

# Electrical Drawing

## AC Wave Winding

AC wave windings can be single layer or double layer

### Single layer wave winding

#### 1. Draw single layer AC wave winding for a machine with 24 slots and 4 poles

*a. Calculations:*

Slot pitch = slots/pole =  $24/4 = 6$

Coil span = 6

slot/pole/phase =  $24/4/3 = 2$     2 Red, 2 Blue, 2 Yellow

slot angle =  $180/6 = 30^\circ$

Red starts from 1<sup>st</sup> slot

Yellow starts from  $1+120/30 = 5^{\text{th}}$  slot

Blue starts from  $1+240/30 = 9^{\text{th}}$  slot

*b. Slot phase table:*

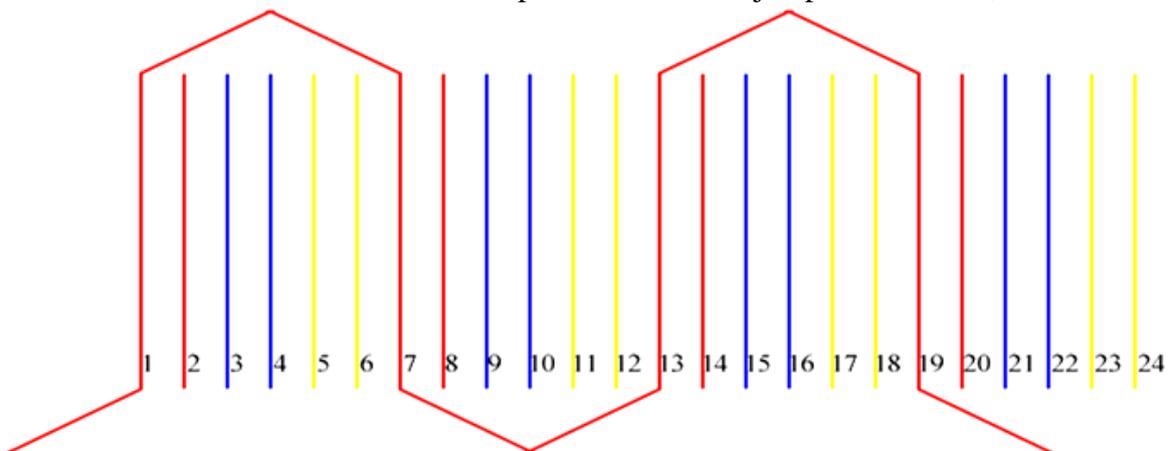
	Red	Blue	Yellow
<b>Pole 1 (N<sub>1</sub>)</b>	1 2	3 4	5 6
<b>Pole 2 (S<sub>1</sub>)</b>	7 8	9 10	11 12
<b>Pole 3 (N<sub>2</sub>)</b>	13 14	15 16	17 18
<b>Pole 4 (S<sub>2</sub>)</b>	19 20	21 22	23 24

