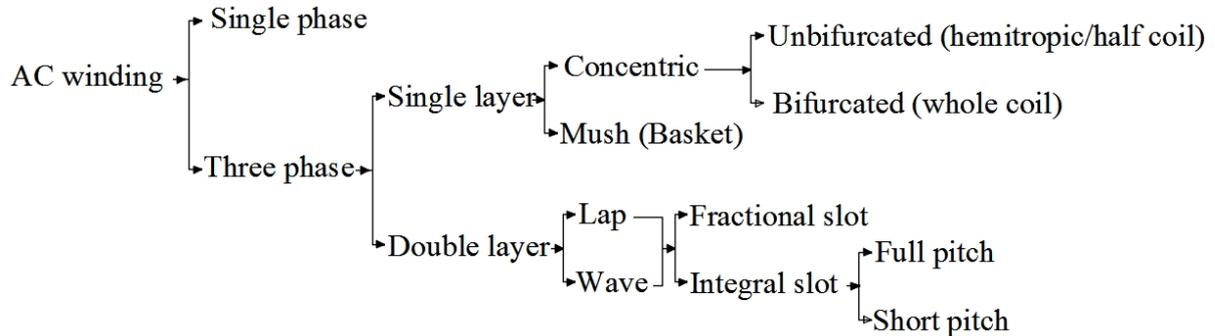


Electrical Drawing

Single Layer Mush Winding

AC winding diagram



Single Layer Mush winding:

It is also called Basket winding. All coils have the same span. Coil span can be 180° electrical, or less. Coil span must always be odd in number. Coil is shaped like a trapezium.

1. Draw developed single layer winding for a 24 slot, 4 pole AC machine

a. Calculations:

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

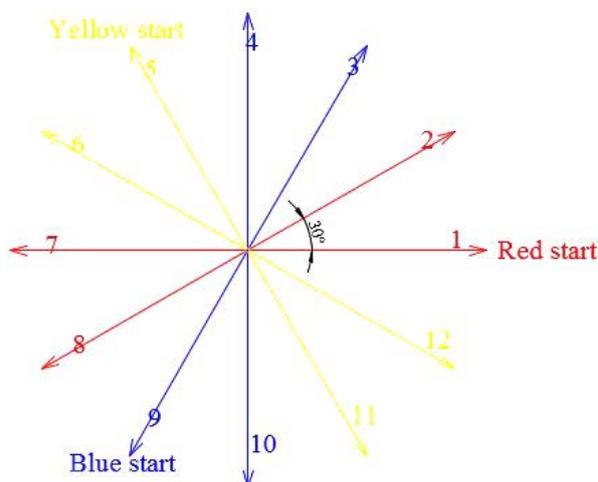
Normally coil span = slot pitch = 6. But coil span must be odd in mush windings

So, coil span – $6-1 = 5$

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

slot/pole/phase = $24/4/3 = 2$ - there are 2 Red, 2 Blue, 2 Yellow slots

Assuming phase sequence to be RYB -



Red is 0° . So it is the first conductor

Yellow is at 120° . Yellow starts from $1+120/\text{slot angle} = 1+120/30 = 5$, 5th conductor

Blue is at 240° . Blue starts from $1+240/30 = 9$, ie., 9th conductor

c. Slot position table:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
R	R	B	B	Y	Y	R	R	B	B	Y	Y	R	R	B	B	Y	Y	R	R	B	B	Y	Y

If coil span is 5, 1st Red must connect to 1+5=6th conductor. But 6th conductor is Yellow. Shift the entire set left by one 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
R	B	B	Y	Y	R	R	B	B	Y	Y	R	R	B	B	Y	Y	R	R	B	B	Y	Y	R

Now 1st Red can connect to 6th slot which is also Red.

