**Experiment-1**

**LOAD TEST ON DC- SHUNT MOTOR**

**AIM:** To study the performance characteristics of DC shunt motor by direct loading.

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SL No.** | **Name of the apparatus** | **Range** | **Qty** |
| 1. | PMMC Voltmeter | 0-300V | 1 |
| 2. | PMMC Ammeter | 0-20A | 1 |
| 3. | Tachometer |  | 1 |
| 4. | Rheostat |  | 1 |
| 5. | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to the circuit diagram.
2. Keep motor field rheostat in minimum position (cut-out) and belt is loosened.
3. Close the supply mains and DPST.
4. Motor is started with the help of three-point starter i.e., by moving its handle from OFF position to ON position.
5. Observe the speed of the motor with the help of tachometer, if the speed is less than rated speed, then slightly vary field rheostat such that to obtain rated speed.
6. Note down all meter readings which indicates No-Load readings.
7. Apply brake drum load in steps, corresponding to each step note down all meter reading till 90% of the load current is achieved.
8. Reduce the load to minimum.
9. Motor is switched off by moving the three-pointer’s handle from ON position to OFF position. Open DPST and switch off main supply.
10. Remove all wire connections.

**TABULAR COULMN:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SL No. | VL(volts) | IL(Amps) | N(rpm) | F1Kg | F2Kg | F1-F2Kg | O/PHP | O/PWatt | η (efficiency) | Torque(N-m) |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

**FORMULAE AND CALCULATIONS:**

 Radius of Brake Drum: R=

Torque T= (F1-F2)\*R

Output of the motor in HP = 2πNT/4500

Output of the motor in Watts = (2πNT/4500)\*745.5

Percentage of efficiency = [(2πNT/4500)\*745.5] / VL IL

**EXPECTED GRAPH:**



**RESULT:**

**Experiment-2**

**LOAD TEST ON DC GENERATOR**

**AIM:** To conduct experiment to obtain performance characteristics of DC Shunt generator.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No** | **NAME OF THE APPARATUS** | **RANGE** | **QTY** |
| 1 | PMMC Voltmeter | 0-300V | 2 |
| 2 | PMMC Ammeter | 0-20A0-2.5A | 11 |
| 3 | Tachometer |  | 1 |
| 4 | Rheostats | 300ohm | 1 |
| 5 | Rheostats | 400ohm | 1 |
| 6 | Rheostat load or lamp load |  | 1 |
| 7 | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to the circuit diagram.
2. Keep motor field rheostat in minimum position (cut-out) and generator field rheostat should be in maximum position(cut-in).
3. Close the supply mains and DPST.
4. Motor is started with the help of three point starter i.e. by moving its handle from OFF to ON position.
5. Observe the speed of the motor with the help of tachometer, if the speed is less than rated speed, then slightly vary field rheostat such that to obtain rated speed.
6. Gradually generator side rheostat is varied till rated generator voltage is achieved.
7. Note down all meter readings, which indicates No load readings.
8. Apply the electrical load in steps corresponding to each step note down all meter reading till rated current of the generator is obtained.
9. Decrease the load to minimum and bring generator rheostat to maximum position.
10. Move the handle of three point starter from ON position to OFF position.
11. Open DPST and switch off the supply mains.
12. Disconnect all connected wires.

**TABULAR COLUMN:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sl No. | VLVolt | ILAmp | If Amp | VLILWatt | Ia=IL+If | IaRaVolt | E=VL+IaRa |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

**MEASUREMENT OF ARMATURE RESISTANCE Ra**

**CIRCUIT DIAGRAM:**



**TABULAR COLUMN:**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No | V Volt | I Amp | Ra=(V/I) ohm |
|  |  |  |  |

1. Circuit connections are made according to circuit diagram and load should be in off position.
2. Close the supply mains and DPST.
3. Switch on the load in two steps observe the corresponding voltmeter and ammeter readings.
4. Decrease the load andand open the DPST and switch off the mains.

**CALCULATIONS:**

Ia= If+IL

Eg= VL+IaRa

**EXPECTED GRAPH:**



**RESULT:**

**Experiment-3**

**LOAD TEST ON DC COMPOUND GENERATOR**

**AIM:** To conduct experiment to obtain Load characteristics of DC Compound

 generator and draw the external characteristics for

1. Cumulative long shunt
2. Cumulative short shunt
3. Differential long shunt
4. Differential short shunt

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | NAME OF APPARATUS | RANGE | QTY |
| 1 | PMMC Voltmeter | 0-300V | 2 |
| 2 | PMMC Ammeter | 0-20A0-2.5A | 11 |
| 3 | Rheostat | 400ohm | 2 |
| 4 | Rheostat load or lamp load |  | 1 |
| 5 | Tachometer |  | 1 |
| 6 | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**