*c. Winding diagram:*

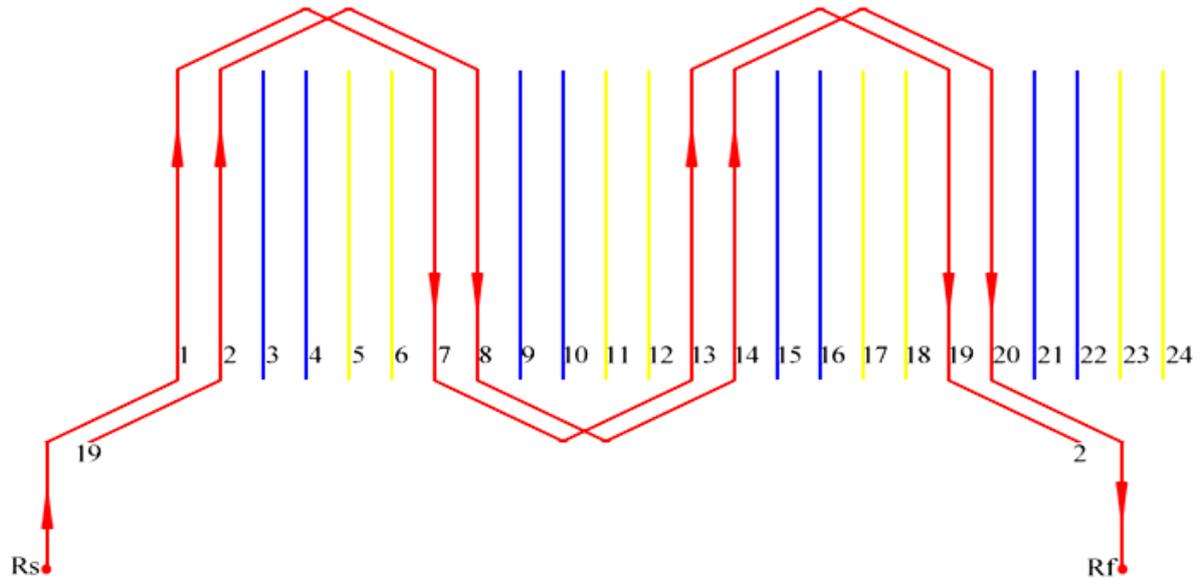
Single layer wave windings are easy to draw. The connections can be found from the slot-phase table.

For Red phase, the path is 1 – 7 – 13 – 19 – 2 – 8 – 14 – 20

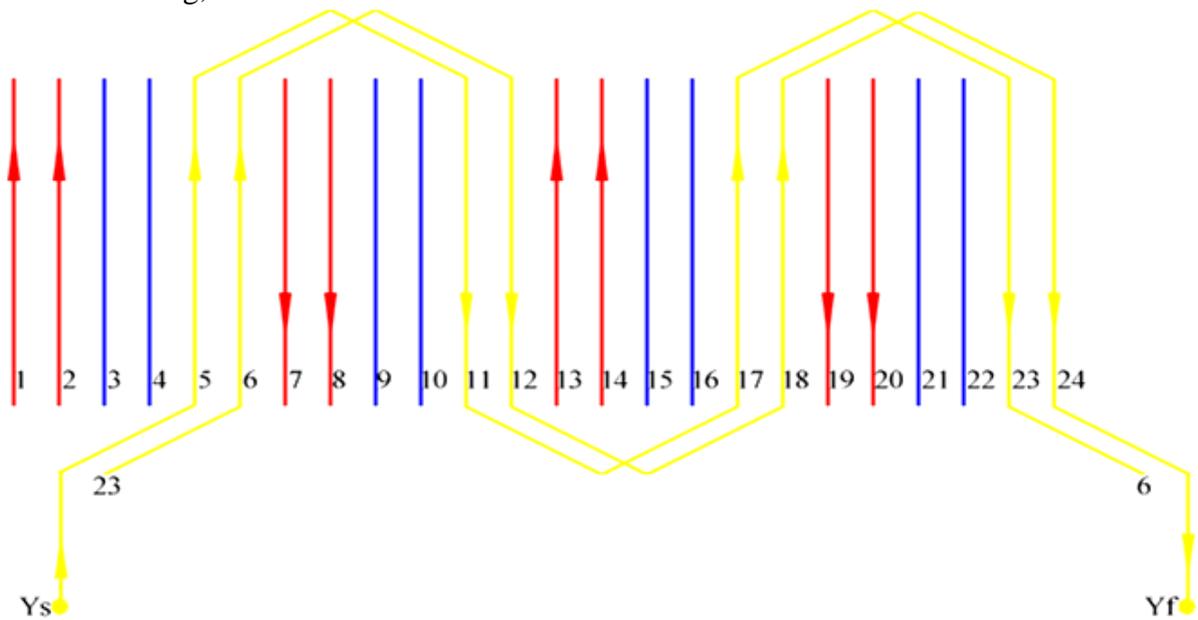
After 19<sup>th</sup> slot, according to the coil span, 19 must connect to  $19+6=25$ , which is 1. But a coil cannot connect to itself and form a closed path. So there is a jump from 19 to 2, instead of 1



