2-Shunt

2.1- for a speed of 850Vpm, Vno?

A) F_{CR}=0

To find Vno load we must draw the Rf= line with occ and the point of intersection represent.

I_f(A)	V_f (v)		
	F_{CR}=0	F_{CR}=10	F_{CR}=30
0	0	0	0
1	20	30	50
2	40	60	100
3	60	90	150
4	80	120	200
5	100	150	250
6	120	180	300
7	140	210	350
8	160	240	400
9	180	270	450
10	200	300	500
11	220	330	550
12	240	360	600
13	260	390	650
14	280	420	700
15	300	450	750
16	320	480	800
17	340	510	850
18	360	540	900
19	380	570	950

At F_{CR}=0 R_f=20, V_f=I_fR_f

V_f =0*20=0, V_f =0.5*20=10

V_f =1*20=20, V_f =2*20=40

From the point of intersection

V_f =257.5V

At F_{CR}=10Ω , R_{ft}= 30 **Ω**

V_f =30*0=0, 30*1=30v, 30*2=60v

From the point of intersection

V_n=208V

At F_{CR}=30 Ω R_{ft}=30+20=50 **Ω**

V_f=50*0=0, 5*1=50

From the point of intersection

V_n=24V

B) R_{cri}=? Isc=? V_t=0

To find R crictical, we draw a line tangent to the occ and take any point intersection between them and find Rcr from Rcr=$\frac{V}{I}$

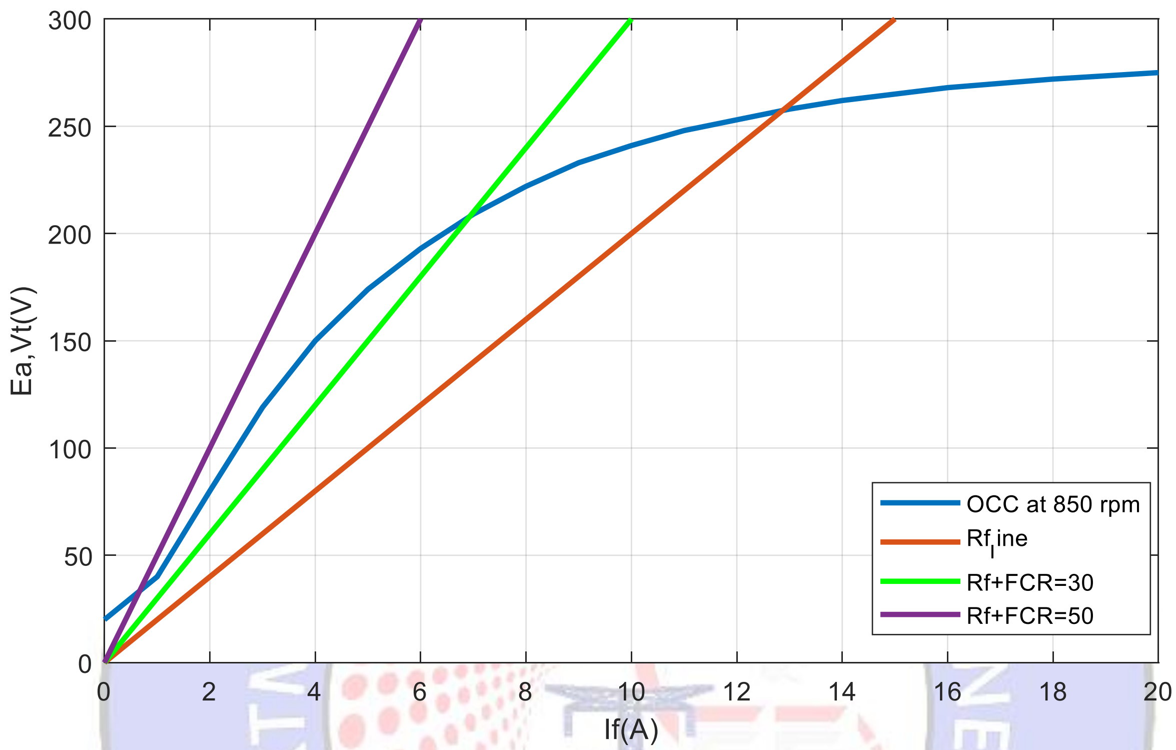
Rcr=$\frac{80}{2} = 40\Omega$

At Short cct I_f=0 E_A=Eres

V_t=0 I_A=Isc

$V_t=E_A-I_AR_A$, $0=E_{res}-I_{s.c}\,R_A$

$I_{s.c}=\frac{Eres}{RA}=\frac{20}{0.25}=80A$



c)