**1)**



**2)**

**3)**

**4)**



**PROCEDURE:**

1. Circuit connections are made according to the circuit diagram (a).
2. Keep motor field rheostat in minimum position(cut-out) and generator field rheostat should be kept in minimum position(cut-in).
3. Close the supply mains and DPST.
4. Motor is started with the help of three point starter i.e. by moving its handle from OFF position to ON position.
5. Observe the speed of the motor with the help of tachometer, if the speed is less than the rated speed, then slightly vary field rheostat such that to obtain rated speed.
6. Gradually generator side rheostat is varied till rated generator voltage is achieved.
7. Note down all meter readings, which indicates no load readings.
8. Apply electrical load in steps. Corresponding to each step note down all the meter readings till 90% of the rated current. And important to note: maintain the speed of the motor to be constant for each load by adjusting the field rheostat.
9. Decrease the load to minimum and also bring the motor rheostat to minimum and generator rheostat to maximum position.
10. Move the handle of the three point starter from ON position to OFF position.
11. Open DPST and switch off the supply mains.
12. Disconnect all connected wires.
13. Repeat above procedure for circuit diagrams (b), (c) and (d).

**TABULAR COLUMN:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl. No | Cumulative long shunt(a) | Cumulative short shunt(b) | Differential long shunt(c) | Differential short shunt(d) |
| VL | IL | VL | IL | VL | IL | VL | IL |
| 1 |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |

 **NOTE: Speed of the motor should be maintained constant for all loads.**

**EXPECTED GRAPH:**



**RESULT:**

**Experiment-4**

**SPEED CONTROL OF A DC SHUNT MOTOR BY ARMATURE CONTROL AND FIELD CONTROL**

**AIM:** To control the speed of a DC shunt motor by armature control and field control.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Name of the apparatus** | **Range** | **Quantity** |
| 1. | PMMC Voltmeter | 0-300V | 2 |
| 2. | PMMC Ammeter | 0-2.5A | 1 |
| 3. | Tachometer |  | 1 |
| 4. | Rheostats | 300ohm100ohm | 11 |
| 5. | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

**PROCEDURE FOR ARMATURE VOLTAGE CONTROL METHOD:**

1. Circuit connections are made according to the circuit diagram. Motor field rheostat and armature rheostat should be in the minimum and maximum position respectively. The belt is loosened.
2. Close the supply mains and the DPST.
3. Motor is started with the help of the three point starter by moving its handle from OFF position to ON position.
4. Vary the field rheostat to set a specific field current, say 1A.
5. Vary the armature rheostat in steps and the corresponding speed and meter readings are noted.
6. Move the three point starter from ON to OFF position. Repeat steps 1 to 4 for a new field current, say 0.9A and repeat steps 5 and 6.
7. After each iteration, to switch off the motor, the three point starter’s handle is moved from ON to OFF position.
8. Open the DPST and switch off the mains.
9. Remove all the connected wires.

**TABULATION:**

|  |  |  |
| --- | --- | --- |
| **QUANTITY** | **FIELD CURRENT** | **FIELD CURRENT** |
| $I\_{f}$ Amp | $I\_{f}$ = 1.0A | $I\_{f}$ = 0.9A |
| Va Volt |  |  |  |  |  |  |  |  |  |  |
| N rpm |  |  |  |  |  |  |  |  |  |  |

**PROCEDURE FOR FIELD CONTROL METHOD:**

1. Circuit connections are made according to the circuit diagram. Motor field rheostat and armature rheostat should be in minimum and maximum position respectively. The belt is loosened.
2. Close the supply mains and the DPST.
3. Motor is started with the help of the three point starter by moving its handle from OFF to ON position.
4. Vary the armature rheostat to set the voltage across the armature to say 180V. Observe the speed of the motor using the tachometer and note it down.
5. Vary the field rheostat in steps. Corresponding to each step, note down the speed and meter readings until 110% of the rated speed is achieved.
6. Bring back the field rheostat to its original position. Vary the armature rheostat to set the armature voltage to say 200V. Repeat step 5.
7. Bring back the field and armature rheostat to original position. Then, the three point starter’s handle is moved from the ON to the OFF position. Open the DPST and switch off the mains.
8. Remove all the connected wires.

**TABULAR COLOUMN:**

|  |  |  |
| --- | --- | --- |
| QUANTITY | ARMATURE VOLTAGE | ARMATURE VOLTAGE |
| Va Volts | Va = 200V | Va = 180V |
| $I\_{f}$ Amp |  |  |  |  |  |  |  |  |  |  |
| N rpm |  |  |  |  |  |  |  |  |  |  |

**EXPECTED GRAPH (ARMATURE CONTROL METHOD):**



**EXPECTED GRAPH (FIELD CONTROL METHOD):**



**RESULT:**

**Experiment-5**

**SWINBURNE’S TEST**

**AIM:** To conduct the Swinburne’s test on the DC machine and determine its efficiency as a motor and generator.

**APPARATUS REQUIRED :**

|  |  |  |  |
| --- | --- | --- | --- |
| **S NO.** | **NAME OF THE APPARATUS** | **RANGE** | **QTY** |
| 1 | PMMC Voltmeter | 0-300V | 2 |
| 2 | PMMC Ammeter | 0-2.5A0-5A | 11 |
| 3 | Tachometer |  | 1 |
| 4 | Rheostats | 300 ohm | 1 |
| 5 | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to the circuit diagram.
2. Keep motor’s Field rheostat in minimum position (cut –out) and belt is loosened.
3. Close the supply mains and DPST.
4. Motor is started by moving three point starter’s handle from OFF position to ON position.
5. Observe the speed of the motor with the help of tachometer, if the speed is less than rated speed, then slightly vary field rheostat such that to obtain rated speed.
6. Note down all meter readings which indicates no-load readings.
7. To switch off the motor, move the three point starter’s handle from ON position to OFF position. Open DPST and switch off the main supply.
8. Disconnect all wire connections.

