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Three Phase AC Double Layer Wave Winding Diagram, a Simplified Method

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ABSTRACT
Winding diagrams are an integral part of electrical machine design. Students of electrical engineering are required to study electrical machine winding diagram as part of their curriculum. DC and AC machines have their own ways of connections, based on the requirement of the machine. AC double layer wave winding diagram is one such type of winding where the method of making connections is slightly complicated and students find it difficult to understand. This paper proposes a simple method to calculate the connections for drawing any type of three phase AC double layer wave winding diagram

Keywords: AC winding, double layer, wave,

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I. INTRODUCTION

Electrical machines are mainly based on DC and AC supply. Rotating machines have windings in their armature for electromagnetic action to take place for the operation of the machine, either as motor or generator. Study of winding diagram is very essential for students of electrical engineering, and electrical drawing is a part of the curriculum. Many universities have electrical drawing subject as computer aided design (CAD) on computers or on the drawing board using conventional tools like drafter, or both.

Windings can be lap or wave. Lap windings are used for high current but low voltage machines while wave windings are for low current, high voltage machines. Two conductors per slot is called double layer winding. End of one coil connected to the beginning of the next is called wave winding, so called because it resembles the shape of a wave.

Three phase AC double layer wave winding diagrams are available on different media like text books, college notes, and in the various websites in the Internet. But we find that the technique of drawing these diagrams is mostly missing. This leads to students not understanding the way they are drawn. This paper tries to give a simple method of drawing AC double layer winding diagram for any number of slots and poles

II. METHOD

The method can be explained by taking an example of 24 slots and 4 poles. The student is required to draw three phase AC double layer winding diagram with the given data.

III. CALCULATION

Slot pitch = slot/pole = 24/4 = 6
Coil span = 6
Slot/pole/phase = 24/4/3 = 2
i.e., 2 Red, 2 Blue, 2 Yellow
Slot angle = 180^o/slot pitch = 180/6 = 30^o

Assuming RBY phase sequence,
Red starts from 1^{st} slot by default
Yellow starts from 1+120/30 = 5^{th} slot
Blue starts from 1+240/30 = 9^{th} slot

Slot-phase table can be written as_

	Red	Blue	Yellow
Pole 1 (N1)	1 2	3 4	5 6
Pole 2 (S1)	7 8	9 10	11 12
Pole 3 (N2)	13 14	15 16	17 18
Pole 4 (S2)	19 20	21 22	23 24

IV. WINDING DIAGRAM

Compared to single layer, double layer wave is not as simple. The winding is a bit complicated with the wave moving in both directions, from left to right, and right to left. The connections for each phase can be found as below:

For Red phase, using the conductors from the slot-phase table:
a. Write the first column along with its bottom conductors like 1 1'
b. After the last row (19 19'), place the second column values, 2 2'
c. Repeat the first row at the end, for both columns
d. Start from 1, go down in a zig zig manner till 19'
e. 19' cannot connect again to 1. This connects to the next column value 2
f. Repeat the zig zig movement down till 20'
g. 20' cannot connect to 2. Connect 20' to 2'. Only here, a bottom conductor connects to another bottom conductor
h. From 2', go up in the same zig zag manner till 8
i. Join 8 to 1', go up till 7. 7th slot upper conductor is the last conductor for Red phase

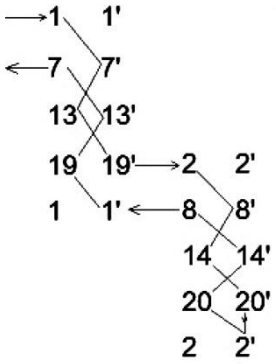

Fig 1: Red phase connections
Note: 1 stands for upper conductor in 1st slot
1' stands for lower conductor in 1st slot

The winding diagram for Red phase can be drawn as

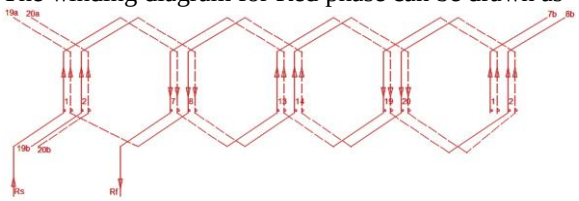

Fig 2: Red phase winding diagram

Similarly for Yellow phase:
Yellow starts from 5th slot. Movement is -
5 – 11' – 17 – 23'
- winding is from left to right
23' – 6 - there is a jump in the overhang
6 – 12' – 18 – 24'
24' – 6' - bottom to another bottom conductor
6' – 24 – 18' – 12
- winding moves from right to left
12 – 5' - there is a jump in the overhang
5' – 23 – 17' – 11
- Top 11 is the last conductor

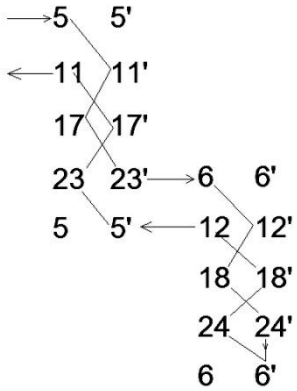

Fig 3: Yellow phase connections

The winding diagram for Yellow phase can be drawn as:

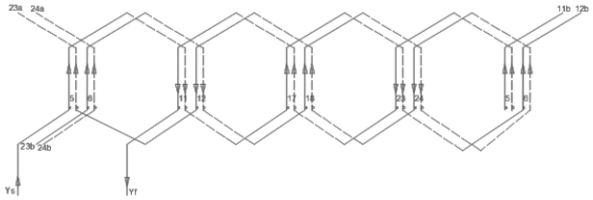

Fig 4: Yellow phase winding diagram

Blue starts from 9th slot. Write 9 9' row first and move the 3 3' row to the last. Same for the second column values also.
Since 9 9' is the first row, that is repeated at the end. Similarly for 10 10'

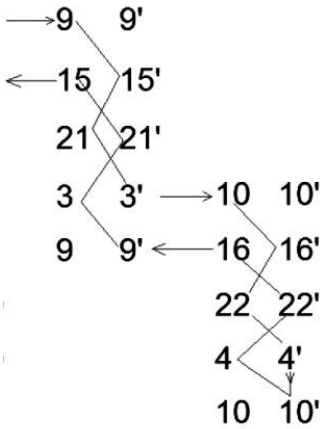

Fig 5: Blue phase connections

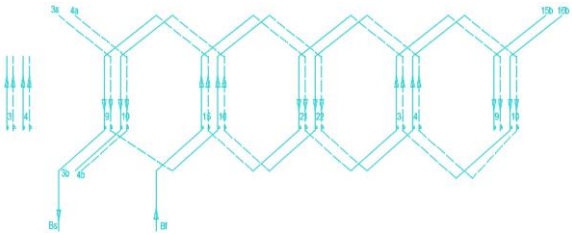

Fig 6: Blue phase winding diagram

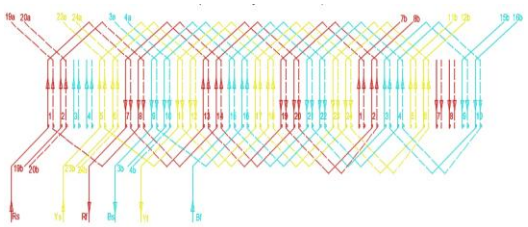

Fig 7: The complete winding diagram

V. CONCLUSION

This method can be applied for any three phase double layer AC wave winding easily.

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