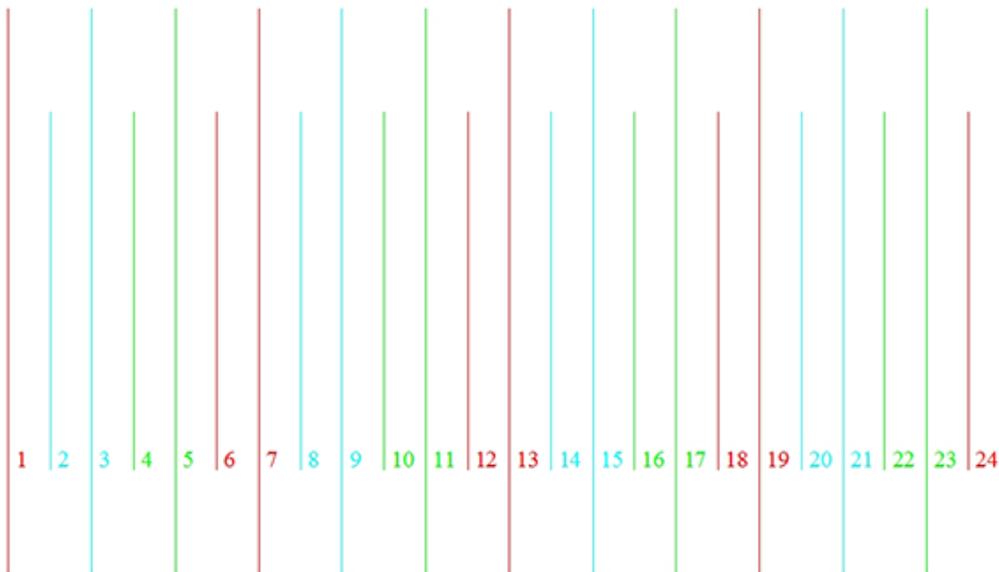
Slot phase table:

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

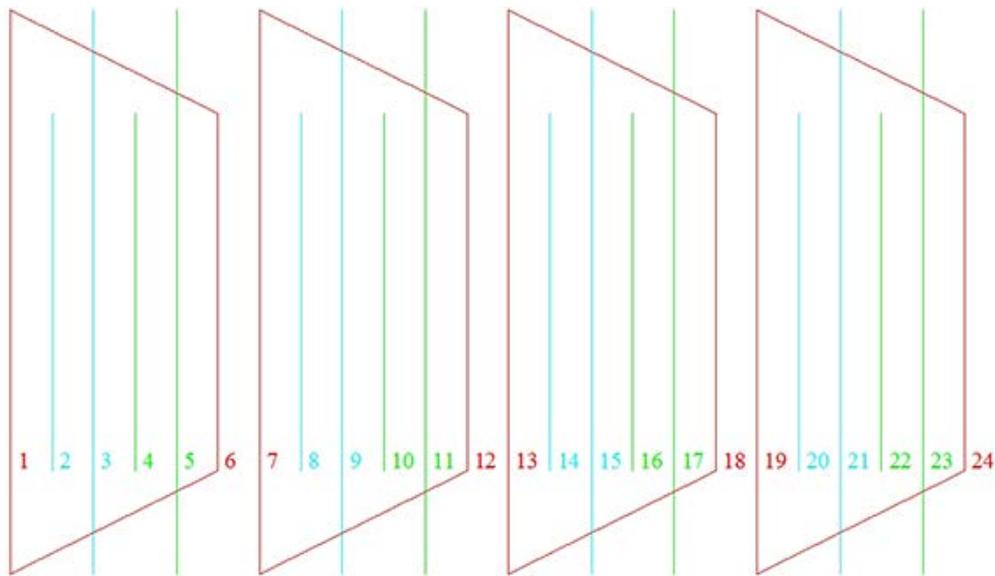
d. Winding diagram:

d1. Draw 24 lines with the colours as given in the slot position table

d2. Odd numbered lines are longer than even numbered lines

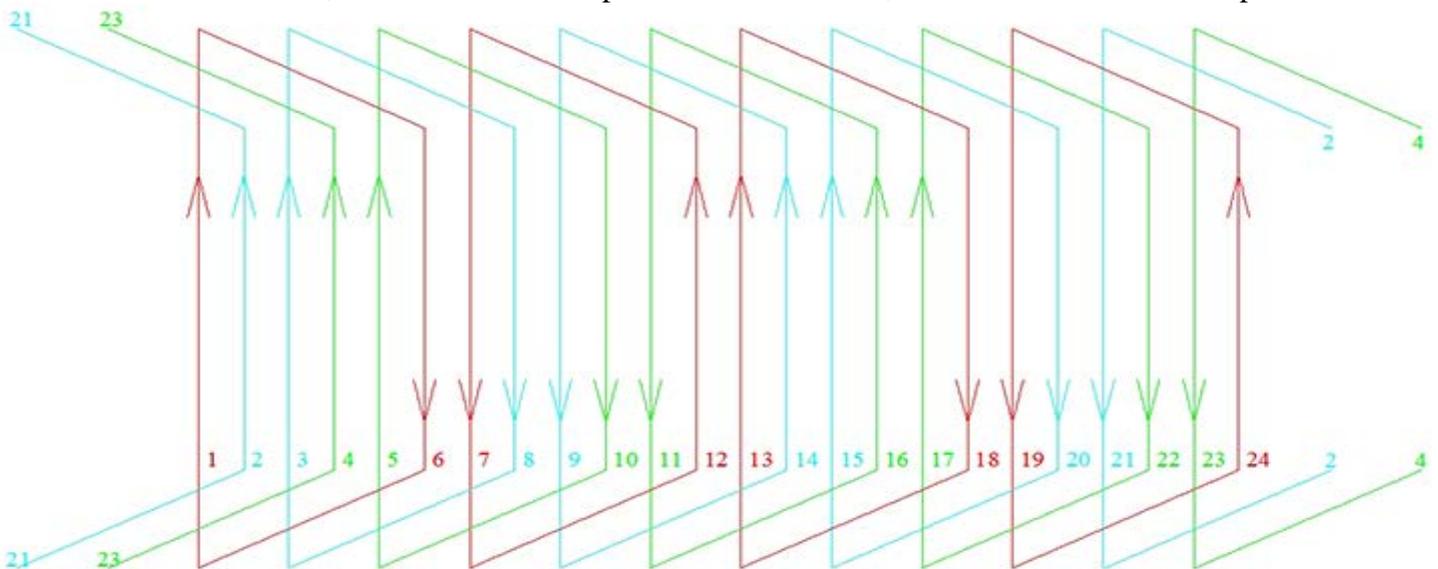


d3. Coil span is 5. Join 1 to 6, 7 to 12, 13 to 18, 19 to 24, i.e., odd long line to even short line



d4. Repeat the above for blue and yellow phases

d5. Place the arrows according to the slot pitch. Since slot pitch is 6, 6 slots have upward arrows, 6 down and so on. Here, the 1st slot has been pushed to the 24th slot, so the 24th slot will have up arrow