**TABULATION:**

|  |  |  |  |
| --- | --- | --- | --- |
| V Volt | $I\_{L}$Amp | If Amp | N rpm |
|  |  |  |  |

**CALCULATIONS :**

Input to motor = V$I\_{L}$ Watt

Armature current = ($I\_{L}$ – If )

 Armature copper loss = ($I\_{L}$ – If )2Ra

Constant loss Wk = V$I\_{L}$ - ($I\_{L}$ – If )2Ra

**Efficiency as a motor :**

If IL is the line current and K is the fraction of any load to full load.

Then

 Input = V(KIL) where K = 0.25,0.5,0.75,1.0

Armature copper loss Wcu = (kIL - If)2Ra

 Total losses = Wk + Wcu

Efficiency = (input – losses)/ input

Efficiency is calculated for all values of K.

**Efficiency as a generator:**

If$ I\_{L}$is the line current, Kis the fraction of any load and *VL*is the load voltage.

Then

Output = VL (KIL) where K = 0.25, 0.5, 0.75, 1.0

Armature copper loss Wcu = (kIL + If)2 Ra

Total losses = Wk + Wcu

Efficiency = output / (output + losses)

Efficiency is calculated for all values of K.

**EXPECTED GRAPH:**

**RESULT :**

**Experiment-6**

**HOPKINSONS TEST(BACK TO BACK TEST) OR**

**HEAT RUN TEST or REGENERATIVE TEST**

**AIM:** To conduct the Hopkinson’s test and to predetermine the efficiency of

 the motor or generator.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **NAME OF APPARATUS** | **RANGE** | **QTY** |
| **1** | PMMC Voltmeter | 0-300V 0-600V | 1 1 |
| **2** | PMMC Ammeter | 0-20A0-2.5A | 21 |
| **3** | Rheostat | 400Ώ + 300 Ώ  | 2 |
| **4** | SPST switch |  | 1 |
| **5** | Tachometer |  | 1 |
| **6** | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to the circuit diagram (a).
2. Keep motor field rheostat in minimum position (cut-out) and generator field rheostat is in maximum position (cut-in) and switch s1 should be open.
3. Close the supply mains and DPST.
4. Motor is started with the help of three point starter i.e. by moving its handle from OFF position to ON position.
5. Observe the speed of the motor with the help of tachometer, if the speed is less than the rated speed, then slightly vary field rheostat such that to obtain rated speed.
6. Gradually generator side rheostat is varied till rated generator voltage is build up across the generator terminals.
7. The voltmeter across the switch s1 is connected to check the polarity. If the polarities are correct the two voltages will be opposing each other and the voltmeter will read zero. If the voltmeter reads double the voltage the polarities are wrong and it is dangerous if s1 is closed. Then the machine must be stopped. The leads from the generator to motor must be interchanged and above procedure is followed.
8. If the polarity is correct the voltmeter reads zero. Then s1 is closed.
9. By observing ammeter connected between MG set vary generator rheostat to such that particular value say 4A or 8A. Note down all the meter values.
10. Bring back generator rheostat such that ammeter between MG set becomes zero.
11. To switch off the MG set move the handle of the three point starter from ON position to OFF position.
12. Open DPST and switch off the supply mains.
13. Disconnect all connected wires.

**TABULAR COLUMN:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  **Vm in volts**  |  **Im in amps** |  **Imf in amps** |  **Ig in amps** |  **Igf in amps**  |  **N in rpm** |  **V across local ckt** |
|  |  |  |  |  |  | **zero** |

 **CALCULATIONS:**

Total power input to the motor**=**Vm(Im+Ig)

Output of generator**=**VmIg

Armature copper loss in generator=(Ig+Igf)2Ra

Armature copper loss in motor=(Im-Imf+Ig)2Ra

copper loss in field winding of generator=Vm\*igf

copper loss in field winding of motor=Vm\*Imf

total losses in generator and motor=power drawn from supply

 =Vm Im

Total stray losses for both the machines Ws=(VmIm)-((Ig+Igf)2Ra+

 (Im-Imf+Ig)2Ra+(Vm\*igf)

 +(Vm\*Imf))

Stray losses for each machine=Ws/2

Total losses for motor=(Im-Imf+Ig)2Ra)+(Vm\*Imf)+(Ws/2)

Total losses for generator=((Ig+Igf)2Ra)+(Vm\*igf)+(Ws/2)

**Efficiency:**

**Motor,**

**%**efficiency=((Input-total losses)/(Input)

**Generator,**

**%**efficiency=(Output)/(output+total losses)

 **EXPECTED GRAPH:**



**RESULT:**

**Cycle II Experiments**

**Experiment-7**

**RETARDATION TEST**

**AIM:** To find the stray losses of the DC motor by conducting Retardation

Test.

