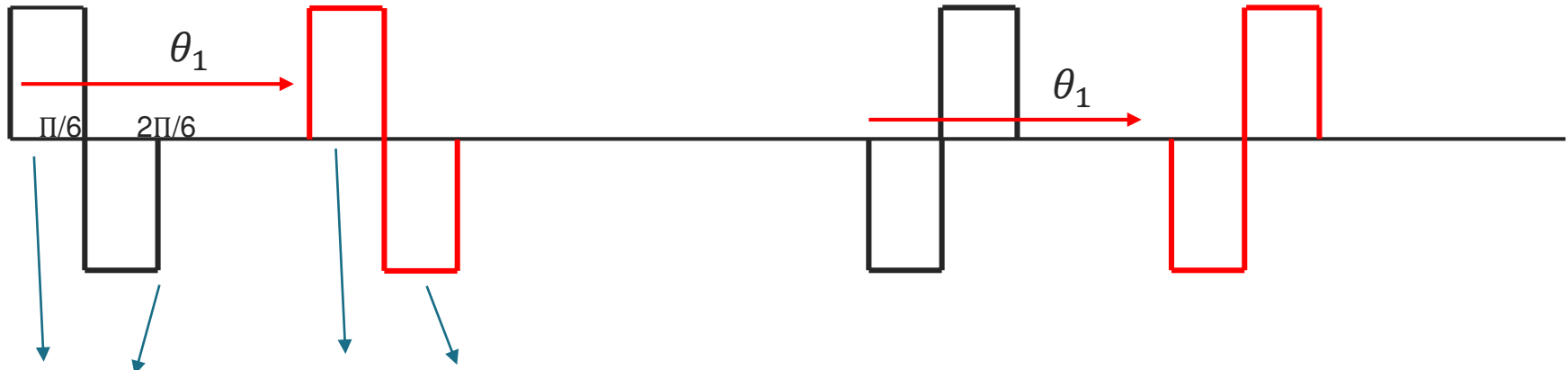


- Two N_s slot, N_p pole winding are formed each having coil pitch = 2 X slot pitch
- These two windings (W1, W2) are mechanically phase shifted by an angle θ_{sh}
- To eliminate certain harmonic, ν this shifting should be selected as $\theta_{sh} = 3\pi/\nu$
- Having wye-delta connection within two coils for each of these windings (W1 and W2) make the current angle electrically 30 degree shifted in time and their positions results 30 degree electrical shift in space. As a result, the resultant MMF for the first sub-harmonics ($\nu = 1$) becomes zero. It also enhances the torque-producing component.
- The resultant stator configuration has twice the number of slot compare to their concentrated wound counterparts which also helps in minimizing cogging torque and this also helps in minimizing torque ripple.

W1 MMF

W2 MMF



Wye Delta

Wye Delta

$$MMF_1 = MI \sin\left(\frac{k\pi}{12}\right) \sin\frac{(k-1)\pi}{12} \sin\left(k\theta - \omega t - \frac{(k-1)\pi}{12}\right)$$

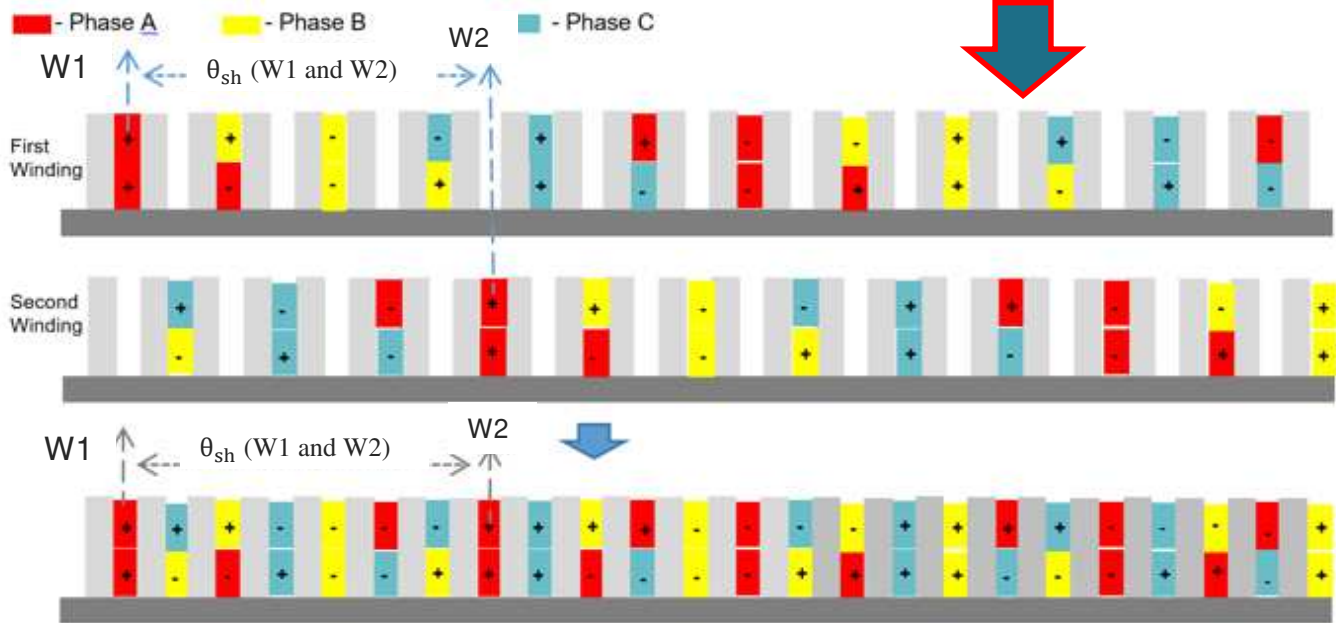
$$MMF_2 = MI \sin\left(\frac{k\pi}{12}\right) \sin\frac{(k-1)\pi}{12} \sin\left(k(\theta - \theta_1) - \omega t - \frac{(k-1)\pi}{12}\right)$$

$$MMF_T = 2MI \sin\left(\frac{k\pi}{12}\right) \sin\frac{(k-1)\pi}{12} \sin\left(k\theta - \omega t - \frac{(k-1)\pi}{12} - \frac{k\theta_1}{2}\right) \cos\left(\frac{k\theta_1}{2}\right)$$

