

**MIDDLE EAST TECHNICAL UNIVERSITY**

**ELECTRICAL AND ELECTRONICS ENGINEERING**

**EE564**

**DESIGN OF ELECTRICAL MACHINES**

**-PROJECT 2-**

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# Winding Design and Motor Parameter Estimation

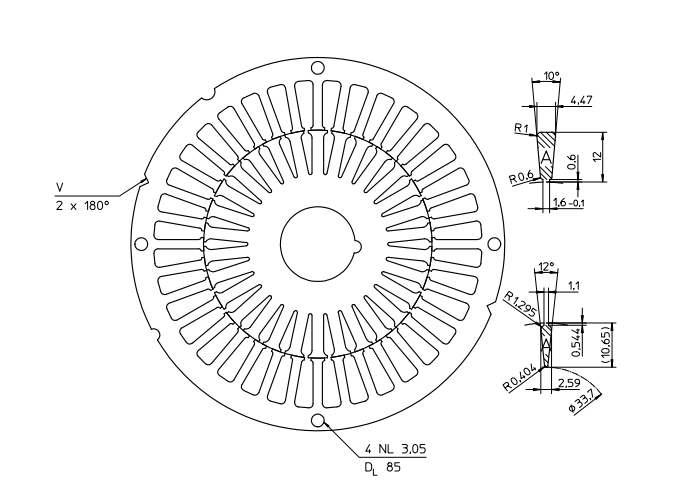


Figure 1. Chosen Lamination to Design Induction Motor

Chosen lamination has 90 mm outer diameter so that this type of lamination is available for high speed low torque and low power application, therefore I aimed that 1kW output power and 4 poles for this design. Then, synchronous speed becomes 1500 rpm.

Also, in order to eliminate 3rd harmonics on the MMF, I have chosen 220Vrms WYE connected input voltage which is equal to the 380Vrms per motor input phase. Moreover, with single layer stator winding; 5th, 7th and others except 3rd harmonics are effected so that in order to reduce 5th harmonic, I have designed double layer winding with 7/9\*180 = 140 integral pitch factor.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| A1 | A2 | A3 | -C1 | -C2 | -C3 | B1 | B2 | B3 | -A4 | -A5 | -A6 | C4 | C5 | C6 | -B4 | -B5 | -B6 |
| A12 | -C10 | -C11 | -C12 | B10 | B11 | B12 | -A1 | -A2 | -A3 | C1 | C2 | C3 | -B1 | -B2 | -B3 | A4 | A5 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** | **35** | **36** |
| A7 | A8 | A9 | -C7 | -C8 | -C9 | B7 | B8 | B9 | -A10 | -A11 | -A12 | C10 | C11 | C12 | -B10 | -B11 | -B12 |
| A6 | -C4 | -C5 | -C6 | B4 | B5 | B6 | -A7 | -A8 | -A9 | C7 | C8 | C9 | -B7 | -B8 | -B9 | A10 | A11 |