**APPARATUS REQUIRED :**

|  |  |  |  |
| --- | --- | --- | --- |
| **S No.** | **APPARATUS ‘S****NAME** | **RANGE** | **QUANTITY** |
| 1 | PMMC Voltmeter |  0-300V |  2 |
| 2 | Rheostats |  0-300Ω |  1 |
| 3 | Stop Clock |  --- |  1 |
| 4 | Connecting Wires |  --- |  20 |

**CIRCUIT DIAGRAM :**



**PROCEDURE :**

1. Circuit connections are made according to the circuit diagram.
2. Motor field rheostat should be in minimum position and armature rheostat should be in maximum position.
3. Close the D.C mains supply and DPST.
4. Now armature rheostat is varied from maximum position to minimum position and observes the speed of the motor using tachometer. If the speed of the motor is less than the rated speed then slightly vary the field rheostat to obtain the rated speed.
5. When the motor is running at rated speed, open DPST keeping mains ON (because field supply is not removed). With the help of stop watch, note down the voltage and time (voltmeter is used to indicate speed because E α N) till motor comes to halt.
6. By noting different amounts of voltage fall in different amounts of time, draw the curve between time and speed.
7. Bring back the armature rheostat to maximum position and open the supply mains.
8. Finally, disconnect all the connections.

**TABULATION :**

|  |  |
| --- | --- |
| **Fall in Voltage** | **Amount of Time taken** |
| InitialVoltageE1(volts) | FinalVoltageE2(volts) | Change inVoltageE=E1-E2(V) | InitialTimet1 (sec) | FinalTimet2 (sec) | Change inTime Periodt=t2-t1 (s) |
|  |  |  |  |  |  |

**EXPECTED GRAPH :**

For any point P which corresponds to normal speed, a tangent AB is drawn.

$\frac{dN}{dt}$ = $\frac{dE}{dt}$ = $\frac{OB(in rpm)}{OA(in seconds)}$ (As E α N)



**CALCULATIONS :**

Kinetic energy is used to meet the rotational losses i.e. friction, windage & iron losses.

Kinetic energy of the armature, K.E = $\frac{1}{2}$ × I × Ѡ²

Where, I = Moment of Inertia

 Ѡ = Angular Velocity

Rotational Losses, W = Rate of loss of kinetic energy

 W = $\frac{d(\frac{1}{2} × I × Ѡ²)}{dt}$ = IѠ×$\frac{dѠ}{dt}$ But Ѡ *=* $\frac{2πN}{60}$

 W= IѠ×$\frac{dѠ}{dt}=I\frac{2πN}{60}\*\frac{d}{dt}\left(\frac{2πN}{60}\right)=\left(\frac{2π}{60}\right)^{2}\*IN\frac{dN}{dt}$

Therefore, the above equations can be written as follows :

* W = 0.011 × I × N × $\frac{dN}{dt}$ (Assume I = 100Kg/m³)
* W = 0.011 × I × N × $\frac{dE}{dt}$ (As E α N)

**RESULT :**

 **Experiment-8**

**REGULATION OF ALTERNATOR BY EMF & MMF METHOD**

**AIM**: To conduct O.C & S.C test on three phase alternator & to find regulation by

Synchronous impedance method & MMF method

**APPARATUS REQUIRED**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl No** | **Name of the part** | **Range** | **Quantity** |
| 1 | M.I. Voltmeter | 0-600V | 2 |
| 2 | PMMC Ammeter | 0-2A | 1 |
| 3 | M.I. Ammeter | 0-10A | 1 |
| 4 | Tachometer |  | 1 |
| 5 | Rheostats | 40ohm200ohm1000ohm | 111 |
| 6 | Connecting Wires |  |  |

**CIRCUIT DIAGRAM**

**1. EMF AND MMF METHOD**



**PROCEDURE**

**O.C TEST**

1. Circuit connections are made according to the circuit diagram.
2. Keep the field rheostat in minimum position (cut out).
3. Close supply mains & DPST.
4. Motor is started by moving the 3point starter’s handle from OFF position to ON

position.

1. Observe the speed of motor with the help of tachometer, if the speed is less than rated speed, then slightly vary field rheostat such that to obtain rated speed.
2. Vary alternator excitation rheostat gradually till rated alternator voltage is achieved and all meters readings are noted down.

**SC TEST**

1. Bring back alternator field rheostat to its original position i.e max. position and close TPST.
2. Carefully vary alternator’s field rheostat such that ammeter shows rated current and note down corresponding field current and stator current.
3. Once again bring back alternator field rheostat to max position. Open TPST.
4. Move 3point starter’s handle from ON position to OFF position and open DPST

 and also switch OFF the supply mains.