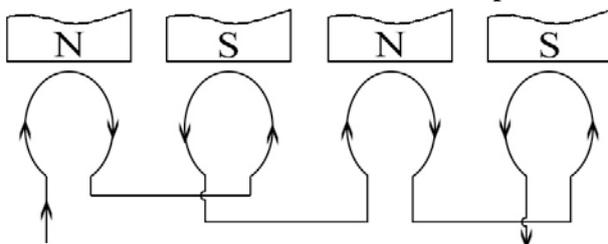


e. *Bottom connections:*

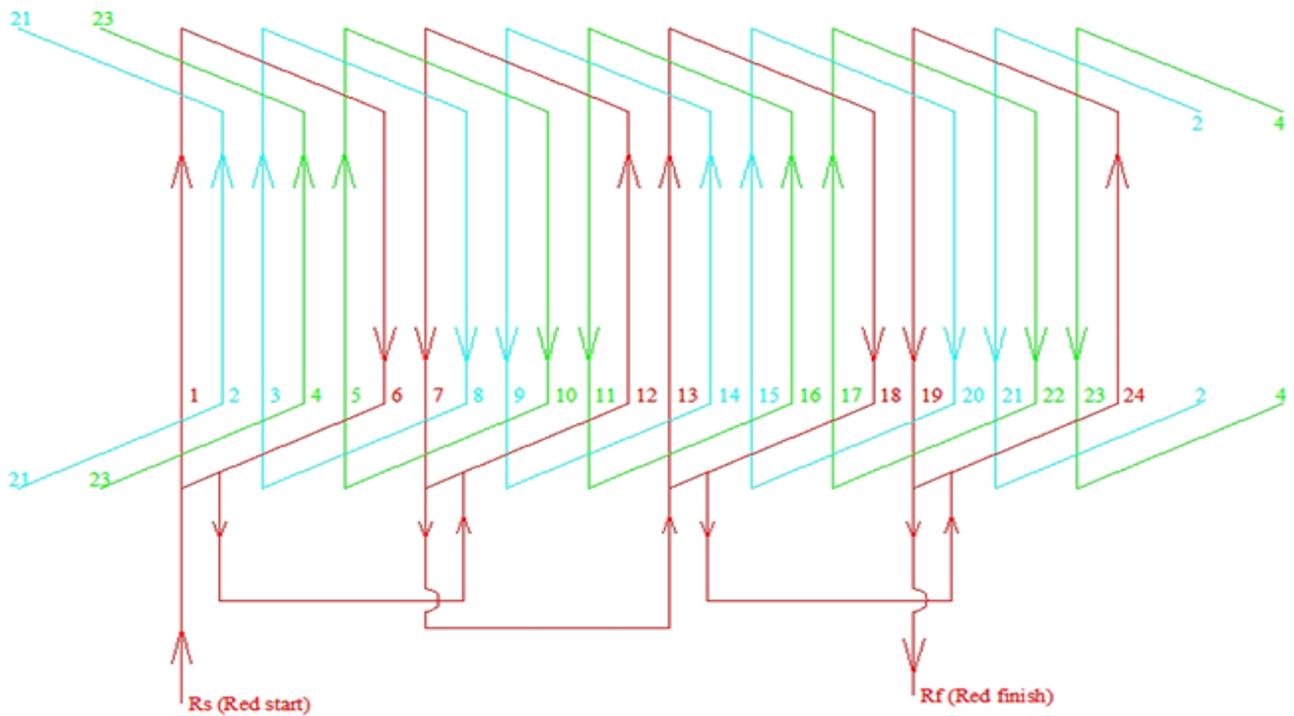
Red starts from 1st slot, Yellow from 5th slot, Blue from 9th slot.

