. Power Factor Derivation Definition: It is the ratio between actual power observed by the load to apparent power flowing in the circuit. The power factor of three phase balanced load condition can be determined and derived from wattmeter readings as follows From equation 9 W1 + W2 = √3 VL IL cos φ Now W1 – W2 = VL IL [cos(300 – φ) – cos (300 + φ)] = VL IL [cos 300 cos φ + sin 300 sin φ – cos 300 cos φ + sin 300 sin φ] = 2 VL IL sin 300 sin φ W1 – W2 = VL IL sin φ ………….. (11) Dividing equations 11 and 9 [W1 – W2 \ W1 +W2] = VL IL sin φ / √3 VL IL cos φ Tan φ = √3 [W1 – W2\W1 +W2] The power factor of the load is given as cos φ = cos tan-1 [√3] [W1 – W2 \ W1 +W2] ………(12) Reactive Power Derivation Definition: It is the ratio between complex power corresponding to storage and revival of energy rather than consumption. To obtain reactive power, we multiply equation 11 with √3 [W1 – W2]= √3 [VL IL sin φ] = Pr Pr = √3 [W1 – W2] ………… (13) Where Pr is the reactive power obtained from 2 wattmeters. Two Wattmeter Method Table The two wattmeter method observations can be noted practically by following the table. S .NO Voltage VL (volts) Current IL (amp) Power W1 (watts) Power W2 (watts) Total Power P = W1 + W2 Power Factor = cos φ 1 2 3 Precaution The following are the precautions to be followed Connections are to be made tightly Avoid the parallel axial error. Advantages of Two Wattmeter The following are the advantages Both balanced and unbalanced load can be balanced using this method In a star connected load, it is optional to connect neutral point and wattmeter In a delta, connected load connections need not be opened to connect wattmeter 3 phase power can be measured using two wattmeter's Both power and power factor is determined on a balanced load condition. Disadvantages of Two Wattmeter The following are the disadvantages Not suitable for 3 phase, 4 wire system Primary windings W1 and secondary windings W2 must be identified correctly to prevent incorrect results. Applications of Two Wattmeter The following are the applications Wattmeters are used to measure the power consumption of any electrical appliances and verify their power ratings. FAQs 1). What is a WattMeter? A wattmeter is an electrical device that is used to measure the electrical power of electrical equipment. 2). What are the Units of Power? Power can be measure using wattmeter in a range of Watts, Kilowatts, Mega Watts. 3). What is Balanced Condition in 3 Phase Two Wattmeter? The 3 phase 2 wattmeter is said to be at a balanced load condition if the current in every phase lag at an angle φ with phase voltage. 4). What is the power equation of 3 Phase Two Wattmeter? The power equation is given as P= √3 VL IL cos φ 5). What is the Power Factor of 3 Phase Two Wattmeter? The power factor is given as cos φ = cos tan-1 √3 [([W1- W2] \ [W1+ W2]) 6). What is the Reactive Power equation of 3 Phase Two Wattmeter? The reactive power is given as Pr = √3(W1- W2) All the electrical device dissipates energy when electrical power is supplied, this power can be measured using an electrical device named wattmeter, which usually measures in watts/kilowatts/megawatts. The 3-phase power of a 3-phase circuit can be measured using 3 ways using 3 Wattmeter Method, 2 Wattmeter Method, 1 Wattmeter Method. This article describes 3 phase 2 wattmeter under balanced load conditions. This condition is valid if the current in every phase lag at an angle φ with phase voltage. The main advantage of this method is that it can measure both balanced and unbalanced load conditions. Sign Up Now &Daily Live Classes3000+ TestsStudy Material & PDFQuizzes With Detailed Analytics+ More BenefitsGet Free Access Now Two Wattmeter Method can be employed to measure the power in a 3 phase, three-wire star or delta connected the balanced or unbalanced load. In two wattmeter method, the current coils of the wattmeter are connected with any two lines, say R and Y and the potential coil of each wattmeter is joined on the same line, the third line i.e. B as shown below in figure (A): The total instantaneous power absorbed by the three loads Z1, Z2 and Z3, is equal to the sum of the powers measured by the two wattmeters, W1 and W2. Contents: Measurement of Power by Two Wattmeter Method in Star Connection Considering the above figure (A) in which Two Wattmeter W1 and W2 are connected, the instantaneous current through the current coil of Wattmeter, W1 is given by the equation shown below: The instantaneous potential difference across the potential coil of Wattmeter, W1 is given as: Instantaneous