1) when $F_{CR}=10$ $n_{cri}=?$

To find critical speed at $F_{CR}=10\Omega$. we draw the $R_{f\text{-line}}$ when Rf=10+20=30 Ω take any value of (I_f) and alling it on occ and Rf-line $F_{CR}=10\ \Omega$ and find the value of E_1 from Rf line and E_0 from occ at new speed and applied :

$\frac{E1}{E0}=\frac{n1}{n0}$ When $I_F=I_A$ $E_0=40V$ from occ at 850Vpm

$E_1=30V$ from R_f line $F_{CR}=10\ \Omega$

$$\frac{E1}{E0}=\frac{n1}{n0}\rightarrow\frac{30}{40}=\frac{n1}{850}\rightarrow n1=637.5\ rpm$$

2) at $F_{CR}=30\ \Omega$, same procedure in (1) using $R_{f\text{-line}}$ when Rf=30+20=50 Ω, when $I_f=3$, $E_0=120V$, $E_1=150$

$$\frac{E1}{E0}=\frac{n1}{n0}\rightarrow\frac{150}{120}=\frac{n1}{850}\rightarrow n1=1062.5\,rpm$$

D)

At F_{CR}=0,to get minimum speed we take any value of (I_f) in the med points of R_f line and falling it on occ and F_{CR}=0 and find E_0 /E_1,At I_f=2

E_0=80 on occ, E_1=40 on R_f (F_{CR}=0 Ω)

$$\frac{E1}{E0} = \frac{n1}{n0} \rightarrow n1 = \frac{40 * 850}{80} = 425Vpm$$

2-2-

A) R_C=? And $I_{s.c}$=? at 1100 rpm, we take the point (80V,2A) from occ at 850Vpm

$E_1=\frac{1100*80}{850} = 103.52$ V, $R_C=\frac{E1}{If} = \frac{103.52}{2} = 51.76\Omega$

$E_1=\frac{1100*20}{850} = 25.88$ V

$I_{s.c} = \frac{25.88}{0.25} = 103.52A$

The good solustion must draw the OCC at 1100 rpm and plot a tangent line to new OCC.

B) V_{nL}=? F_{CR}=0

We plot occ at N=1100 rpm

And plot the R_f line (F_{CR}=0)

R_f=20 850 Vpm

$V_f=I_FR_F$, V_f=0*20=0

V_f=20*0.5=10, V_f=20*1=20

$E_A=\frac{E0*1100}{850}$

$E_A=\frac{20*1100}{850} = 25.88$

$E_A=\frac{24*1100}{850} = 31.05$

The intersection point between the OCC and Rf-line get

V_n load=351.5 V

Vf(v) FCR(0)	EA at 1100Vpm	If	EA
0	25.88	0	20
20	51.76	1	40
40	103.52	2	80
60	154	3	119
80	194.11	4	150
100	225.17	5	174
120	249.76	6	193
140	270.47	7	209
160	287.29	8	222
180	301.529	9	233
200	311.88	10	241
220	320.94	11	248
240	327.41	12	253
260	333.88	13	258
280	339.05	14	262
320	346.88	16	268
360	352	18	272
400	355.88	20	275

2-3-

$V_t=E_A-I_AR_A$, The intersection point between the OCC and Rf-line get at F_{CR}=0

V_n lood=257.5

A)