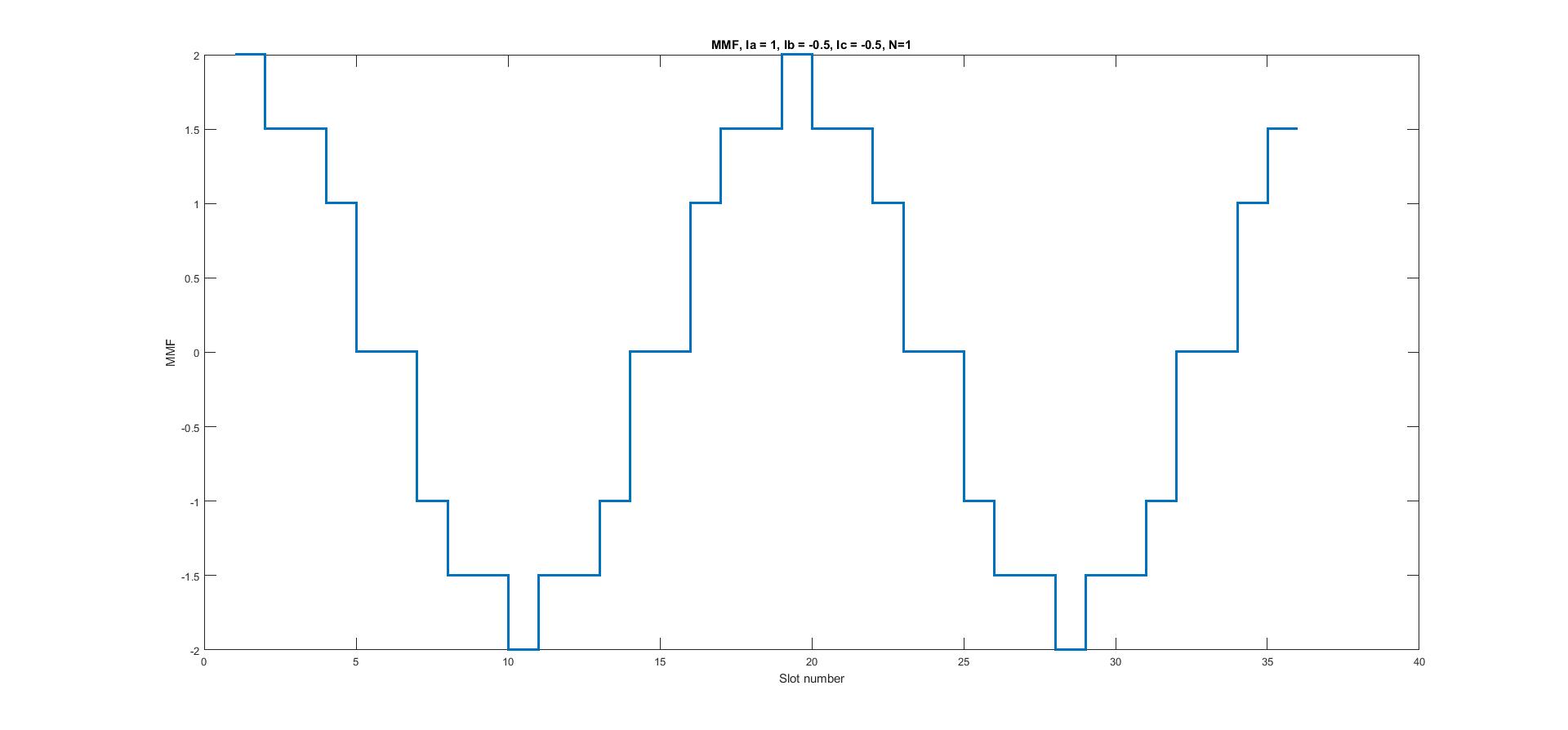


Figure 2.