In AC lap windings, the current loops in –

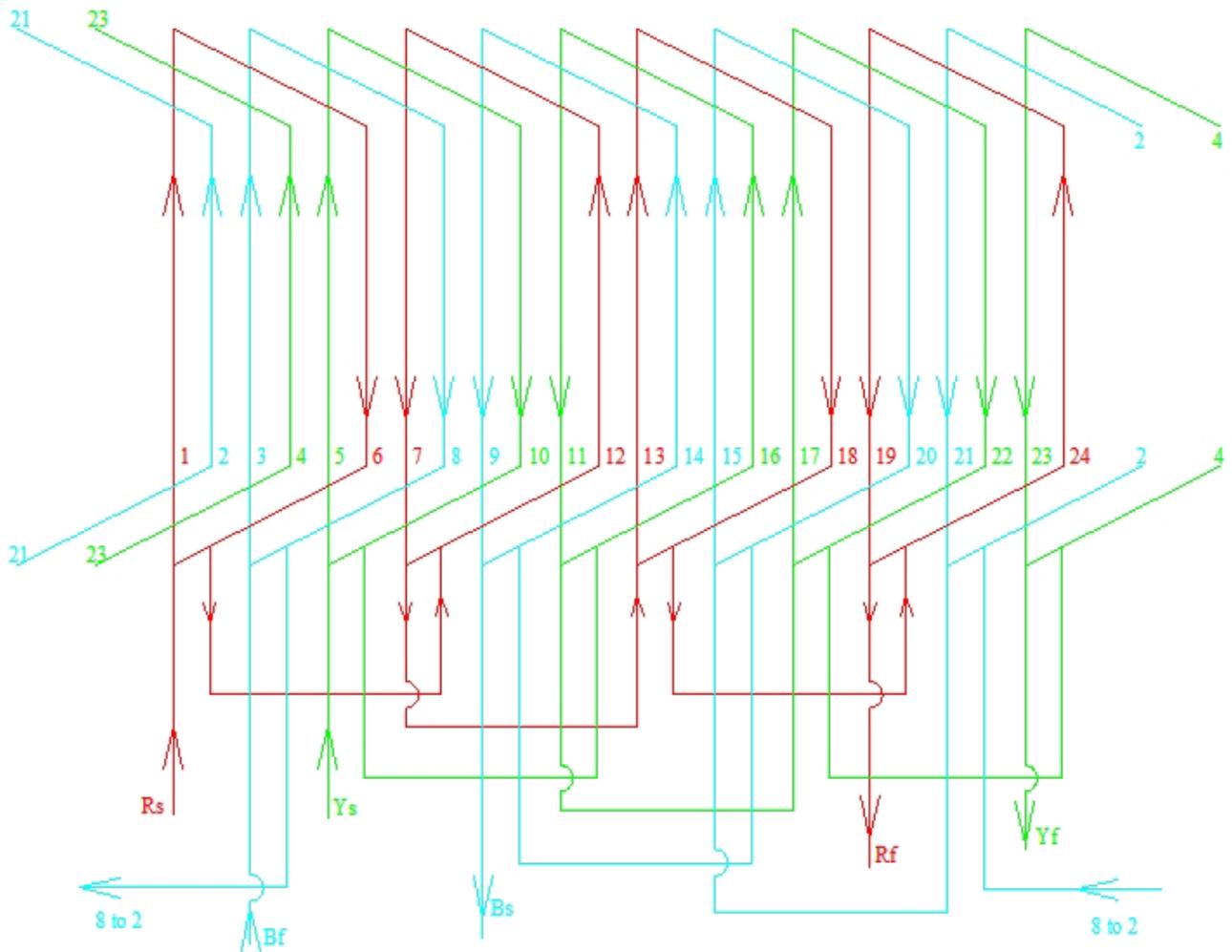
- clockwise direction under North pole
- anti-clockwise direction under South pole