power measured by the Wattmeter, W1 is The instantaneous current through the current coil of Wattmeter, W2 is given by the equation: The instantaneous potential difference across the potential coil of Wattmeter, W2 is given as: Instantaneous power measured by the Wattmeter, W2 is: Therefore, the total power measured by the two wattmeters W1 and W2 will be obtained by adding the equation (1) and (2). Where, P – the total power absorbed in the three loads at any instant. Measurement of Power by Two Wattmeter Method in Delta Connection Considering the delta connected circuit shown in the figure below: The instantaneous current through the coil of the wattmeter, W1 is given by the equation: Instantaneous power measured by the Wattmeter, W1 will be: Therefore, the instantaneous power measured by the wattmeter, W1 will be given as: The instantaneous current through the current coil of the Wattmeter, W2 is given as: The instantaneous potential difference across the potential coil of wattmeter, W2 : Therefore, the instantaneous power measured by the wattmeter, W2 will be: Hence, to obtain the total power measured by the two wattmeter the two equations, i.e. equation (3) and (4) has to be added. Where P is the total power absorbed in the three loads at any instant. The power measured by the Two Wattmeter at any instant is the instantaneous power absorbed by the three loads connected in three phases. In fact, this power is the average power drawn by the load since the Wattmeter reads the average power because of the inertia of their moving system. All the electrical equipment and machines work on supplying electric power and dissipating large amounts of energy. The supplied power is usually measured in terms of watts using a device namely a wattmeter. A wattmeter is also called a deflection meter which is mainly used in electrical labs. It not only measures power in terms of watts but also measures in terms of Kilowatts and Megawatts. The wattmeter usually consists of two coils "CC" current coil which is usually connected in series with load current and a voltage/pressure/ potential coil "PC", this coil is usually connected across the load circuit. Electrical power can be represented in three forms they are Active power, Reactive power and Apparent power. The following theory describes the two-wattmeter method at a balanced load condition. Three-phase two-wattmeter measures the current and voltage from any of the 2 supply lines of 3 phases corresponding to the 3rd supply line of 3 phases. The 3-phase two-wattmeter is said to be at a balanced load condition if the current in every phase lags at an angle "φ" with phase voltage. Construction of Two Wattmeter Method The 3-phase power of a 3-phase circuit can be measured using three ways: Three Wattmeter Method Two Wattmeter Method One Wattmeter Method The main concept of two two-wattmeter with 3 phase voltage is to balance the 3 phase load by satisfying the condition of current lagging at an angle 'φ' with the phase voltage. The circuit diagram of 3 phase two wattmeter is shown below: Fig. 1 Three-phase power measurement using Two Wattmeter It consists of two Wattmeters like P1 and P2, Where each wattmeter has a current coil 'CC' and a pressure coil 'PC'. Here, One end of wattmeter P1 is connected to the '1' terminal whereas one end of wattmeter P2 is connected to the '2' terminal. The circuit also consists of 3 resistors which are constructed in a star topology. The two ends of resistors are connected to 2nd terminals of a wattmeter whereas the third terminal of the resistor is connected to 3. Derivation of Two Wattmeter Method Two Wattmeter is used to determine two main parameters they are, Active Power Power factor Consider the load used as a resistive load which is represented by following the phasor diagram as shown below. Fig 2. Phasor diagram for balanced Star Connected Load Instantaneous power consumed by load = v1i1 + v2i2 + v3i3 Let us consider two wattmeters connected to measure power in three-phase circuits as shown in Fig. 1 Star connection. Instantaneous reading of P1 wattmeter p1 = i1 (v1-v3). Instantaneous reading of P2 wattmeter p2 = i2 (v2-v3). Sum of Instantaneous readings of two wattmeters = p1 + p2 $$=i_1 (v_1-v_3) + i_2 (v_2-v_3) = v_1i_1 + v_2i_2 - v_3 (i_1+i_2)$$ From Kirchhoff's law, $$i_1 + i_2 + i_3 = 0$$ $$i_3 = -(i_1+i_2)$$ Therefore, Sum of Instantaneous readings of two wattmeters = v1i1 + v2i2 + v3i3 Therefore, The sum of the two-wattmeter reading is equal to the power consumed by the load. This is irrespective of whether the load is