Slot pitch is 6. There are 6 up arrows and 6 down arrows alternatively, from 1 to 24



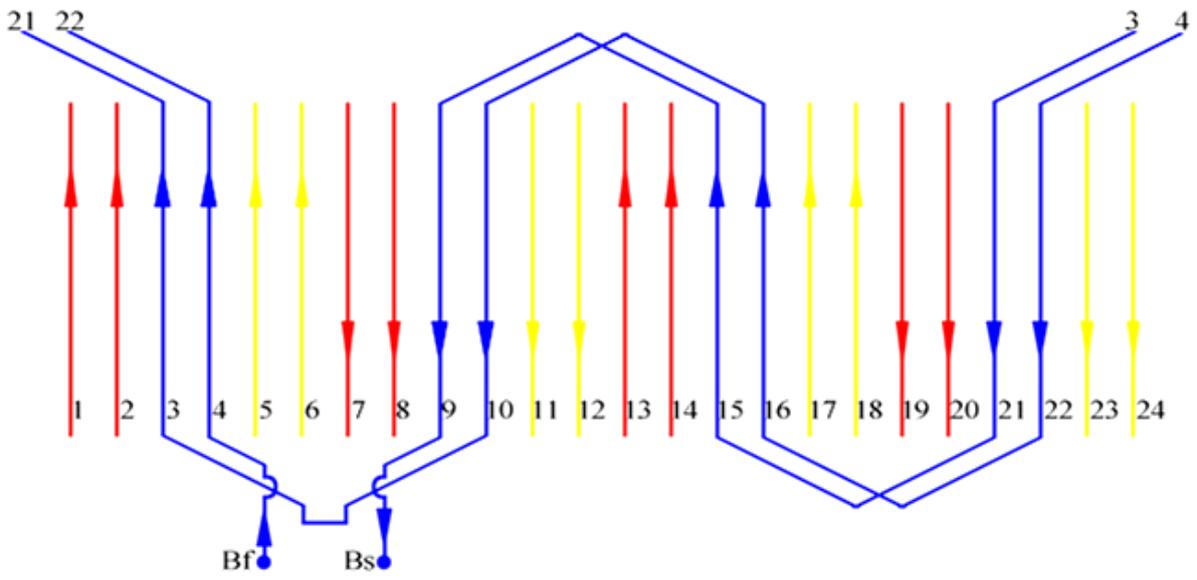
Similarly for Yellow, path is 5 – 11 – 17 – 23. After 23, instead of  $23+6=29$  (5), it connects to 6. Continuing, 6 – 12 – 18 – 24