This is same for all Lap windings, single layer or double layer, full pitch and short pitch



Similarly for Yellow and Blue. For Blue, the direction of movement is from 9, though the current direction looks downward.



2. Draw single layer winding diagram for a 18 slot, 2 pole AC machine

a. Calculations:

Slot pitch: Slots/pole = $18/2 = 9$

Coil span = slot pitch = 9

slot angle = $180/\text{slot pitch} = 180/9 = 20^\circ$ electrical

slot/pole/phase = $18/2/3 = 3$ - there are 3 Red, 3 Blue, 3 Yellow conductors

Red is 0° . So it is the first conductor

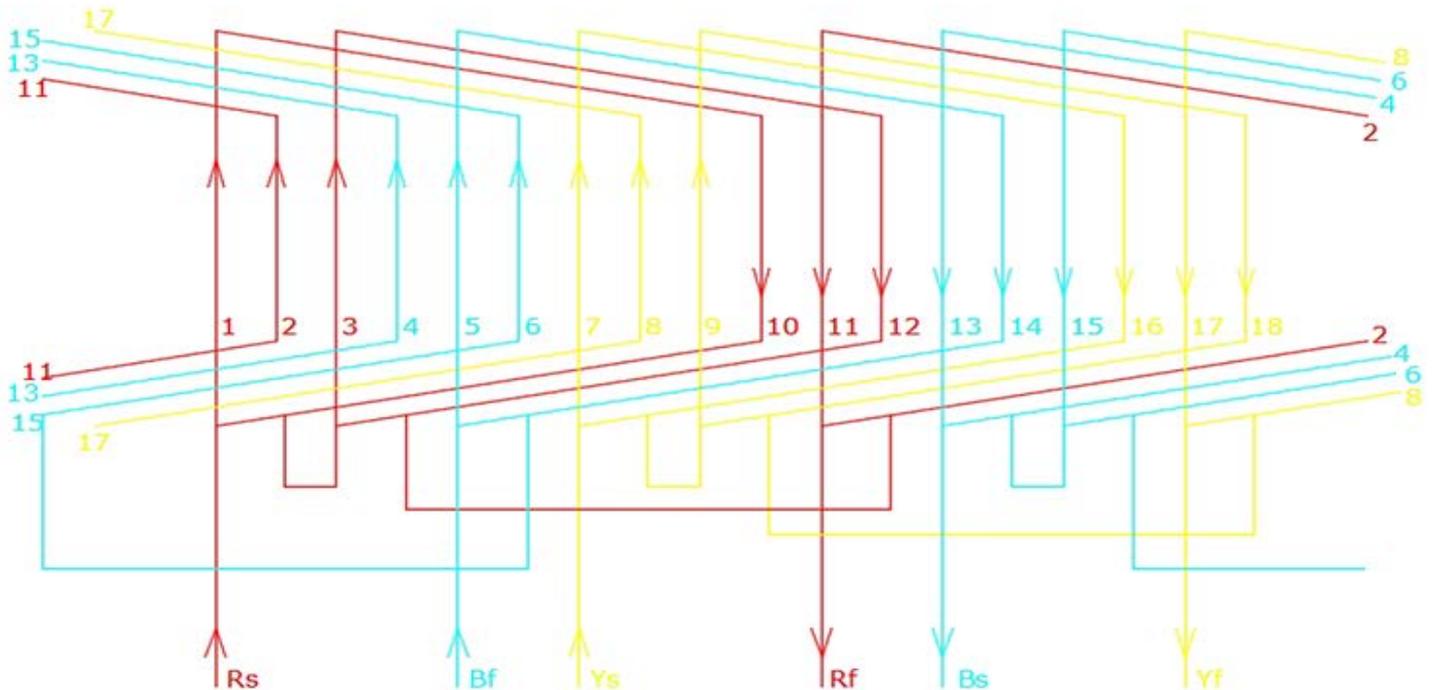
Yellow is at 120° . Yellow starts from $1+120/\text{slot angle} = 1+120/20 = 7$

Blue is at 240° . Blue starts from $1+240/20 = 13$

c. Slot position table:

Pole 1 (N)									Pole 2 (S)								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
R	R	R	B	B	B	Y	Y	Y	R	R	R	B	B	B	Y	Y	Y

d. Winding diagram:



Note: There are two coils under one pole. So the current loops around before joining the second coil

