EE568-Assignment 2

1. 20 pole machine, 120 slots and 3 phase. For the design process, 2/3 pitch is selected (short pitch). Its slot per pole per phase (q) can be calculated as follows:

Its winding diagram will be as follows:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| A1 | A2 | -C1 | -C2 | B1 | B2 | -A1 | -A2 | C1 | C2 | -B1 | -B2 |
| B1 | B2 | -A1 | -A2 | C1 | C2 | -B1 | -B2 | A1 | A2 | -C1 | -C2 |

Then, angle between each coil (electrically) can be calculated as follows:

Furthermore coil pitch can be found as follows:

Then, distribution factor, pitch factor and winding factor can be calculated for fundamental harmonic

For 3rd harmonic, distribution factor, pitch factor and winding factor can be calculated as follows:

For 5th harmonic:

The dominant harmonic is fundamental harmonic as expected. On the other hand, choosing 2/3 short pitch, 3rd harmonic is eliminated. Moreover, magnitude of 5th harmonic is smaller. Thus, THD of the induced voltage is smaller and is close pure sinusoidal.

2) In this part, motor with 22 poles and 24 slots is chosen according to Emetor Winding Design. Its phase angle can be calculated as follows:

165°

Its winding diagram is given as follows:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Slot no.** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **E. Angle** | **0** | **1815** | **3630** | **1485** | **3300** | **1155** | **2970** | **825** | **2640** | **495** | **2310** | **165** |
| **Angle** | **0** | **15** | **30** | **45** | **60** | **75** | **90** | **105** | **120** | **135** | **150** | **165** |
| **Phase** | A | B | -B | B | -B | -C | C | -C | C | A | -A | A |
| **Slot no.** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| **E. Angle** | **1980** | **3795** | **1650** | **3465** | **1320** | **3135** | **990** | **2805** | **660** | **2475** | **330** | **2145** |
| **Angle** | **180** | **195** | **210** | **225** | **240** | **255** | **270** | **285** | **300** | **315** | **330** | **345** |
| **Phase** | -A | -B | B | -B | B | C | -C | C | -C | -A | A | -A |