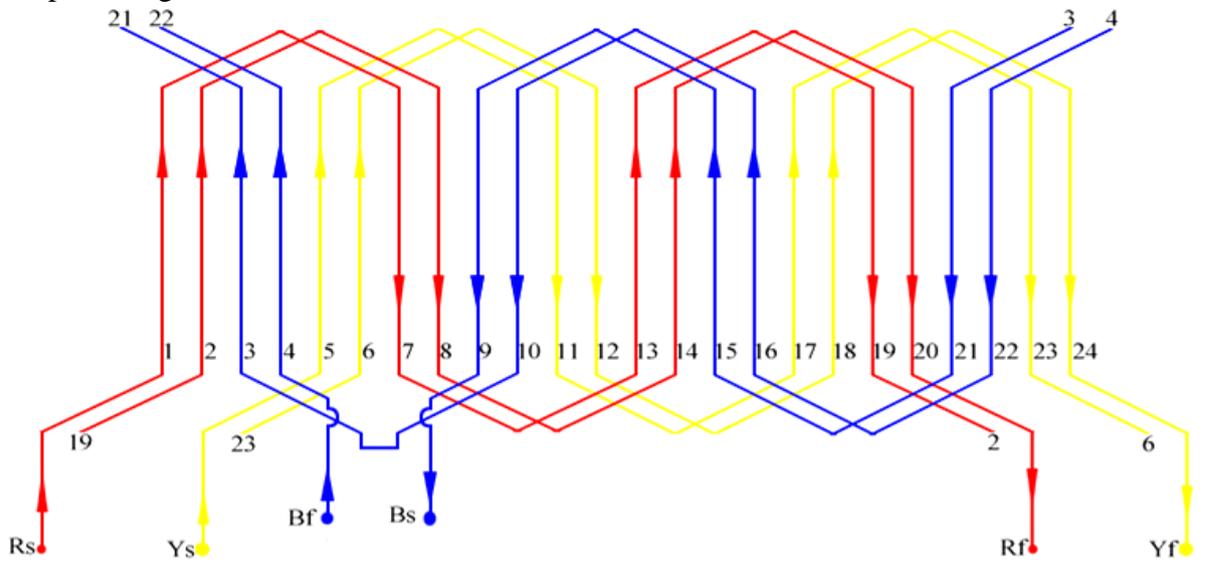
For Blue, starting is 9<sup>th</sup> slot

<b>Blue</b>
9 10
15 16
21 22
3 4

Path is 9 – 15 – 21 – 3  
 Jump to 10 instead of 9, and continue  
 10 – 16 – 22 – 4



Complete diagram



## 2. Draw single layer AC winding connected as wave, with 36 slots and 4 poles

a. Calculations:

Slot pitch = slot/pole =  $36/4 = 9$

coil span = 9

slot/pole/phase =  $36/4/3 = 3$  - 3 Red, 3 Blue, 3 Yellow

slot angle =  $180/9 = 20^\circ$

Red starts from 1<sup>st</sup> slot

Yellow starts from  $1+120/20 = 7^{\text{th}}$  slot

Blue starts from  $1+240/20 = 13^{\text{th}}$  slot

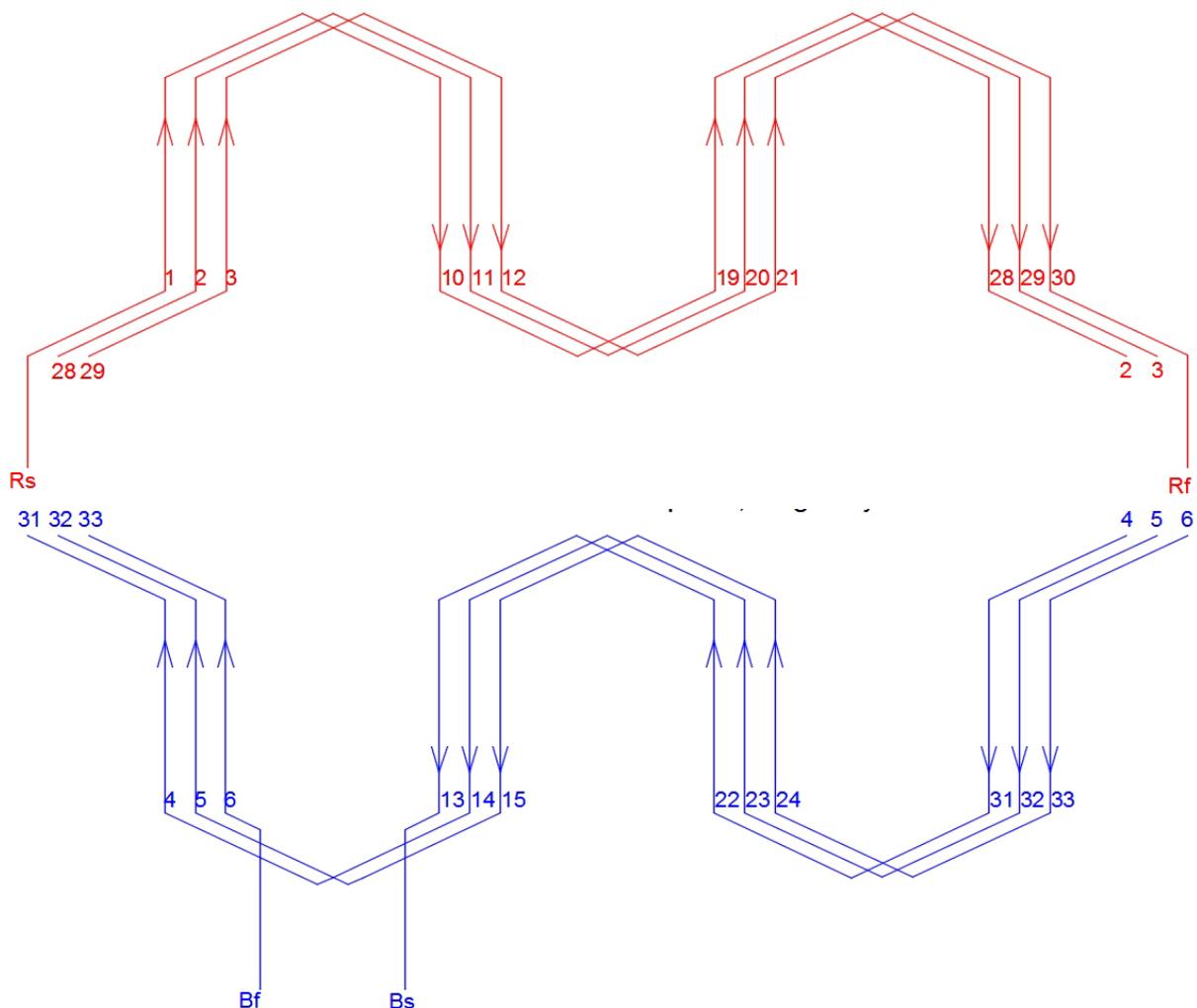
b. Slot phase table:

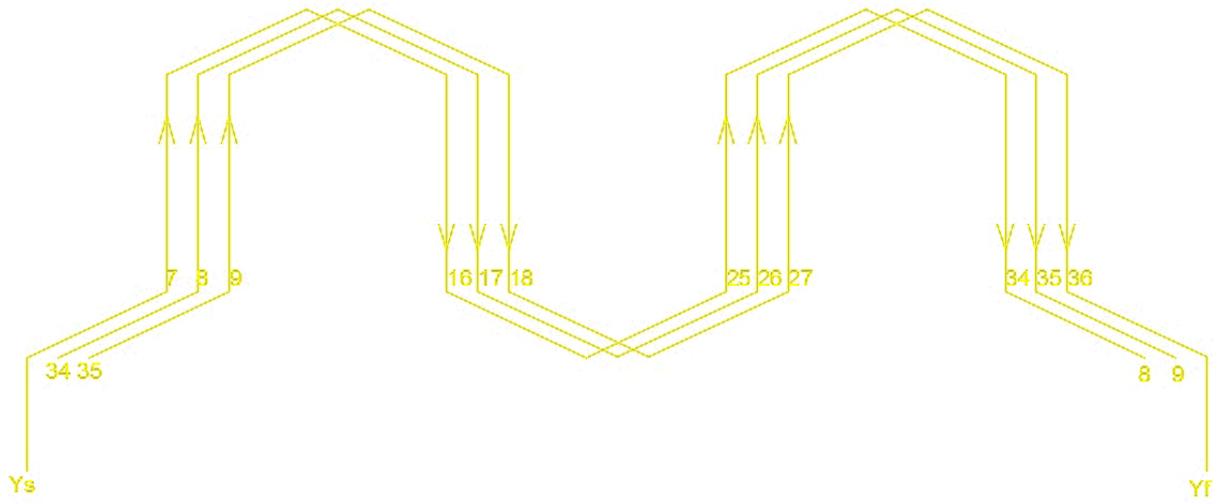
	Red	Blue	Yellow
<b>Pole 1 (N<sub>1</sub>)</b>	1 2 3	4 5 6	7 8 9
<b>Pole 2 (S<sub>1</sub>)</b>	10 11 12	13 14 15	16 17 18
<b>Pole 3 (N<sub>2</sub>)</b>	19 20 21	22 23 24	25 26 27
<b>Pole 4 (S<sub>2</sub>)</b>	28 29 30	31 32 33	34 35 36