For Red phase, current -

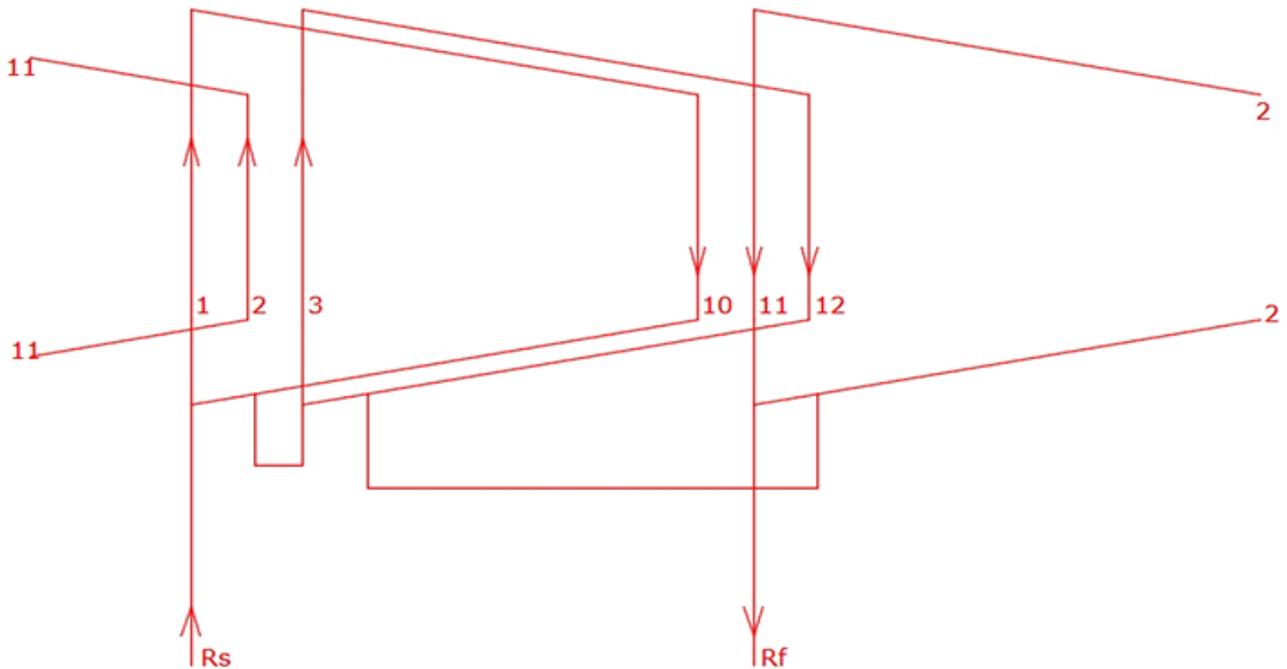
goes up slot 1, comes down 10

makes a loop, and

goes up 3, comes down 12,

and then goes to the next coil made of 2 and 11

Similarly the Blue and Yellow phases make loops wherever two coils are under one pole



3. Draw winding diagram of a 12 slot, 2 pole, single layer AC machine

a. Calculations:

Slot pitch: Slots/pole = $12/2 = 6$

Coil span = slot pitch. Since slot pitch is even, coil span = $6-1=5$

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

slot/pole/phase = $12/2/3 = 2$ - there are 2 Red, 2 Blue, 2 Yellow conductors

Red is 0° . So it is the first conductor

Yellow is at 120° . Yellow starts from $1+120/\text{slot angle} = 1+120/30 = 5$

Blue is at 240° . Blue starts from $1+240/30 = 9$

c. Slot position table:

$1+5=6$. But Red cannot make contact with Yellow which is in 6th slot. So the entire set is shifted by one slot to the left. 1st Red becomes the 12th slot

N pole						S pole					
12	1	2	3	4	5	6	7	8	9	10	11
R	R	B	B	Y	Y	R	R	B	B	Y	Y

4. Draw winding diagram of a 12 slot, 4 pole, single layer AC machine

a. Calculations:

Slot pitch: Slots/pole = $12/4 = 3$

Coil span = slot pitch = 3

slot angle = $180/\text{slot pitch} = 180/3 = 60^\circ$ electrical

slot/pole/phase = $12/4/3 = 1$ - there are 1 Red, 1 Blue, 1 Yellow conductors

Red is 0° . So it is the first conductor

Yellow is at 120° . Yellow starts from $1+120/\text{slot angle} = 1+120/60 = 3$

Blue is at 240° . Blue starts from $1+240/60 = 5$

c. Slot position table:

N ₁			S ₁			N ₂			S ₂		
1	2	3	4	5	6	7	8	9	10	11	12
R	B	Y	R	B	Y	R	B	Y	R	B	Y

5. Draw winding diagram of a 36 slot, 4 pole, single layer AC machine

a. Calculations:

Slot pitch: Slots/pole = $36/4 = 9$

Coil span = slot pitch = 9

slot angle = $180/\text{slot pitch} = 180/9 = 20^\circ$ electrical

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

Red is 0° . So it is the first conductor

Yellow is at 120° . Yellow starts from $1+120/\text{slot angle} = 1+120/20 = 7$

Blue is at 240° . Blue starts from $1+240/20 = 13$

c. Slot position table:

Pole 1 (N)									Pole 2 (S)								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
R	R	R	B	B	B	Y	Y	Y	R	R	R	B	B	B	Y	Y	Y

The above pattern repeats for Pole 3 and 4, for slots 19 to 36

6. Draw winding diagram of a 36 slot, 6 pole, single layer AC machine

a. Calculations:

Slot pitch: Slots/pole = $36/6 = 6$

Coil span = slot pitch-1 = $6-1=5$

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

slot/pole/phase = $36/6/3 = 2$ - there are 2 Red, 2 Blue, 2 Yellow conductors

Red starts from 1

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

Blue starts from $1+240/30 = 9$

	Red	Blue	Yellow
N₁	36 1	2 3	4 5
S₁	6 7	8 9	10 11
N₂	12 13	14 15	16 17
S₂	18 19	20 21	22 23
N₃	24 25	26 27	28 29
S₃	30 31	32 33	34 35