Table 1: Slots, phases and phase angles of the machine with 22 poles 24 slots

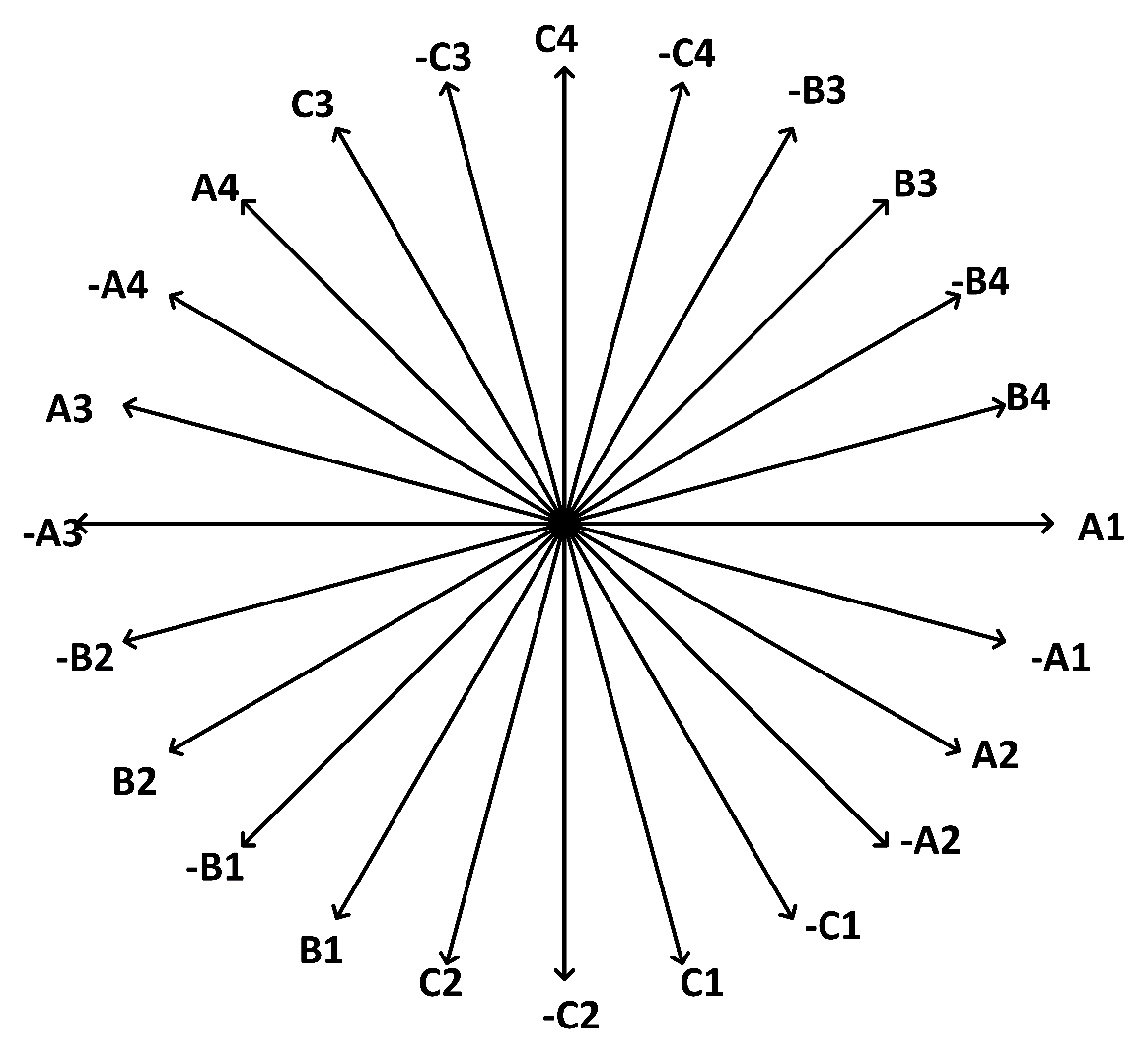


Figure 1: Phasor diagram of the machine for fundamental harmonic of the machine with 22 poles and 24 slots

For 3rd harmonic;