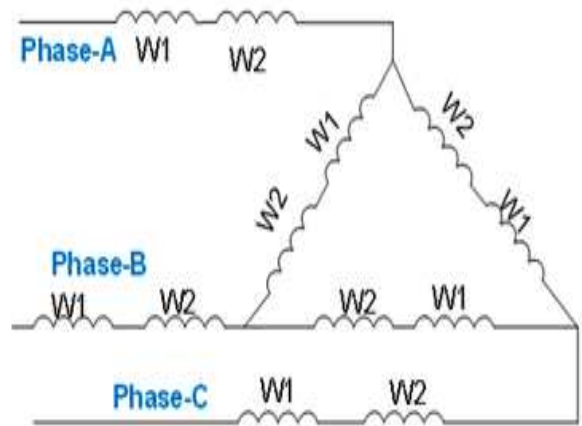
$$\frac{k\theta_1}{2} = 90 \text{ or } 270 \Rightarrow \theta_1 = 77.15 \text{ degree} = \frac{5\pi}{24} + 2.14 \quad \text{To eliminate 7th Harmonics}$$

$$\frac{k\theta_1}{2} = 270 \Rightarrow \theta_1 = 108 = 7 \cdot \pi/24 + 3 \quad \text{To eliminate 5th Harmonics}$$

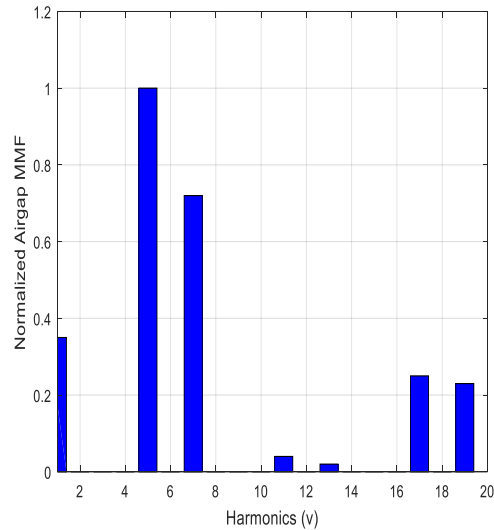
Proposed winding Layout



Coil configuration

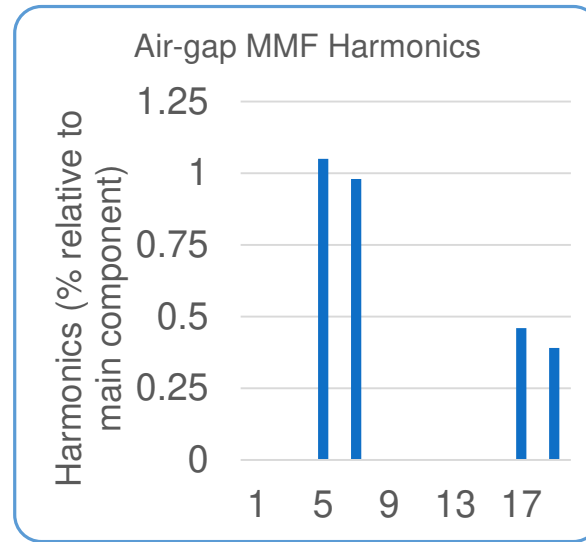


Conventional 10P/12S



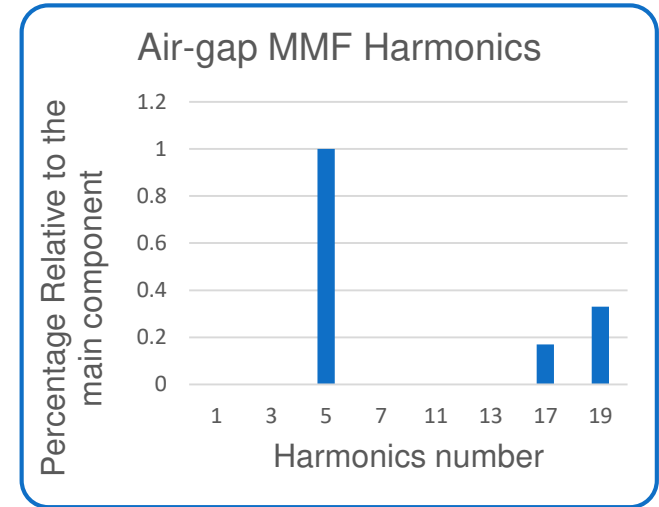
(a)

10P/12S with wye-delta



(b)

Proposed 10P/24S



(c)

- From conventional 10P/12S (Fig. a), the first sub-harmonic is eliminated with wye-delta connection (Fig. b). The torque producing component is also enhanced by 3.5%.
- From Fig. b, the unwanted 7th harmonic is eliminated by proposed coil shifting concept. This also reduces the higher order harmonics like 17th, 31st, 41st etc.
- Overall, compare to the conventional 10P/12S winding (Fig. a), the proposed concept (Fig. c) reduces THD by 61.22% and enhances the fundamental by 1.5%.