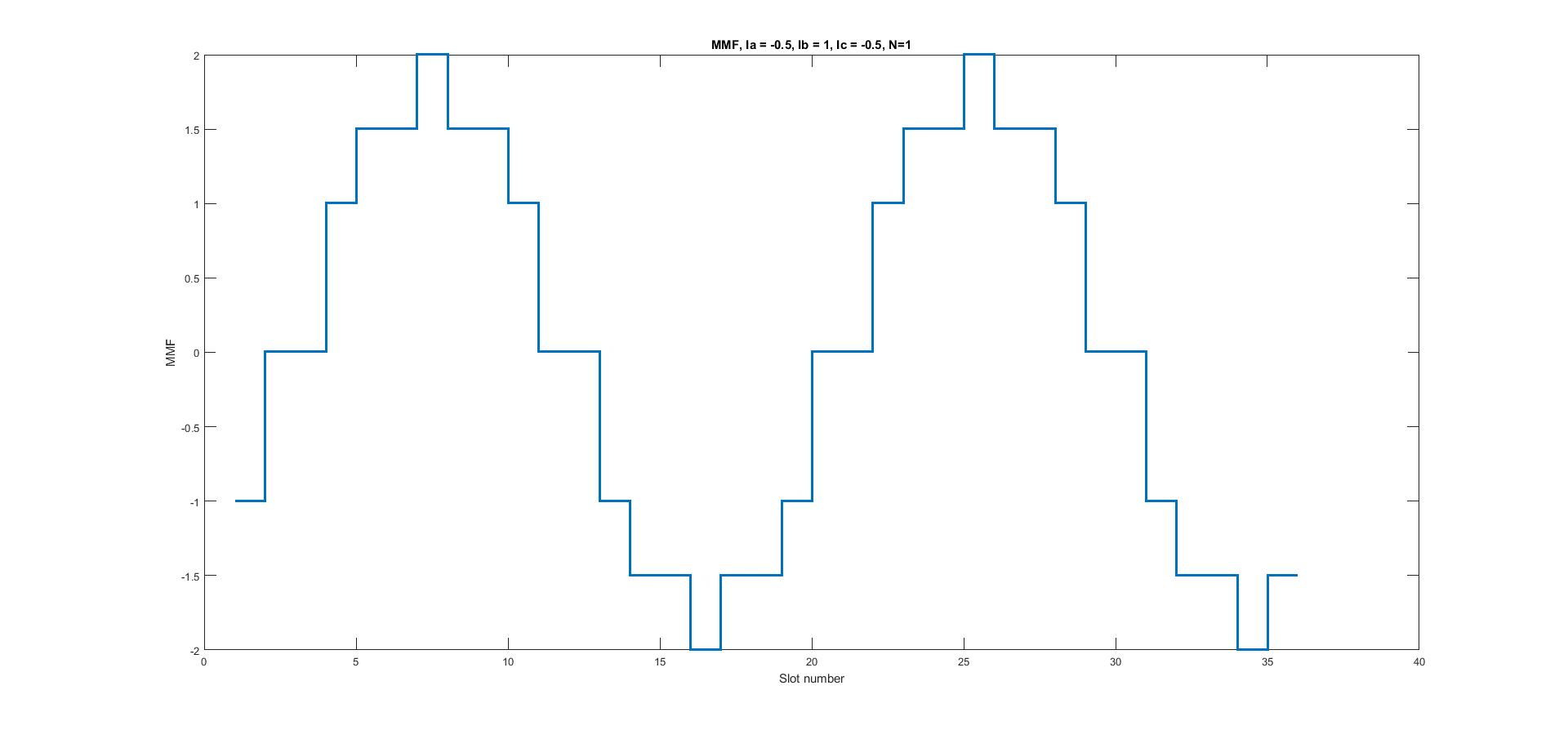


Figure 3.