$V_t=E_A=257.5$ V when $I_A=0$

$V_t=257.5-150*0.25=220$

B) $V_t=220V$ $I_L=?$ $V_r=?$

$E_A=V_t+I_AR_A$

$I_A=\frac{EA-Vt}{RA}=\frac{257.5-220}{0.25}=150A$

$I_L=I_A-I_f$ → $I_L=150-11=139A$

$V_R=\frac{VNL-Vt}{VT}=\frac{257.5-220}{220}*100\%=17\%$

C) $V_T=?$ $I_L=?$ $V_R=?$ $R_L=1.5\Omega$

$V_t=I_L*R_L$

$V_T=0*1.5=0$ → $I_L=0$

$V_t=30*1.5=45$

$V_t=60*1.5=90$

from occ , $V_t=221V$, $I_L=148A$

$V_R=\frac{VNL-Vt}{VT}=\frac{257.5-221}{221}*100\%$

$V_R=16.5\%$

D) from the curves of OCC and rf-line

I break down = I max= $\frac{\Delta V}{R0}=\frac{193-120}{0.25}$

$\Delta V=73$ FCR=0

I max=$\frac{73}{0.25}=292A$

2-4-

$F_{CR}=?$ $V_t=220$ $I_L=80A$

Using external characteristic when IL=80A, Vt=227V

$E_A=V_t+I_AR_A$, $E_A=220+80.(0.25)=240$ V

When EA=240 V,from OCC so $I_f=10A$

So $R_{ft}=220/10=22\ \Omega$

So FCR=22-20=2 Ω

2-5-

N=350 R_{pv} $F_{CR}=0$ $V_b=2V$

$\Delta E=?$ $\Delta I_f=?$ $V_t=220$

$I_L=56A$, $I_f=\frac{220}{20}=11A$

From occ $E_0=248V$, $I_A=I_L+I_f=56+11=67$

$E_A=V_t+I_A\ R+V_b$

E_A=220+67(0.25)+2=238.75V, From occ I_f*=9.7

Δ E=E_0-EA, ΔE=248-238.75=9.25V

ΔIf= I_f-I_f* ΔIf=11-9.7=1.3A

3-Compound short shunt, cumulative, n=850 rpm, Nf=600 Rf=20

3-1- F_{CR}=0 V_t=220 I_L=150 N_s=? V_r=? Rs=0

$I_f = \frac{220}{20} = 11A$ $Is = IL = 150$

I_A=I_f=I_L ➡ I_A=150+11=161A

E_A=V_t+I_AR_A ➡ E_A=220+161*0.25=260.25

From occ Ieq=13.5

$Ieq = I_f + \frac{Ns}{Nf} * Is$

$13.5 = 11 + \frac{Ns}{600} * 150$

$2.5 = \frac{Ns}{600} * 150$ $Ns = 10turns$

V_n load =257.5V

$Vr = \frac{VnL - Vt}{Vt} * 100\%$

$Vr = \frac{257.5 - 220}{220} * 100\% = 17\%$

3-2-

N_s=15 Rs=0.05 F_{CR}=0 V_b=2V

V_t=220V I_L=80A I_A=? E_A=?

KVL, V_{sh}=V_t+Vs, V_{sh}=220+0.05*80, V_{sh}=224

$I_f = \frac{Vsh}{Rf} = \frac{224}{20} = 11.2A$, I_A=I_f+I_L=80+11.2=91.2A

E_A=V_t+I_A (R_A+Rs)+2

E_A=220+91.2(0.25+0.05)+2=249.36V

$Ieq = 11 + \frac{15}{600} * 80 = 13A$

E_0=258V, ΔE=258-249=9 V

3-3-

N_s=16 Rs=0.05 I_L=150 I_f=10 V_b=2V

Fund F_{CR}=? V_r,V_t

I_L=I_s=150

IA=150+10=160A

$I_{eq}=I_f+\frac{N_s}{N_f}*I_s$

$I_{eq}= 10+\frac{16}{600}*150=14A$

From occ E_A=262.5V

$V_t=E_A-I_A(R_A+R_s)-V_b$

V_t=262.5-160(0.25+0.05)-2=212.5V

$V_{sh}=V_f=V_t+V_s$

V_{sh}=212.5+150*0.05=220

$R_f=\frac{220}{10}=22$ $FCR=22-20=2\Omega$

$V_{sh}=R_fI_f=0$ ⇨ I_f=0A, V_{sh}= 22*1=22V, V_{sh}=22*2=44V

From occ , V_n load =250V

$VR=\frac{250-212.5}{212.5}$ *100%=17.6%

EXERCISES

Unless otherwise stated, assume that (a) winding resistances are given at the working temperatures, (b) the demagnetizing effect of armature reaction is negligible, and (c) the brush contact drop is 2V.

Answers obtained from graphical solutions are approximate and cannot be reproduced exactly. In some questions you have to use your judgment to make simplifying assumptions.

Questions 1-8 refer to **machine 1** which is a dc generator rated at 3 KW, 125 V, and 1150 rpm. The OCC is given in the adjacent table. The armature winding resistance is 0.38 Ω and the commutating winding resistance is 0.0716 Ω. The field winding has 1070 turns per pole and its resistance is 66.6Ω.