**TABULAR COLUMN:**

**O.C TEST**

|  |  |
| --- | --- |
| Field Current in Amps | Terminal Voltage in Volts |
|  |  |
|  |  |

**S.C TEST**

|  |  |
| --- | --- |
| Field Current in Amps | Short Circuit Current in Amps |
|  |  |
|  |  |

**EMF METHOD**

From OCC and SCC test characteristics find,

ZS=VOC/ISC  for same field current If

RA=

XS=$√$(Zs2-Ra2)

To find Eph,

Eph=$\sqrt{\left(V\_{ph}cosø+I\_{a}R\_{a}\right)2+ (V\_{ph}cosø\pm I\_{a}X\_{s})2}$

+ for lagging p.f and – for leading p.f.

Corresponding to O.C find induced voltage Eo from the graph for different power factors

Regulation= (Eo-V)/V \* 100

**VECTOR DIAGRAM FOR EMF METHOD:**



**REGULATION (Assuming different power factors)**

E0=√[(Vcosф (+/-) IRa)2+(Vsinф (+/-) IXS)2]

(+Sign for lagging power factor and – sign for leading power factor.)

%Regulation= (E0-V)\*100/V

Calculate regulation for power factors 1,0.9,0.8,0.7 etc. both leading and lagging power factors.

**EXPECTED GRAPH:**



**VECTOR DIAGRAM FOR MMF METHOD:**



**GRAPH FOR MMF METHOD:**



From OCC and SCC characteristics,

Find $I\_{f1}$ corresponding to rated terminal voltage from OCC, $I\_{f2}$ corresponding to rated current from SCC and find $I\_{f3}$ i.e resultant of $I\_{f1}$and $I\_{f2}$ using

$$I\_{f3 }=√ I\_{f1 }^{2}+I\_{f2 }^{2}-2I\_{f1 }I\_{f2 }cos⁡(angle between I\_{f1 } and I\_{f2 })$$

**Angle between** $I\_{f1 } and I\_{f2 }$ **is:**

* $(90+φ) for lagging p.f and $
* $(90-φ) for leading p.f$

**EXPECTED GRAPH:**



**RESULTS:**

**REGULATION OF ALTERNATOR BY**

**ZPF METHOD**

**AIM:** To determine the Regulation of alternator using ZPF method

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl No | Name of the part | Range | Quantity |
| 1 | M.I Voltmeter | 0-600V | 2 |
| 2 | PMMC Ammeter | 0-2A | 1 |
| 3 | M.I Ammeter | 0-10A | 1 |
| 4 | Tachometer |  | 1 |
| 5 | Rheostats | 40ohm200ohm1000ohm | 111 |
| 6 | Connecting Wires |  |  |

**CIRCUIT DIAGRAM:**



**O.C TEST:**

1. Circuit connections are made according to Circuit diagram
2. Keep the field rheostat cut out
3. Close supply mains & DPST
4. Motor is started by moving the 3pt starter’s handle from OFF position to ON position
5. Observe the speed of motor with the help of tachometer, if the speed is less than rated speed ,then slightly vary field rheostat such that to obtain rated speed
6. Vary alternator excitation rheostat gradually till rated alternator voltage is achieved and all meters readings are noted.

|  |  |
| --- | --- |
| Field Current in Amps | Terminal Voltage in Volts |
|  |  |
|  |  |

**ZPF TEST**

1.Once again O.C Test procedure is followed up to rated voltage builds up at alternator terminals then Star connected Inductive load is connected by closing TPST shown in the circuit. Apply the load in steps and simultaneously terminal voltage is maintained at rated value by excitation. For every step all meter readings are noted down till rated 90% of rated current is achieved

2. Reduce the load to min. position. TPST on load side is removed. Bring back alternator rheostat to max. Position and move 3pt starter from ON to OFF position. Open DPST and switch of supply mains.

**Construction of POTIER TRIANGLE:**

1. Plot O.C.C characteristic on graph.

2. Plot the excitation corresponding to zero terminal voltage i,e s.c full load zero power factor current. This point is A. Another point is rated voltage when alternator is delivering full load current at zero p.f lagging which is at P.

3. Draw tangent to O.C.C through origin which is line OB as shown dotted which is called AIR LINE.

4. Draw horizontal line PQ parallel and equal to OA.

5. From point Q draw line parallel to air line which intersects O.C.C at point R. Join RQ and join PR. This is called POTIER TRIANGLE.

6. From point R drop perpendicular on PQ to meet at point S.

7.The zero p.f full load saturation curve is now be constructed by moving the triangle PQR so that R remains always on O.C.C and line PQ always stays horizontal.

8. Through the point A draw line parallel to PR meeting O.C.C at point B.From B draw perpendicular on OA to meet it at point C. Triangles OAB & PQR are similar triangles.