balanced or unbalanced. Let V1, V2, V3 be the rms values of phase voltage and I1, I2, I3 be the rms values of phase currents. The load is balanced, therefore Phase voltages V1 = V2 = V3 = V (say) Line voltages V13 = V23 = V12 = √3V Phase currents I1 = I2 = I3 = I (say) Line currents I1 = I2 = I3 = I Power factor = cosφ The phase currents lag the corresponding phasor voltages by an angle φ. The current through wattmeter P1 is I1 and the voltage across its pressure coil is V13. I1 leads V13 by an angle (30° - φ). Therefore, Reading of P1 wattmeter, $$P_1 = V_{13}I_1cos(30° - φ) = √3VIcos(30° - φ)$$ The current through wattmeter P2 is I2 and voltage across its pressure coil is V23. I2 lags V23 by an angle (30° + φ). Therefore, Reading of P2 wattmeter, $$P_2 = V_{23}I_2cos(30° + φ) = √3VIcos(30° + φ).$$ A sum of reading of two wattmeters, $$P_1 + P_2= √3VI[cos(30° - φ) + cos(30° + φ)] = 3VIcosφ$$ This is the total power consumed by the load. Therefore, Total power consumed by load P = P1 + P2 Difference of readings of two wattmeters $$P_1-P_2 = √3VI[cos(30° - φ) - cos(30° + φ)] = √3VIsinφ$$ $$\frac{P1-P2}{P1+P2} = \frac{√3VIsinφ}{3VIcosφ} = \frac{tanφ}{√3}$$ $$φ = tan^{-1}√3\frac{P1-P2}{P1+P2}$$ Power factor, $$cosφ = cos \left (tan^{-1}√3\frac{P1-P2}{P1+P2} \right)$$ Advantages of Two Wattmeter Method: Both balanced and unbalanced loads can be balanced using this method. In a star-connected load, it is optional to connect the neutral point and wattmeter. In a delta, connected load connections need not be opened to connect the wattmeter. 3-phase power can be measured using two two-wattmeter. Both power and power factor are determined on a balanced load condition. Disadvantages of Two Wattmeter Method: Not suitable for 3-phase, 4-wire system. Primary windings P1 and secondary windings P2 must be identified correctly to prevent incorrect results. Applications of Two Wattmeter Wattmeters are used to measure the power consumption of any electrical appliances. All electrical devices run on electrical power, the consumed energy is measured in terms of watts. the device used to measure consumed power is called a watt meter. to measure three-phase power mainly two methods are used namely two wattmeter method and three wattmeter method.In this article, we will discuss two wattmeter method of power measurement.In 2 watt meter method, the current coils of two watt meters are connected in series with R and Y lines. The potential coil of each watt meter is connected to the third line B.The algebraic sum of the reading of two watt meters gives the total power consumption of the connected load even if the load is balanced or unbalanced.Total power=W1+W2As shown in two wattmeter method connection diagram, two watt meters are connected to three phase star connected load for power measurement.Wattmeter current coils are connected in series with two lines of load R & Y and the pressure coils (potential coil) of two wattmeters jointed to third line B.The instantaneous power consumed by three phase load is indicated by W1 and W2.The instantaneous potential difference across W1=eRB=eR-eBInstantaneous current through W1 =IRInstantaneous current through W2 =IYThe instantaneous potential difference across W2=eYB=eY-eBInstantaneous power consumed by load=W1+W2=IReRB+IYeYB=IR(eR-eB)+IY(eY-eB)=IReR-IReB+IYeY-IYeB=IReR+IYeY-eB(IR+IY)=IReR+IYeY+IBeB …… as the load is balanced IR+IY+IB=0 and IR+IY=-IBHence,W1+W2=P1+P2+P3Where,P1=power consumed by load L1P2=power consumed by load L2P3=power consumed by load L3P= total power consumed=W1+W2Total power absorbed by three phase load can be calculated using two watt metersWhen load is considered as inductive then the vector diagram for star connected balance load isLet three phase rms voltages are ER EY and EB and rms currents are IR, IY and IBAs considered load is inductive in nature, current lags behind the voltage by angle ΦCurrent through wattmeter W1=IRThe potential difference across the potential coil of W1 isW1=ERB=ER-EBFrom the vector diagram value of ERB is obtained by compounding ER and EB reversed. and phase difference between ERB and IR is (300-Φ)Wattmeter W1 reading=W1=ERB*IR*cos (300-Φ)Current through wattmeter W2=IY and potential difference across pressure coil of W2=EYB=EY-EBEB is derived by compounding EY and EB in reversed.the phase angle between EYB and IY is cos (300+Φ)but the load is balancedERB=EYB=EL and IR=IY=IBW1=EL*IL*cos (300-Φ)W2=EL*IL*cos (300+Φ)P=W1+W2=EL*IL*(cos (300-Φ)+cos (300+Φ))using cos (A)+cos (B) formula and solving this we get equationP=√3 *EL*IL*cos (Φ)