27/30 excellent

| Q | Mark |
|---|---|
| 1 | 28/32 |
| 2 | 19/25 |
| 3 | 25/25 |
| 4 | 18/18 |
| Sum | 90/100 |

University of Jordan

Electrical Eng. Dept

0963581 Power System Reliability 27 — Second Exam.

Prof. D.Dalabeih — 15-5-2014

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28/32

Q1) a-Find the Lead time of a generating unit with ORR=0.000685 and $\lambda$=3 f/yr. [7%]

7/7

$OOR = \lambda T$

$0.000685 = 3 \times T \Rightarrow T = 2.28\bar{3}\times 10^{-4}$ years

$= 2.0002$ ~~minute~~ hour

$T = 2.28\bar{3}\times 10^{-4}$ year's $= 2.0002$ hour

b- Two generaring units, each one has capacity of 20 MW and FOR=0.02 Evaluate the Security Function, if the load to be supplied by the units Is 30 MW. [10%]

2-generating unit mean 4-state

10/10

$$S(t) = \sum_{i=1}^{4} P_i(t)\,Q_i(t) = P_1(on,on)\,Q_1 + P(on,off)\,Q_2 + P(off,on)\,Q_3 + P(off,off)\times Q_4$$

$$= 0 + 0.02\times 0.98 + 0.02\times 0.98 + (0.02)^2$$

$$= 0.0396$$

c-Two identical thermal generating units, each one has the following data: capacity=60 MW, $\lambda$=4 f/yr and response rate=1 MW/min. If the 2 units are used as spinning reserve and for 5 minute response Period, evaluate the Response Risk table. [15%]

11/15

response capacity = 1MW/min × 5 = 5MW

$OOR = \lambda \times T = \frac{4\times 5}{8760\times 24} = \cancel{0.0002281} \to 0.0000380517$

| | | |
|---|---|---|
| G | 60 | 60 |
| L | 0 | 0 |
| R | 5 | 5 |

| ~~Response~~ | ~~Probability~~ |
|---|---|
| ~~10mw~~ | ~~0.99771169~~ |
| ~~5mw~~ | ~~0.004555775~~ |
| ~~Zero~~ | ~~0.0000052125~~ |

Response Risk Table

| Response(mw) | probability |
|---|---|
| 10mw | 0.99992389 ?? |
| 5mw | 0.00007610050 ?? |
| Zero | Zero |

Q2) A generating system A is used to assist another system by means of a Tie line having a capacity of 10 MW. System A has a capacity of (5*10 MW+1*25 MW), daily peak load of 50 MW and a capacity outage table as shown below.

a-Evaluate the equivalent assisting unit model of system A. [15%]

b-Find the Tie-Line constrained equivalent unit model of A. [10%]

19/25

System A

| State i | Cap. out $C_i$(MW) | Individual prob. $p(C_i)$ | Cum. prob. $P(C_i)$ |
|---|---|---|---|
| 1 | 0 | 0.88584238 | 1.00000000 |
| 2 | 10 | 0.09039207 | 0.11415762 |
| 3 | 20 | 0.00368947 | 0.02376555 |
| 4 | 25 | 0.01807841 | 0.02007608 |
| 5 | 30 | 0.00007530 | 0.00199767 |
| 6 | 35 | 0.00184474 | 0.00192237 |
| 7 | 40 | 0.00000077 | 0.00007763 |
| 8 | 45 | 0.00007530 | 0.00007686 |
| 9 | 50 | 0.00000000 | 0.00000156 |
| 10 | 55 | 0.00000154 | 0.00000156 |
| 11 | 65 | 0.00000002 | 0.00000002 |
| 12 | 75 | 0.00000000 | 0.00000000 |

$\boxed{1}$

13/15

| assisting @ (mw) | probabillity |
|---|---|
| 25 | 0.88584238 |
| 15 | 0.09039207 |
| 5 | 0.00368947 |
| 0 | 0.0180781 |

$\boxed{2}$ out

0 @ capacity out of tie line equall zero the probabillity are = 0.88584238 + 0.0903920

6/10 = 0.97623445

@ capacity of of tie line equal 10 mw the probabillity = 1 − 0.97623445

$\boxed{2}$ Tie-Line constrained equivelant model A

| cap. out of tie line | probabillity |
|---|---|
| 0 | 0.97623445 |
| 10 | 0.02376555 |

25/25

Q3) A committed generating system withe a lead time of 4 hrs has the capacity outage probability table shown below.

a-If the acceptable unit committed risk level is 0.001, fid the required spinning reserve. [7%]

7/7

if acceptable = 0.001 → spinning reserve = 70 MW

if acceptable = 0.001 then spinining reserve

~~it's equal~~ ~~spm reserve~~ and

b-If the expected load is 150 MW and the load forcast ucertainties are normally distributed and has σ=6%, evaluate the unit commitment risk level. Given that for normal distribution:

| Middle point of interval | 0 | 1σ | 2σ | 3σ |
|---|---|---|---|---|
| Area of the interval | 0.382 | 0.242 | 0.061 | 0.006 |