I_f(A)	E_A(v)
0.0	6
0.08	11
0.20	26
0.40	52
0.50	64.5
0.66	79
0.84	94
1.08	110
1.34	125
1.67	140
1.93	150
2.20	159
2.52	167
2.92	175
3.40	183

1. Machine 1 is separately excited from a 150 V source.
   a. Find the field current at rating; also find the setting of the field control resistor and the voltage regulation.
   b. The load resistance and field control resistance remain as in part (a), but the speed is raised to 1500 rpm. Find the terminal voltage and current, and the voltage regulation.
   c. The generator runs at 1500 rpm and delivers rated current at rated voltage. Find the field current, FCR, and VR.
   d. The machine is delivering rated current at rated at rated voltage with FCR set at 40 Ω. Find the speed and VR.
2. Machine 1 is separately excited from a 150 V source, but it has no interpoles. The brushes are shifted to improve commutation. The generator operates are rating with FCR set at 16Ω.
   a. Find the voltage regulation.
   b. Determine the demagnetizing effect of armature reaction in volts and in field amps.
3. Machine 1 is operated as a shunt generator.
   a. The generator is started with no external field resistance. Find the voltage to which it builds up at 1150 rpm, and find the minimum speed at which it can build up.
   b. repeat part (a) for a cold start (assume an ambient temperature of 20 ^{0}c).
   c. what is the maximum field circuit resistance that allows build-up at 1150 rpm? at 800 rpm? at 1500 rpm?

  d. Find the field circuit resistance that allows the generator to build up to rated voltage at rated speed.
  e. With no external field resistance, what is the maximum accelerating voltage during build-up at 1150 rpm? What is the corresponding field current?
  f. The generator build –up to rated voltage with the external field resistance set to zero. Find the speed.

4. Machine 1 is operated as a shunt generator at 1150 rpm.
  a. Find the short circuit current.
  b. Find the breakdown current when the external field resistance is set to give rated voltage at no load.
  c. Find the maximum breakdown current.
5. Machine 1 is operated as a shunt generator at 1150 rpm. The terminal voltage is at rated value.
  a. Find the current and VR when FCR is shorted out.
  b. Repeat part (a) for a field control resistor of 20Ω.
  c. Find the value of the external field resistance when the generator delivers rated current; also find VR.
6. Machine 1 runs at 1150 rpm and supplies a load current of 20A with a field current of 1.58 A. find VR and. FCR for the following cases:
  a. Separate excitation as in problem I.
  b. Shunt connection.
  c. Cumulative compound, long shunt connection. The series field winding has 18 turns/pole and its resistance is 0.069 Ω.
  d. Cumulative compound, short shunt connection. Series field winding as in part c.
  e. Differential compound, short shunt connection. Series field winding as in part c.
7. Machine 1 is connected in long shunt cumulative with a series field wdg of 18 turns/pole and 0.069 Ω resistance. It is operating at rating with a diverter across the series field wdg.

a. Estimate the diverter resistance when the shunt field external resistance is set at 20 Ω and the ratio of diverter resistance to series field resitance is 0.5 ; also find the voltage regulation.

b. Estimate the diverter resistance when VR is zero.

8. Machine 1 is connected in long shunt cumulative compound as in problem 7. There is no diverter and no interpoles. The brushes are shifted from the q-axis to improve commutation. Find the demagnetising effect of armature reaction in volts and in field amps.

9. The machine described in the exercises of pages 4.6 and 5.4 is runas a generator at 800 rpm. Armature current is 100 A. The no load voltage is 271 V, and the Armature reaction is not negligible. Find the load current, terminal voltage, and voltage regulation for the following cases:

a) Separate excitation.

b) Shunt connection.

c) Cumulative compound long shunt connection. The series field wdg has 12 turns /pole and its resistance is 25 mΩ.

Amps	volts
0	5
4	20
8	39
10	49
15	69
20	87
26	107
30	117
35	126
40	131
45	134
50	136
60	140
80	144

10. A series generator has the OCC given in the table. The armature resistance is 0.6Ω. The field wdg has 50 turns /pole, and its resistance is 0.1Ω. The brushes are shifted from the q-axis so that the demagnetizing armature reaction is 750 AT/pole when the load current is 60A.

a) Plot the external characteristic up to a load current of 90 A.

b) What is the load current and terminal voltage when the load resistance is 2Ω?

c) What is the critical load resistance?

d) Find the load current when the terminal voltage is 85 V?

e) What is the maximum voltage?

f) A diverter 0.15Ω is connected across the field winding; find the terminal voltage when the load current is 70A?