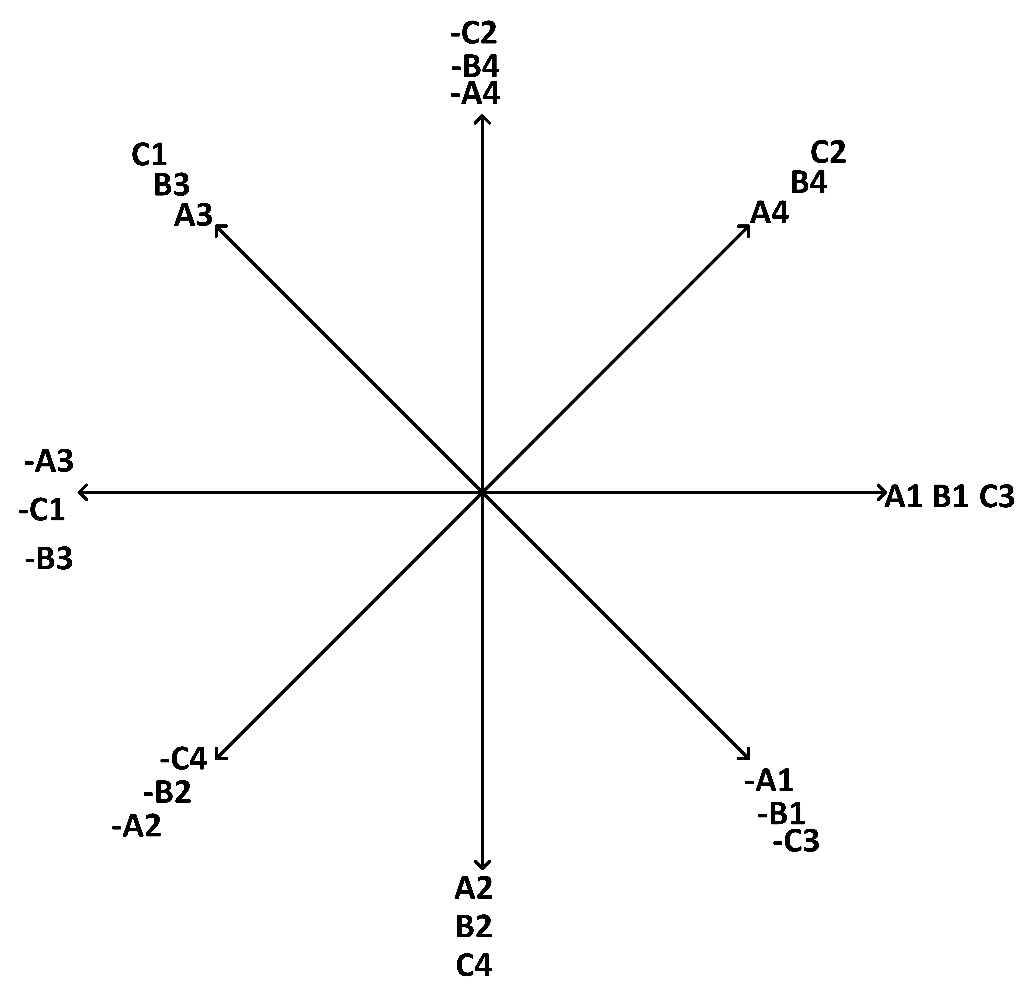


Figure 2: Phasor diagram of the machine for 3rd harmonic of the machine with 22 poles and 24 slots

For 5th harmonic:

