

(1) 電樞反應是指電樞，在直流發電機為轉子，在定子中產生的磁通與永磁鐵產生的磁通相互作用，在未飽和下線性疊加。

(2)

$N_{sm} = N_s / N_m = 15/4 \Rightarrow S^* = \max [f(x(N_{sm}), 1)] = 3$   
 $\theta_s = \frac{4}{15} \cdot 180^\circ E = 48^\circ E$

| coil  | 1 | 2  | 3  | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  |
|-------|---|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Angle | 0 | 48 | 96 | 144 | 192 | 240 | 288 | 336 | 384 | 432 | 480 | 528 | 576 | 624 | 672 |

  

| In  | 1 | 2 | 3 | 4 | 5 | 6 | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 |
|-----|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| out | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1  | 2  | 3  |

↓  
180° < 180°E

| coil  | 1 | 2  | 3  | 4   | 5    | 6    | 7   | 8   | 9  | 10 | 11  | 12  | 13   | 14  | 15  |
|-------|---|----|----|-----|------|------|-----|-----|----|----|-----|-----|------|-----|-----|
| Angle | 0 | 48 | 96 | 144 | -168 | -120 | -72 | -24 | 24 | 72 | 120 | 168 | -144 | -96 | -48 |

  

| In  | 1 | 2 | 3 | 4 | 5 | 6 | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 |
|-----|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| out | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 1  | 2  | 3  |

↓

| coil  | 1 | 2  | 3   | 4  | 5  | 6  | 7   | 8   | 9  | 10 | 11  | 12  | 13 | 14 | 15  |
|-------|---|----|-----|----|----|----|-----|-----|----|----|-----|-----|----|----|-----|
| Angle | 0 | 48 | -84 | 36 | 12 | 60 | -72 | -24 | 24 | 72 | -60 | -12 | 36 | 84 | -48 |

  

| In  | 1 | 2 | 6 | 7 | 8 | 9 | 7  | 8  | 9  | 10 | 14 | 15 | 1  | 2  | 15 |
|-----|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| out | 4 | 5 | 3 | 4 | 5 | 6 | 10 | 11 | 12 | 13 | 11 | 12 | 13 | 14 | 3  |

5 coil per phase  $\frac{15}{3} = 5 \therefore$  phase A

| coil  | 1 | 5  | 12  | 9  | 8   |
|-------|---|----|-----|----|-----|
| Angle | 0 | 12 | -12 | 24 | -24 |

  

| In  | 1 | 8 | 15 | 9  | 8  |
|-----|---|---|----|----|----|
| out | 4 | 5 | 12 | 12 | 11 |

phase B

|       |     |     |     |     |     |
|-------|-----|-----|-----|-----|-----|
| coil  | 11  | 15  | 7   | 4   | 3   |
| Angle | -60 | -48 | -72 | -36 | -84 |

|      |     |     |     |     |    |
|------|-----|-----|-----|-----|----|
| coil | 120 | 132 | 108 | 144 | 96 |
|------|-----|-----|-----|-----|----|

|     |    |    |    |   |   |
|-----|----|----|----|---|---|
| In  | 11 | 3  | 10 | 4 | 3 |
| out | 14 | 15 | 7  | 7 | 6 |

phase C

|     |   |    |   |    |    |
|-----|---|----|---|----|----|
| in  | 6 | 13 | 5 | 14 | 13 |
| out | 9 | 10 | 2 | 2  | 1  |

| Not | A        | B        | C        |
|-----|----------|----------|----------|
| 1   | In       |          | out      |
| 2   |          |          | out, out |
| 3   |          | In, In   |          |
| 4   | out      | In       |          |
| 5   | out      |          | In       |
| 6   |          | out      | In       |
| 7   |          | out, out |          |
| 8   | In, In   |          |          |
| 9   | In       |          | out      |
| 10  |          | In, In   | out      |
| 11  | out      | In       |          |
| 12  | out, out |          |          |
| 13  |          |          | In, In   |
| 14  |          | out      | In       |
| 15  | In       | out      |          |

(3)

$$L_g = N^2 \frac{2\pi \mu_0 I_{sc} R_{ro}}{y + \frac{L_m}{\mu_r L_g}} \left\{ \frac{14.13}{15} \right\}$$