Volte	Amp
15.5	0.0
15.4	2.0
15.2	3.8
14.9	5.7
14.7	6.8
14.5	7.8
14.0	9.8
13.5	11.5
13.0	13.0
12.2	14.6
11.9	15.8
10.5	19.0

11. A battery is rated at 12 V and 10 A. it has a constant internal resistance of 0.2 Ω.
    a) Find the load resistance and VR at rating.
    b) Find the voltage, current, and VR when the load resistance is 0.8Ω and when it is 1.6 Ω.
12. A dc generator has the external characteristic given in the adjacent table.
    a) Find the voltage, current, and VR when the load resistance is 0.8 Ω and when 'it is 1.6 Ω.
    b) Find the load current, load resistance, and VR when the terminal voltage is 12.5 V.
    c) Find the terminal ve1tage, load resistance, and VR when the load current is 18 A.
13. The battery of problem 11 and the generator of problem 12 are operated in parallel.
    a) Find the voltage, current; and VR when the load resistance is 0.8 Ωand when it is1.6Ω.
    b) Determine who the battery and generator share the load current sin port a.
    c) Find the voltage and currents when there is no external load. What does this case represent?
14. The adjacent table gives the (V-I) characteristics for two dc generators, G1 and G2 and for a nonlinear resistor.
    a) Find the voltage, current, voltage regulation (VR) when G1 is only loaded by (i) 1.5 Ω resistor (ii) R_n resistor (iii) 1.5Ω parallel with R_n.
    b) Repeat part (a) for G2 is only.
    c) Repeat part (a) when G1 and G2 are in parallel.
    d) Determine the current sharing of the two generators for part (c).

	volts		
Amp.	G1	G2	R_n
0	360	360	0
50	351	357	50
100	339	352	114
150	323	347	180
200	302	338	230
250	277	326	265
300	244	310	291
350	202	286	312
400	----	256	328
450	----	221	340
500	----	----	343

ANSWERS

Recall that answers obtained from graphical solutions are approximate and cannot be reproduced exactly. That is, your solution might be correct although your answer appears different from the one given here. An error is indicated only if the difference is rather large.

1. a. 1.61A, 26.6Ω, 10.2 %. b. 163.6 V, 31.4A, 9.8%.

c. 1.0A, 82 , 10.2%. d. 1235 rpm, 10.2%.

2. a. 16.8%, b. 9.9V, 0.24 A.
3. a. 167.5 V, 589 rpm. b. 181.5 V, 485 rpm. c. 130Ω, 90.5Ω, 170 Ω.
   d. 93 Ω, e. 39 V, 0.96 A. f. 968 rpm.
4. a. 8.86 A. b. 34.8 A. c. 81 A.
5. a . 45.7 A, 34%. b. 4.3 A, 9.2 %. c. 10Ω, 22.4%.]
6. a. 8.8%, 28.3Ω. b. 19.4%, 12.4Ω. c. 0.9%, 20.3Ω.
   d. 1.5%, 22.1Ω. e. 50.5%, 2.18Ω.
7. a. 73mΩ, 9.2%. b. 208mΩ.
8. 30 V, 0.42 A.
9. a. 100 A, 248.5 V, 9%. b. 94A, 240 V, 12.8%. c. 94A, 261 V, 3.8%.
10. a. volts: 30.5, 57, 78.5, 95,101.7, 102, 100.4, 98,95. b. 67.4A, 100.8V; 50.8A, 101.7V.
    c. 2.9Ω. d. 40A, 90A. e.102 V. f.67.8V.
11. a. 1.2, 16.7. b. 11.2 V, 14 A, 25%; 12.4V, 7.8A, 12.5%.
12. a. 12.2V, 15.2A, 27.4%; 14.3V, 0.61Ω, 42%. b. 14.3, 0.87Ω, 24%. C. 11V,0.61Ω, 42%.
13. a. 13.2V, 16.5A, 14%; 14.1V, 8.8A, 6.4%. b. 4.1A, 12.4A; - 0.6A, 9.4A. c. 15V, 5.1A.
14. a. 301V, 201A, 19.6%; 270.5V, 261A, 33.1%; 217.5V, 333A, 65.5%. b. 333V, 223A, 8.1%; 300V, 321A, 20%; 253.5V, 402A, 42%. C. 345V, 231A, 4.4%, 325.5V, 392 A, 10.6%; 301V, 522A, 19.6% d. 74A, 160A; 143A, 251A; 202A, 320A.