Path of Red phase: 1 – 10 – 19 – 28 – 2 – 11 – 20 – 29 – 3 – 12 – 21 – 30

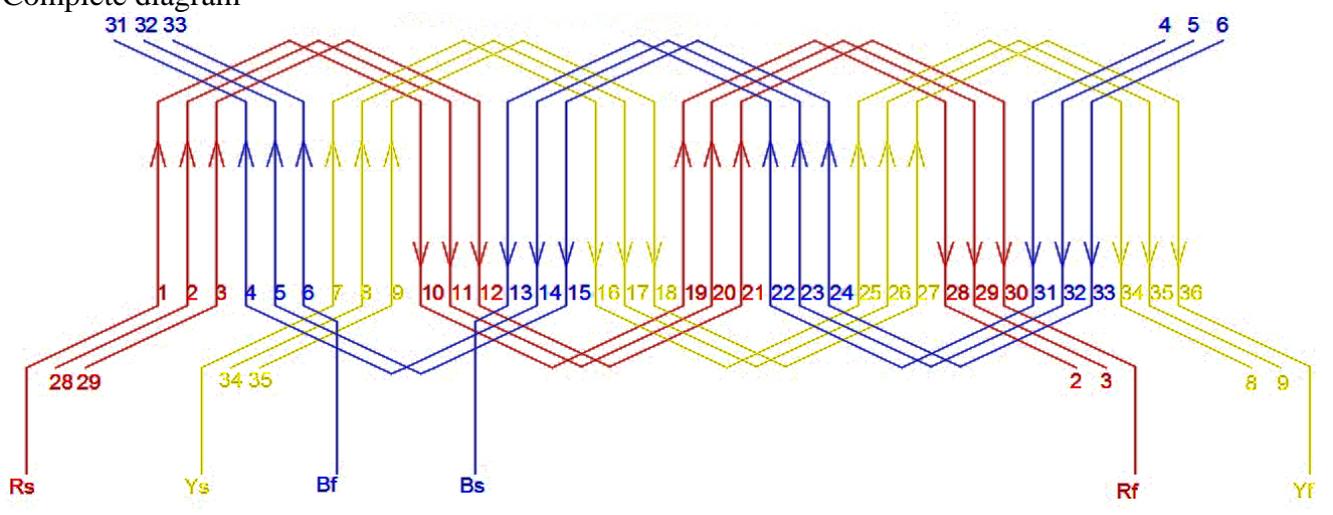
Path of Yellow phase: 7 – 16 – 25 – 34 – 8 – 17 – 26 – 35 – 9 – 18 – 27 – 36

Path of Blue phase: 13 – 22 – 31 – 4 – 14 – 23 – 32 – 5 – 15 – 24 – 33 – 6





Complete diagram



## Double layer wave winding

### 1. Draw double layer wave winding with 24 slots and 4 poles

a. Calculations:

$$\text{Slot pitch} = \text{slot/pole} = 24/4 = 6$$

$$\text{coil span} = 6$$

$$\text{slot/pole/phase} = 24/4/3 = 2 \quad - 2 \text{ Red, 2 Blue, 2 Yellow}$$

$$\text{slot angle} = 180/6 = 30^\circ$$

Red starts from 1<sup>st</sup> slot

Yellow starts from  $1+120/30 = 5^{\text{th}}$  slot

Blue starts from  $1+240/30 = 9^{\text{th}}$  slot

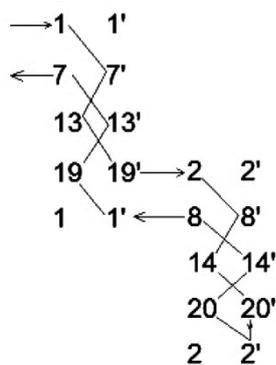
b. Slot phase table:

	Red	Blue	Yellow
<b>Pole 1 (N<sub>1</sub>)</b>	1 2	3 4	5 6
<b>Pole 2 (S<sub>1</sub>)</b>	7 8	9 10	11 12
<b>Pole 3 (N<sub>2</sub>)</b>	13 14	15 16	17 18
<b>Pole 4 (S<sub>2</sub>)</b>	19 20	21 22	23 24

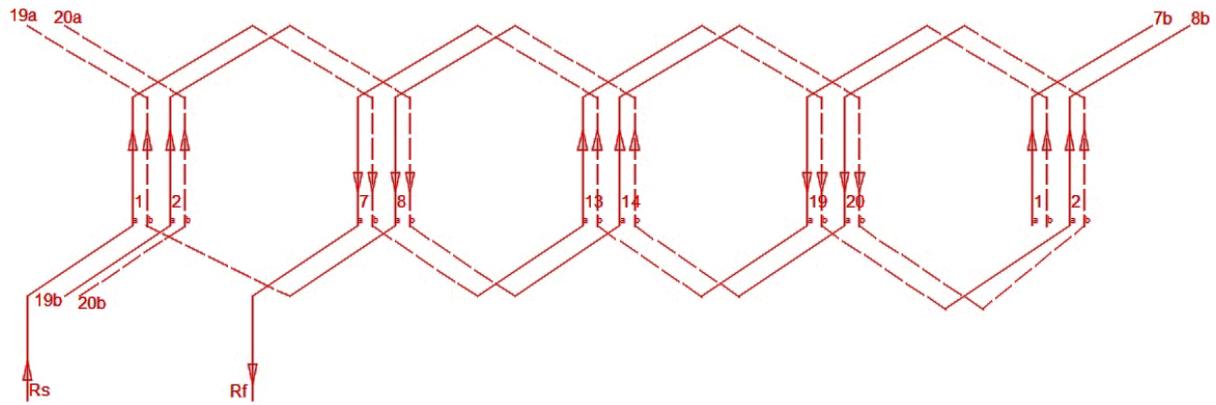
c. Winding diagram:

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 –

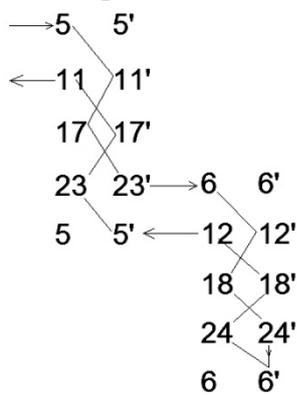
Red phase:



1. Write the first column along with its bottom conductors like 1 1'
2. After the last row (19 19'), place the second column values, 2 2'
3. Repeat the first row at the end, for both columns
4. Start from 1, go down in a zig zig manner till 19'
5. 19' cannot connect again to 1. This connects to the next column value 2
6. Repeat the zig zig movement down till 20'
7. 20' cannot connect to 2. Connect 20' to 2'. Only here, a bottom conductor connects to another bottom conductor
8. From 2', go up in the same zig zag manner till 8
9. Join 8 to 1', go up till 7. 7<sup>th</sup> slot upper conductor is the last conductor for Red phase