9. The perpendicular RS gives voltage drop due to armature leakage reactance IXL.

10. Length PS gives field current necessary to overcome demagnetizing effect of armature reaction at F.L.

11. The length SQ represents field current required to induce an emf for balancing leakage reactance drop RS.

So l(RS)=l(BC)=(IAph)FL\*XLph.

XLph=l(RS)/(IAph)FL This is called Potier Reactance.

**DIAGRAM:**



**Curve for ZPF method:**



**Calculations:**

Eph2=(Vph­cosø)2+(Vph­sinø +­ or ­- ­­­IphXLph)2

­+ for LAG

-For LEAD

%Regulation=(Eph-Vph)/Vph

**Result:**

**Experiment-9**

**SYNCHRONISATION OF ALTERNATOR TO THE BUS BAR**

**AIM:** To connect the two alternators in parallel and study the effect of change

in excitation.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **NAME OF APPARATUS** | **RANGE** | **QTY** |
| 1 | MI voltmeter |  0-600V | 3  |
| 2 | PMMC Ammeter |  0-20A 0-5A | 22 |
| 3 | MI ammeter |  0-20A  | 3 |
| 4 | TPST switch |  | 1 |
| 5 | Tachometer |  | 1 |
| 6 | UPF wattmeter |  0-600V, 20A  | 2 |
| 7 | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to the circuit diagram (a).
2. Keep motor field rheostat in minimum position(cut-out) and alternator field rheostat is in maximum position(cut-in) and switch s1 should be open.
3. Close the supply mains and DPST.
4. Motor is started with the help of three point starter i.e. by moving its handle from OFF position to ON position.
5. Observe the speed of the motor with the help of tachometer, if the speed is less than the rated speed, then slightly vary field rheostat such that to obtain rated speed.
6. Alternator’s field rheostat is gradually varied to obtain rated alternator voltage. The lamp set is energised by the currents in the local circuit starts flickering. If all the lamps go bright or dim one after the other then the phase sequence is wrong. It can be corrected by interchanging any two leads of infinite bus side or alternator side.
7. If lamps flicker simultaneously, then adjust the speed of any one set until the flicker is very small and dark period persists over a longer period. At dark period close the TPST which completes the synchronisation of alternator to the bus bar.
8. Alternator paralleling switched off and excitation is reduced to minimum. .
9. Move the 3 point starter’s handle from ON position to OFF position.
10. Open DPST and busbar side TPST.
11. Disconnect all connected wires.

**CONDITIONS FOR SYNCHRONISATION:**

1. The voltage generated by alternator and busbar voltage must be same.

2. The alternator frequency must be same as busbar frequency.

3.The phase sequence of alternator and busbar must be same.

**RESULT:**

**Experiment-10**

**SLIP TEST**

**AIM:** To determine Xd and Xq of a salient pole alternator and pre-determination of Regulation.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI.NO.** | **NAME OF THE APPARATUS** | **RANGE** | **QUANTITY** |
| **1.** | PMMC Ammeter | 0-5 A | 1 |
| **2.** | PMMC Voltmeter | 0-300 V | 2 |
| **3.** | Rheostat | O-300 ohm,0-100 ohm | 2 |
| **4.** | Three phase auto-transformer |  | 1 |
| **5.** | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to circuit diagram.
2. Keep motor field rheostat in minimum position and 3 phase auto-transformer should be in minimum position. TPST switch should be open.
3. Close supply mains and DPST.
4. Motor is started with the help of three point starter by moving its handle from OFF position to ON position and observe the speed of the motor using tachometer if speed is less than rated speed slightly vary field rheostat to obtain rated speed.
5. Switch on the 3-phase supply mains and close TPST switch.
6. Vary 3-phase auto-transformer such that the voltmeter should show 20 to 30V.
7. Observe and note ammeter and voltmeter swings. (To obtain large swing slightly vary motor field rheostat)
8. Bring back the auto-transformer to minimum position. open TPST switch and 3-phase supply mains.
9. Bring back the motor field rheostat to minimum position and move the 3 point starter handle from ON position to OFF position.
10. Open DPST and switch off the supply mains.
11. Measure stator resistance per phase of the alternator by ammeter voltmeter method.

**TABULAR COLUMN :**

Resistance of stator per phase R = 1.2Rdc =

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **SI. NO.** | **Vmax** | **Vmin** | **Imax** | **Imin** | **Xd= (Vmax/Imin)** | **Xq= (Vmin/Imax)** |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

**CALCULATIONS:**

Direct axis synchronous reactance per phase Vmax(ph)/Imin(ph)

Quadrature axis synchronous reactance per phase Vmin(ph)/Imax(ph)

Let α be the angle between V and Eo

Xd=Vmax/Imin

Xq=Vmin/Imax

Tan α = (Ia (Xd cos φ- Ra sin φ))/(V+Ia(Ra cos φ + Xqsin φ))

Id = Ia sin (α + φ)

Iq = Ia cos φ

Eo = V cos α ± Ia Xd sin (α + φ) + Ia Ra cos (α + φ)