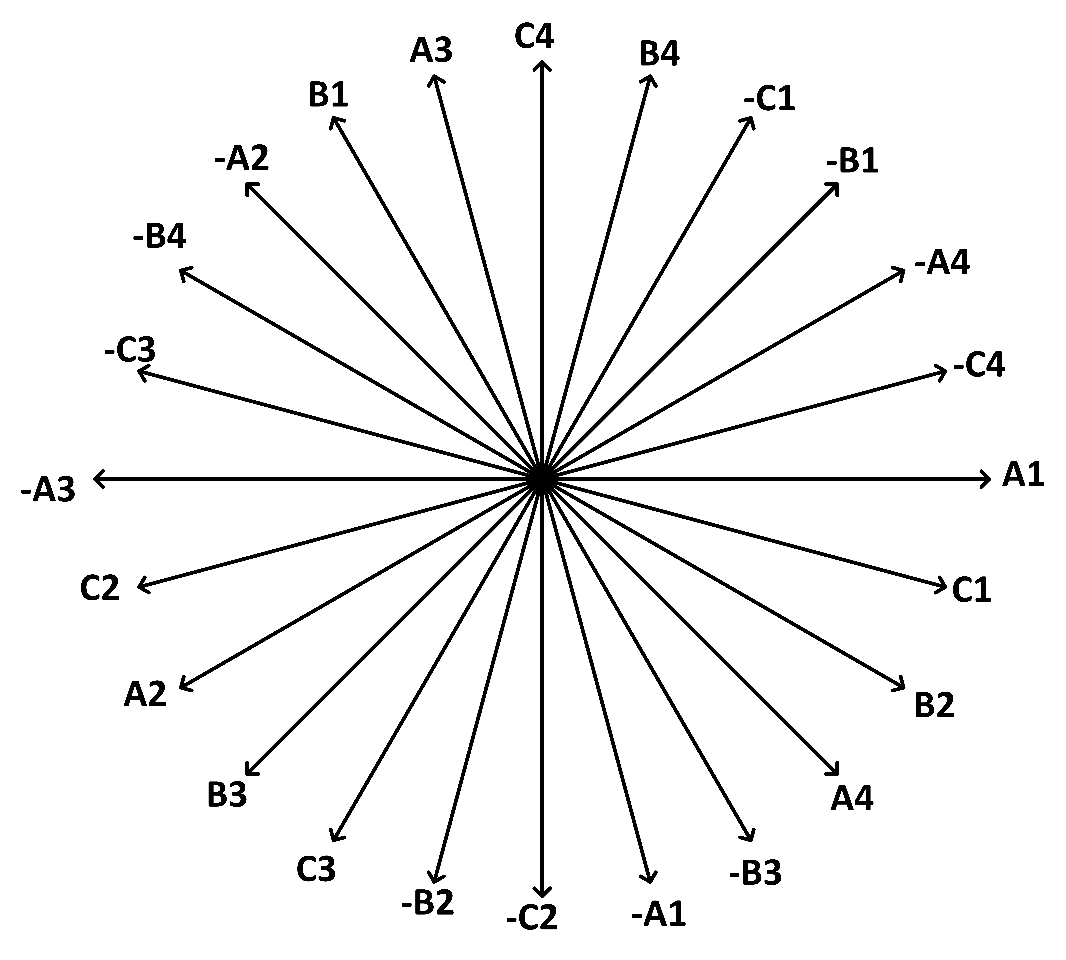


Figure 3: Phasor diagram of the machine for 5th harmonic of the machine with 22 poles and 24 slots

For another fractional slot machines design, 22 pole and 30 slots are considered.

132°

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Slot no** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **El. Angle** | 0 | 1452 | 2904 | 396 | 1848 | 330 | 792 | 2244 | 3696 | 1188 |
| **Angle** | 0 | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 |
| **Phase** | A | B | C | A | B | -B | -C | -A | -B | -C |
| **Slot no** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **El. Angle** | 2640 | 132 | 1584 | 3036 | 528 | 1980 | 3432 | 924 | 2376 | 3828 |
| **Angle** | 120 | 132 | 144 | 156 | 168 | 180 | 192 | 204 | 216 | 228 |
| **Phase** | C | A | B | C | A | -A | -B | -C | -A | -B |
| **Slot no** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| **El. Angle** | 1320 | 2772 | 264 | 1716 | 2168 | 660 | 2112 | 3564 | 1056 | 2508 |
| **Angle** | 240 | 252 | 264 | 276 | 288 | 300 | 312 | 324 | 336 | 348 |
| **Phase** | B | C | A | B | C | -C | -A | -B | -C | -A |

Table 2: Slots, phases and phase angles of the machine with 22 poles 30slots

For the fundamental harmonic:

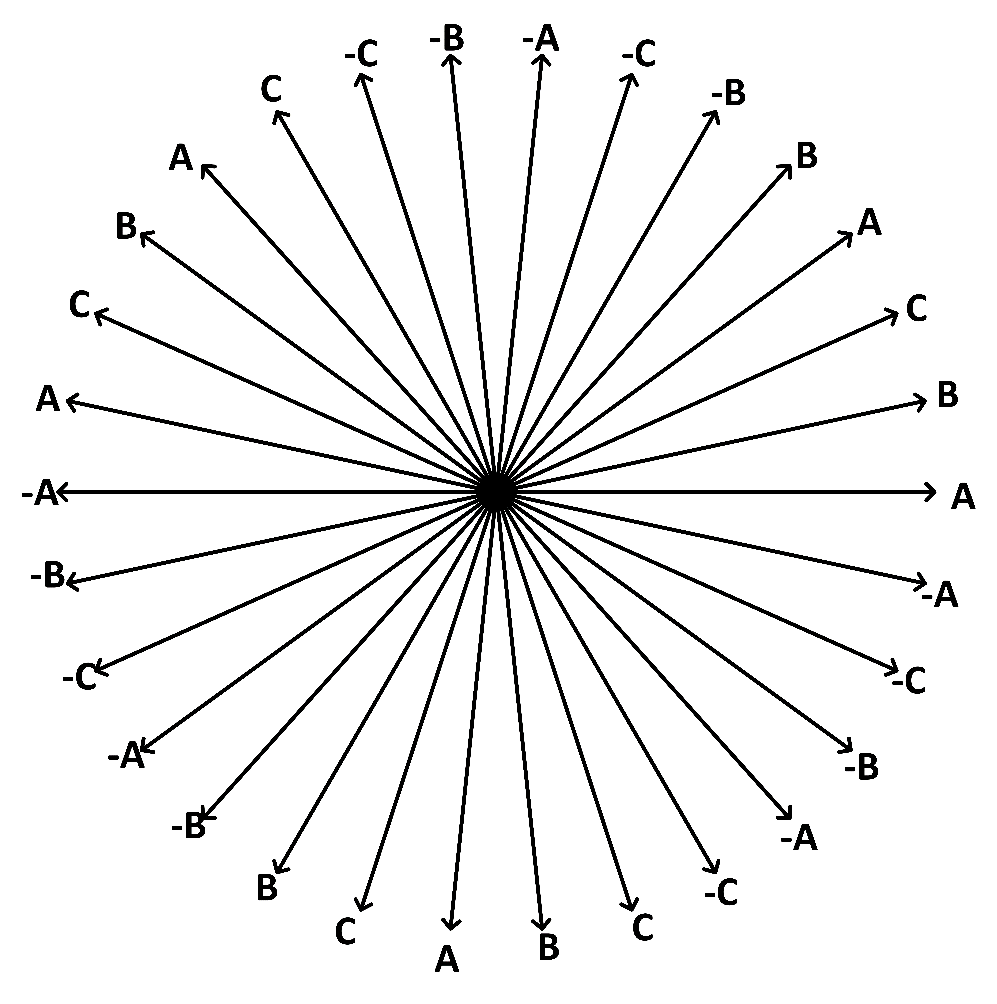
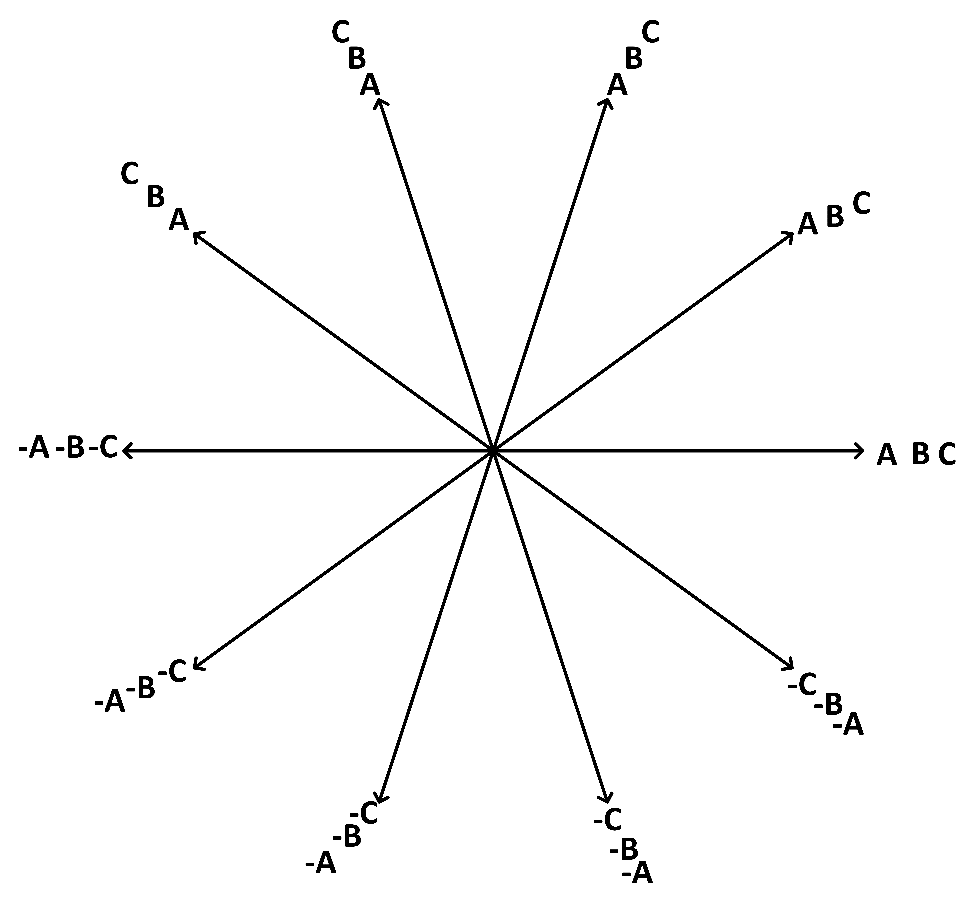