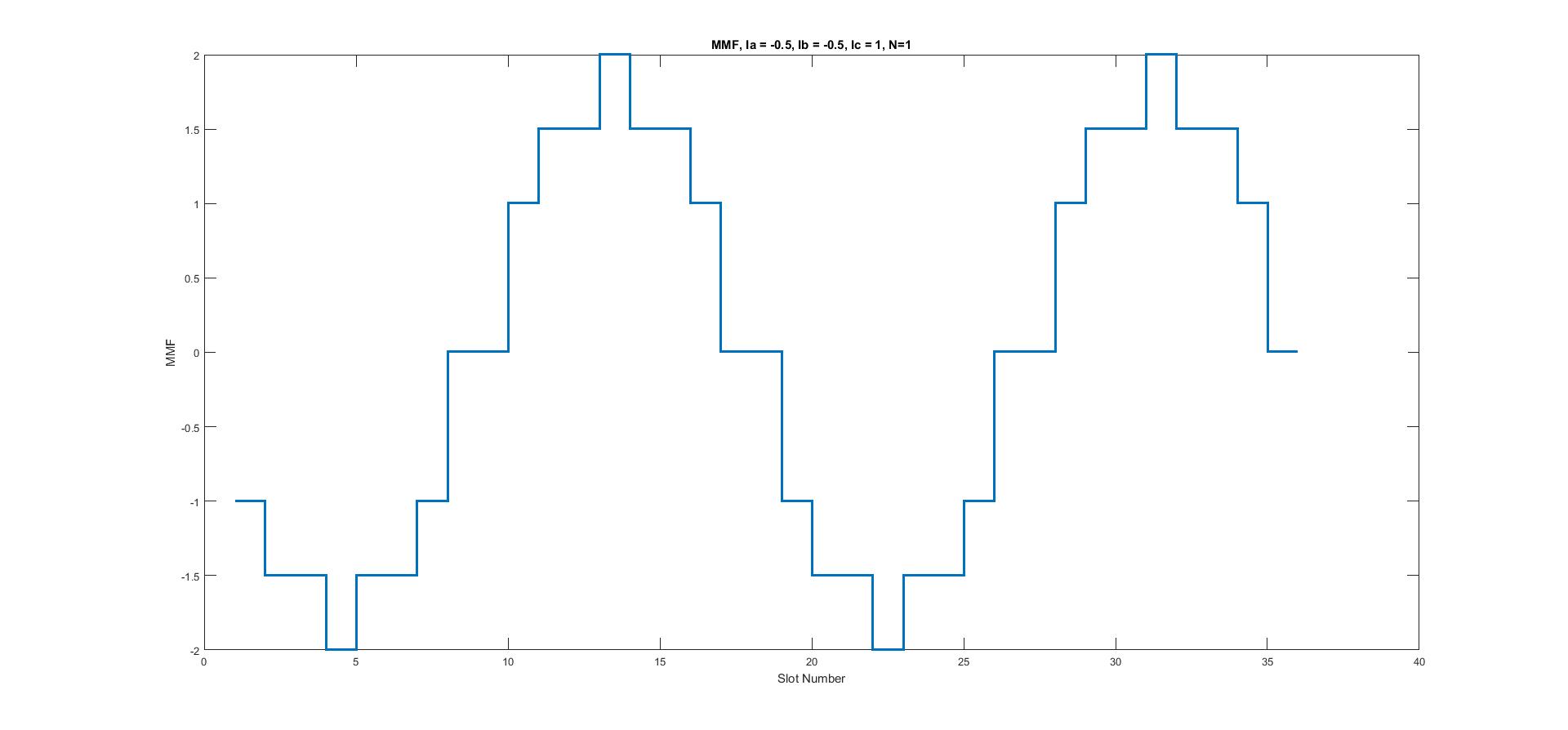


Figure 4.

Winding factors of fundamental and other harmonics are at below. Coil angle is 180/9 = 2 degree. Coil pitch degree is 7\*20 = 140 degree. q is slot per pole per phase (q=36/4/3 = 3).

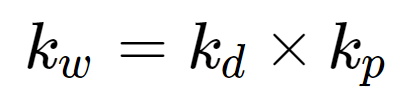
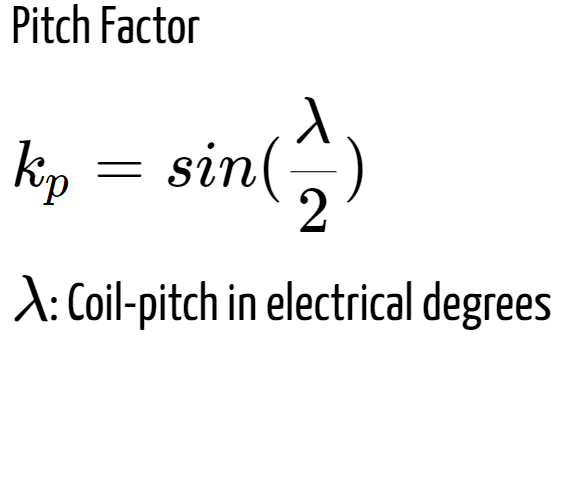
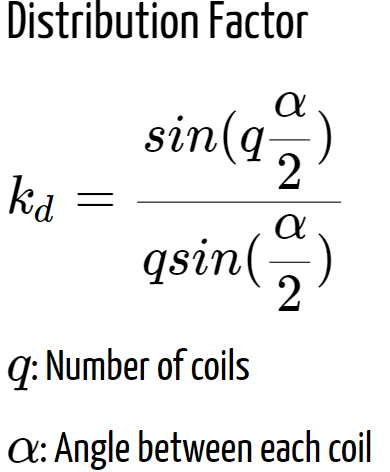


Figure 5.

By using formulas at figure 5;

Kw1= [sin(30) / (3\*sin(10)) ]\*sin(70) = 0.9

Kw3 = [sin(3\*30) / (3\*sin(3\*10)) ]\*sin(3\*70) = -0.33

Kw5 = [sin(5\*30) / (3\*sin(5\*10)) ]\*sin(5\*70) = -0.037

Kw7 = [sin(7\*30) / (3\*sin(7\*10)) ]\*sin(7\*70) = -0.13

Kw9= [sin(9\*30) / (3\*sin(9\*10)) ]\*sin(9\*70) = 0.33

Kw11= [sin(11\*30) / (3\*sin(11\*10)) ]\*sin(11\*70) = 0.33