% Voltage Regulation = (Eo-V)/V \* 100

**Vector Diagram:**



**RESULT:**

**Experiment-11**

**“V” AND INVERTED “V” CURVES OF SYNCHRONOUS MACHINE**

**AIM:**  To study the performance of a synchronous motor for variation in its excitation at constant output.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.NO.** | **NAME OF APPARATUS** | **RANGE** | **QUANTITY** |
| **1.** | M.I. voltmeter | 0-600 V | 1 |
| **2.** | PMMC Ammeter | 0-2 A | 1 |
| **3.** | M.I. Ammeter  | 0-10 A | 1 |
| **4.** | Tachometer |  | 1 |
| **5.** | Rheostat | 700 Ohm,2 A | 1 |
| **6.** | UPF Watt meters | 0-5 A,600 V | 2 |
| **7.** | Connecting Wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are according to circuit diagram.
2. Keep the three phase auto-transformer in minimum position, excitation rheostat in maximum position and the belt is loosened.
3. Close supply mains and TPST.
4. Vary three phase auto-transformer gradually to read rated voltage i.e. 400V.
5. Close DC supply mains and excitation DPST.
6. Vary field rheostat in steps and corresponding to each step, stator current and wattmeter readings are noted.
7. The stator current is minimum at UPF.
8. Bring back the field rheostat to original position.
9. Open DPST and switch off DC mains.
10. Bring back the three phase auto-transformer to minimum position and open TPST and switch of the mains.
11. Disconnect the connected wires.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S.NO.** |  **V1** **Volts** |  **Ia** **Amp** |  **If** **Amp** |  **W1** **Watt** |  **W2** **Watt** |  **W1+W2** **Watt** |  **COS ф** |
|  |  |  |  |  |  |  |  |

**TABULAR COLUMN :**

**CALCULATIONS:**

Total input power Wi = W1+W2

Power factor cos ф = $\frac{ Wi }{\sqrt{3} V1.Ia}$

Also, Tanф = $\frac{ \sqrt{3} (W1-W2)}{\left(W1+W2\right)}$

**RESULT:**

**Experiment-12**

**FIELD TEST ON DC SERIES MOTOR**

**AIM:** To control the speed of a DC shunt motor by armature control and field control.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Name of the apparatus** | **Range** | **Quantity** |
| 1. | PMMC Voltmeter | 0-300V | 2 |
| 2. | PMMC Ammeter | 0-2.5A | 1 |
| 3. | Tachometer |  | 1 |
| 4. | Rheostats | 300ohm100ohm | 11 |
| 5. | Connecting wires |  |  |

**CIRCUIT DIAGRAM:**



**PROCEDURE:**

1. Circuit connections are made according to circuit diagram. Keep rheostat in maximum position.

2. Keep the load to be about 40% ON and remove fuse of load and short it with thick wire.

3. Keep the brake load drum say 2kgs.

4. Close D.C Supply mains and DPST.

5. Vary rheostat, note down all meter readings and apply load till 90% of the rated current is reached.

6. Reduce the load to 40% and then open DPST and switch of the mains.

7. Disconnect the connected wires.

8. Measure the armature resistance and series resistance by Ammeter-Voltmeter method.

**TABULAR COLUMN:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sl.No | V1 Volt | V 2Volt | I1 Amp | I2 Amp | N rpm |
|  |  |  |  |  |  |

**CALCULATIONS:**

Input to the whole dg set = V1I1

Output of the whole dg set = V2I2

Total losses of the entire set w1 = V1I1 – V2I2

 Armature and field copper losses of the set Wcu = (Ra – 2Rsc)I12 + I22Ra

Stray losses of the set W = W1 –Wcu

Stray losses per machine Ws =W/2 = (W1 – Wcu)/2

Motor efficiency =$\frac{Input-Losses}{Input}$ where $W\_{m}=W\_{cu}.I^{2}(R\_{a}+R\_{se}) $

**EXPECTED GRAPH:**



**RESULTS:**

**Experiment-14**

**Measurement of sequence reactance and calculation of fault current for a synchronous generator**

**AIM**:

Measurement of X1, X2 and X0 (Z1, Z2 and Z0) of a synchronous generator and calculation of fault current for an LG, LL or LLG fault.

**RELATED THEORY**:

 In a power system, the value of fault current at any point in the system must be known for

i) Planning or expansion of the system.

ii) To design proper protective relaying system.

iii) For choosing proper circuit breaker of short circuit KVA/MVA capacity to handle the fault and clear it.

Hence symmetrical/unsymmetrical faults are simulated on the alternator to get positive, negative and zero sequence impedances. The fault current for any type of fault LL, LG and LLG can be pre-determined.

**a) Determination of positive sequence Impedance (Reactance)**

**Procedure**

i) Conduct open circuit, short circuit and drop test on the alternator.

Graphically, find the synchronous impedance. Zs itself is the positive sequence impedance i.e. Z1=Zs.

 **Circuit diagram for OC and SC test on a 3 phase alternator**

**b) Determination of negative sequence Impedance (Reactance)**

**Circuit diagram**



**Procedure**

i) Start the prime mover and run it at rated speed.

ii) Close the switch S1 to produce LL fault.

iii) Cut out field rheostat and for each excitation note down the readings up to full-load.

iv) Cut-in field rheostat, switch off S1 and stop the prime mover.