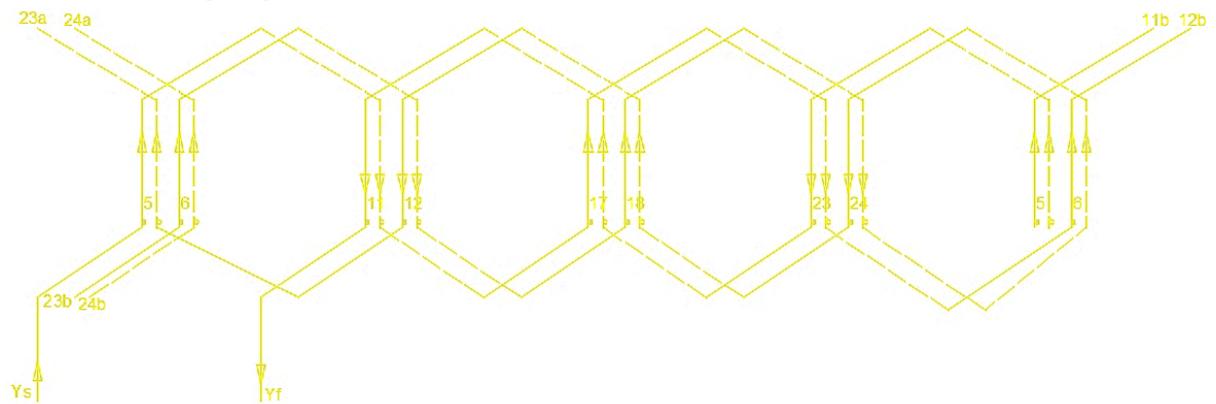


Yellow phase:

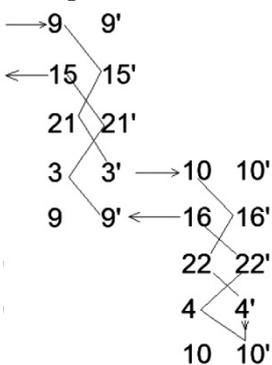


Yellow starts from 5<sup>th</sup> slot. Movement is -

- 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



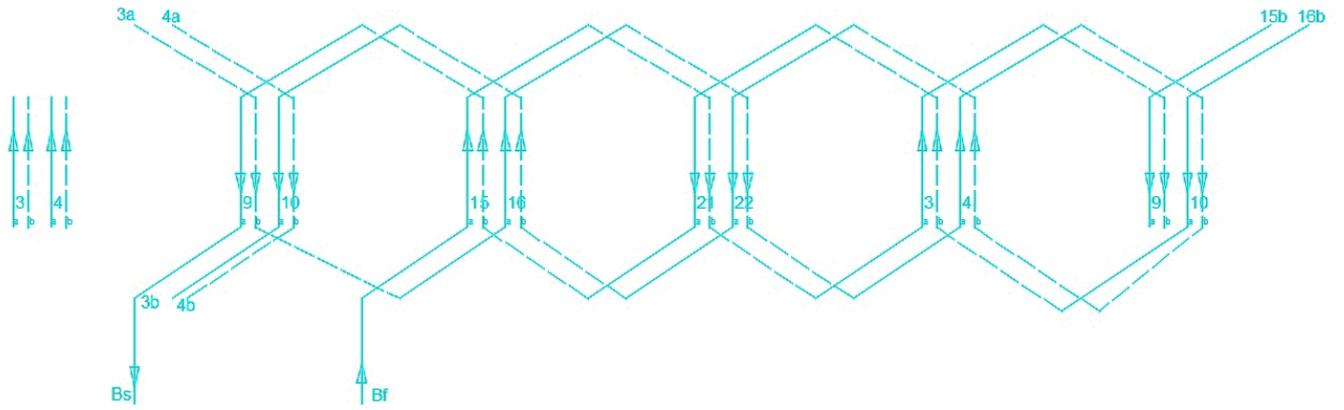
Blue phase:



Blue starts from 9<sup>th</sup> 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'



The complete diagram

