

MIDDLE EAST TECHNICAL UNIVERSITY

Electrical and Electronics Engineering Department

EE568 Selected Topics on Electrical Mahines

PROJECT 1

MOTOR Winding Design and Analysis

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# Introduction

# Integral Slot Winding Design

We have a 20-pole,120 slot, 3-phase machine. For distributed coils, algebraic sum of the coil voltages are not equal to vector sum of the coil voltages. The differences can be formulated with respect to coil numbers electrical angle between two coils and harmonic numbers .

(1)

Also, the voltage of two coils are summed arithmetically, if the electrical angle between two coils are 180°, so full-pitched. Tangle between two coils are bigger than 180°, named as over-pitch coils or smaller than 180°, named as under-pitch coil. It can be formulated with respect to electrical pitch angle between two coils and harmonic numbers . Also, the pitch angle can be used to eliminate the harmonics.

(2)

Design is chosen as 120° pitch angle to eliminate 5th harmonics.

* First of all, number of slots per pole per phase is calculated as

In this part, design is shown for only a pole-pair (2 pole).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A1 | A2 | B1 | B2 | C1 | C2 | -A3 | -A4 | -B3 | -B4 | -C3 | -C4 |
| B3 | B4 | C3 | C4 | -A1 | -A2 | -B1 | -B2 | -C1 | -C2 | A3 | A4 |

* By using formula 1 and 2, and taken the variables as:

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* Distributed winding causes a small voltage drops due to vector sum of the voltages and it is formulated as distribution factor. The distribution winding factor is smaller if the harmonic number increases. Thus, distribution winding attenuates the harmonics respectively increasing order. Also, coil pitch can be adjusted to eliminate a harmonic. In this part, it is chosen as 120 degree to eliminate harmonic. Thus, there is no voltage contribution from harmonic.

# Fractional Slot Winding Design

In this part, 3-phase permanent-magnet synchronous machine with fractional-slot winding will be analysed. Firstly, pole number and slot number are chosen by using [Emetor](https://www.emetor.com/windings/). Pole number is chosen as 20 and slot number is chosen as 24 because the configuration brings high winding factor as 0.966.

* slot= 24, pole=20, phase =3 🡺 q=

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Slot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Degree  (Elec) | 0 | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 | 1650 | 1800 | 1950 | 2100 | 2250 | 2400 | 2550 | 2700 | 2850 | 3000 | 3150 | 3300 | 3450 |
| Degree  (Elec) | 0 | 150 | 300 | 90 | 240 | 30 | 180 | 330 | 120 | 270 | 60 | 210 | 0 | 150 | 300 | 90 | 240 | 30 | 180 | 330 | 120 | 270 | 60 | 210 |
| Phase | A+ | A- | B+ | B- | C+ | C- | A- | A+ | B- | B+ | C- | C+ | A+ | A- | B+ | B- | C+ | C- | A- | A+ | B- | B+ | C- | C+ |