Figure 4: Phasor diagram of the machine for fundamental harmonic of the machine with 22 poles and 30 slots

 Figure 5: Phasor diagram of the machine for 3rd harmonic of the machine with 22 poles and 30 slots

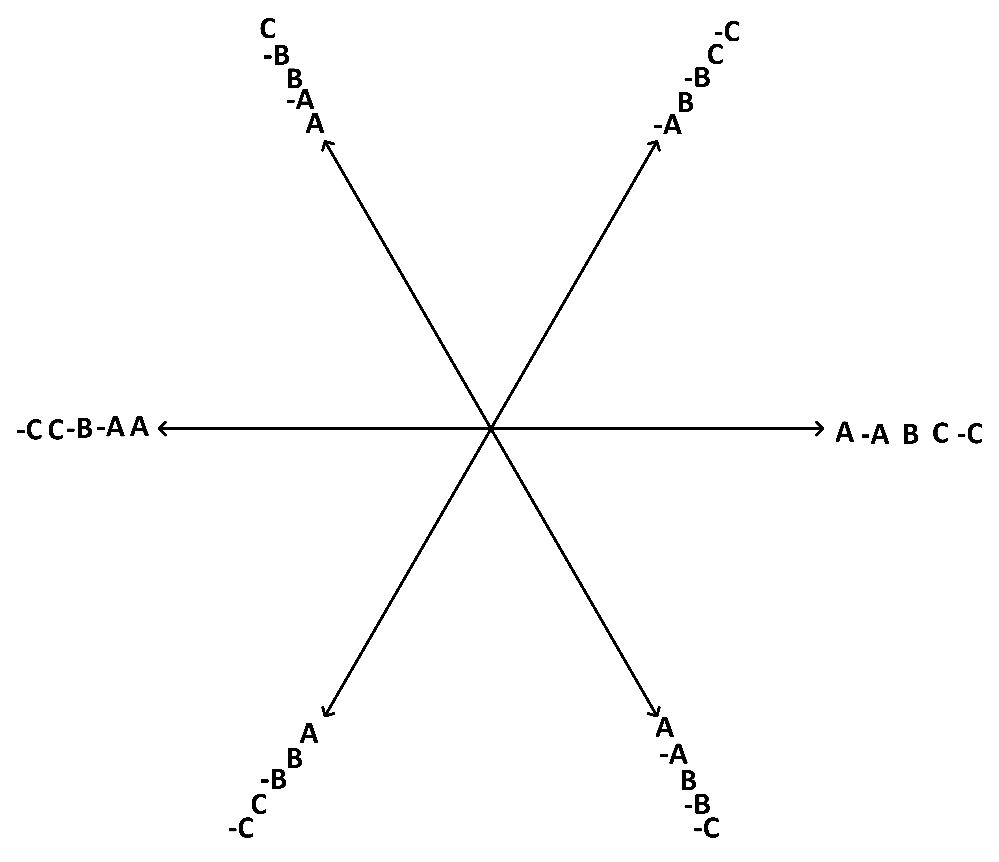


Figure 6: Phasor diagram of the machine for 5th harmonic of the machine with 22 poles and 30 slots

**Comparison of the designs:**

|  |  |  |
| --- | --- | --- |
|  | **22 poles and 24 slots** | **22 poles and 30 slots** |
| **Fundamental harmonic** | 0.958 | 0.873 |
| **Third harmonic** | -0.653 | 0.201 |
| **Fifth harmonic** | 0.205 | -0.1 |

Table 3: Winding factors of the harmonics and designs

As can be seen in Table 3, winding factor of the machine with 24 slots harmonics are higher than the machines’ with 30 slots harmonics. However, winding factor of fundamental harmonic of the first machine is higher. Also first machine windings are close to each other and length of the wires are shorter. This situation concludes with smaller resistance and least copper losses. As a result, second design has lower induced voltage under same conditions and higher copper losses. Thus, it can be said that first design is better.