[18%]

18/18

| Capacity Out (MW) | Capacity In (MW) | Cumulative probability 4 hours |
|---|---|---|
| 0 | 200 | 1.000000 |
| 10 | 190 | 0.010455 |
| 20 | 180 | 0.007740 |
| 30 | 170 | 0.003665 |
| 40 | 160 | 0.003654 |
| 50 | 150 | 0.003648 |
| 60 | 140 | 0.003648 |
| 70 | 130 | 0.000028 |
| 80 | 120 | 0.000018 |
| 120 | 80 | 0.000003 |

unit commitment risk level = $\boxed{0.003653102}$

table

| deviation | load capacity | prob. of load | LoLE | LoLE * prob of load |
|---|---|---|---|---|
| 3σ | 177 | 0.006 | 0.00774 | 0.00004644 |
| 2σ | 168 | 0.061 | 0.003665 | 0.000223565 |
| 1σ | 159 | 0.242 | 0.003654 | 0.000884268 |
| 0σ | 150 | 0.382 | 0.003648 | 0.0013935 |
| -1σ | 141 | 0.242 | 0.003648 | 0.000882816 |
| -2σ | 132 | 0.061 | 0.003648 | 0.000222345 |
| -3σ | 123 | 0.006 | 0.000028 | 0.000000168 |

Σ LoLE = 0.0036531

18/18

Q4) A composite system shown in Fig. 1, has the state values shown below for load point L. Plant 1 has (4*20 MW) and plant 2 has (2*30MW). If load L is 110 MW, evalute its probability and Frequency of failure. **[18%]**

load point = 110MW

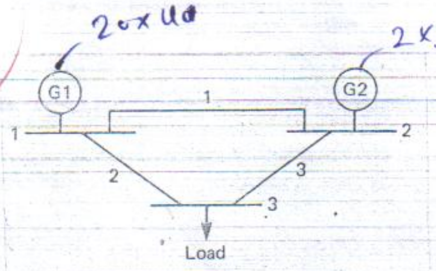


**Fig. 1**

load point Failure

indecies

| State | Elements out | Probability $P_i$ | Frequency $F_i$ (occ/yr) | Capacity in (MW) | $P_{LJ}$ | ~~Freq~~ Probabillity faillur | Frequancey Faidllur |
|---|---|---|---|---|---|---|---|
| 1 | — | 0.85692158 | 18.85227476 | 140 | 0 | 0 | 0 |
| 2 | G1 | 0.03462309 | 4.15477080 | 120 | 0 | 0 | 0 |
| 3 | G1, G1 | 0.00052449 | 0.11436062 | 100 | 1 | 0.00052449 | 0.11436062 |
| 4 | G1, G2 | 0.00364454 | 0.63414996 | 90 | 1 | 0.00364454 | 0.63414996 |
| 5 | G1, L1 | 0.00012648 | 0.15329376 | 120 | 0 | 0 | 0 |
| 6 | G1, L2 | 0.00015810 | 0.19145910 | 120 | 0 | 0 | 0 |
| 7 | G1, L3 | 0.00011857 | 0.11774001 | 120 | 0 | 0 | 0 |
| 8 | G2 | 0.09020227 | 6.85537252 | 110 | 0 | 0 | 0 |
| 9 | G2, G2 | 0.00237374 | 0.30858620 | 80 | 1 | 0.00237374 | 0.3085862 |
| 10 | G2, L1 | 0.00032951 | 0.38783327 | 110 | 0 | 0 | 0 |
| 11 | G2, L2 | 0.00041188 | 0.48438029 | 110 | 0 | 0 | 0 |
| 12 | G2, L3 | 0.00030891 | 0.29315559 | 110 | 0 | 0 | 0 |
| 13 | L1 | 0.00313030 | 3.48402390 | 140 | 0 | 0 | 0 |
| 14 | L1, L2 | 0.00001430 | 0.03150290 | 60 | 1 | 0.0000143 | 0.0315029 |
| 15 | L1, L3 | 0.00001072 | 0.02128992 | 80 | 1 | 0.00001072 | 0.02128992 |
| 16 | L2 | 0.00391288 | 4.35112256 | 140 | 0 | 0 | 0 |
| 17 | L2, L3 | 0.00001340 | 0.02659900 | zero | 1 | 0.00001340 | 0.026599 |
| 18 | L3 | 0.00293466 | 2.62652070 | 140 | 0 | 0 | 0 |
| | | | | | | $\boxed{0.00658149}$ | $\boxed{1.1364886}$ |

Faillure Pohability

Faillure Frequamcy

$$P_{LJ} = \begin{cases} 0 & \text{capacity} \geq 110 \\ 1 & \text{capacity} < 110 \end{cases}$$

$$\text{Probability faillure} = \sum P_{LJ}\, P(B_J)$$

$$\text{Frequancey faillure} = \sum P_L\, F(B_J)$$