**Tabular column**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SL.No. | V(Volts) | I(Amps) | W\*K(Watts) | N and f | $$R\_{2}$$ | $$Z\_{2}$$ | $$X\_{2}$$ | Cosⱷ |
|  |  |  |  | 1500 rpm50 Hz |  |  |  |  |

**Calculations:**

Cosⱷ=P/VI where P=W\*K

$Z\_{2}$=Negative sequence impedance per phase= $\frac{V}{√3.I}$

X2/ph =$ Z\_{2}$ Cosⱷ -ve sequence reactance

R2/ph= -$ Z\_{2}$ sinⱷ -ve sequence resistance

**c) Determination of zero sequence Impedance (Reactance)**

**Procedure**

i) The prime mover is started and made to run at rated speed.

ii) A low voltage about 5V is applied to armature, field being shorted and the readings are noted down.

iii) Readings are noted.

iv) Machine is switched off.

**Circuit diagram**

**CALCULATION:**

Z0=Zero sequence impedance = 3V/I.

Z0= j Xo

Let $I\_{f}$ is fault current.

For a 3-ph symmetrical fault

$I\_{f}$ = $\frac{Ep\left⌊0\right..}{Z\_{2}}$

For a single line to ground fault (LG fault)

$I\_{f}$ = $\frac{Ep\left⌊0\right.}{\dot{Z\_{1}}+\dot{Z\_{2}}+Z\_{0}}$

For a line to line fault (LL fault)

$I\_{f}$ = $I\_{b}$ = $I\_{c}$ = $\frac{\sqrt{3}Ep\left⌊0\right.}{\dot{Z\_{1}}+\dot{Z\_{2}}}$

For a double line to ground fault (LLG fault)

$I\_{f}$ = $\frac{3Ep\left⌊0 \dot{Z\_{2}}\right.}{\dot{Z\_{0}}\dot{Z\_{1}}+\dot{Z\_{1}}\dot{Z\_{2}}+\dot{Z\_{2}}\dot{Z\_{0}}}$

**RESULTS:**

**BEYOND SYLLABUS Experiment**

**VOLTAGE REGULATION OF ALTERNATOR BY ASA METHOD**

**AIM:** To determine the voltage regulation of the given alternator by American

standards association (ASA) method.

**APPARATUS REQUIRED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SL No** | **Name of components** | **Range** | **No.** |
| **1** | MI Voltmeter | (0-600V) | 1 |
| **2** | MI Ammeter | (0-10A) | 1 |
| **3** | MC Ammeter | (0-2A) | 1 |
| **4** | Tachometer | - | - |
| **5** | Rheostat | 40Ω,200Ω,1KΩ | 1 each |
| **6** | 3Ph Inductive load | - | - |

**CIRCUIT DIAGRAM:**

**i) OC & SC test**



**ii) ZPF Test on alternator.**



**PROCEDURE:**

1. Measure armature resistance per phase.
2. Conduct OC test, for drawing OCC curve.
3. Conduct SC test. Note down field current for circulating rated current through the armature winding, under short circuit connections.
4. Conduct ZPF test and note down the value field current required for supplying full load current to 3ph inductive load and terminal voltage of the alternator.

**TABULAR COLUMN:**

**O.C. TEST**

|  |  |  |
| --- | --- | --- |
| SL No. | Field curent (If)Amps | Terminal Voltage (V)Volts |
|  |  |  |

**S.C.Test**

|  |  |  |
| --- | --- | --- |
| SL No. | Field curent (If)Amps | S.C. Current (Isc)Amps |
|  |  |  |

**CALCULATIONS, GRAPH:**



* Draw OCC Curve.
* From ZPF test, draw the potier triangle PQR & calculate the value of the leakage reactance, XL in Ω/Phase.
* XL = (Length of RS) x (Voltage scale)/( √3 x Ia),
* Where Ia is the rated current of alternator.
* Find the value of E’ using the equation

E’ = V + Ia(Ra+jXL).

* Find the magnitude of E’ and the angle δ.
* From the OCC curve read the value of field current corresponding to E’. Let the field current be If0 (Amp).
* Find the resultant of currents Ifar and If0 using the expression-

IR2 = Ifar2 + 2 If0 Ifar cos(90+ψ+δ), where ψ is the power factor angle.

* IR = √ IR2.
* Draw the tangent to the OCC curve from the origin. Locate E’ on the Y-axis and draw a horizontal straight line through it. This line cut the tangent line at B’ and the OCC curve at B.
* Measure BB’ to scale and add to IR. Let the value be IR(Effective).
* Read from OCC curve, the voltage E is read corresponding to field current of IR(effective).
* Regulation by ASA Method = (Eph=Vph)\*100/Vph

**RESULT:**

The regulation of the alternator is \_\_\_\_\_\_\_\_\_\_% as per ASA method.