# Torque Ripple Minimization in a PM-assisted Synchronous Reluctance Motor with Different Flux Barrier Rotor


*Nazir Aamir, Guohai Liu, Xuhui Zhu*

The school of Electrical and Information Engineering, Jiangsu University



Presented at the MT-25

RAI – Amsterdam

**Session number: Tue-Af-Po2.06-01 [65]**

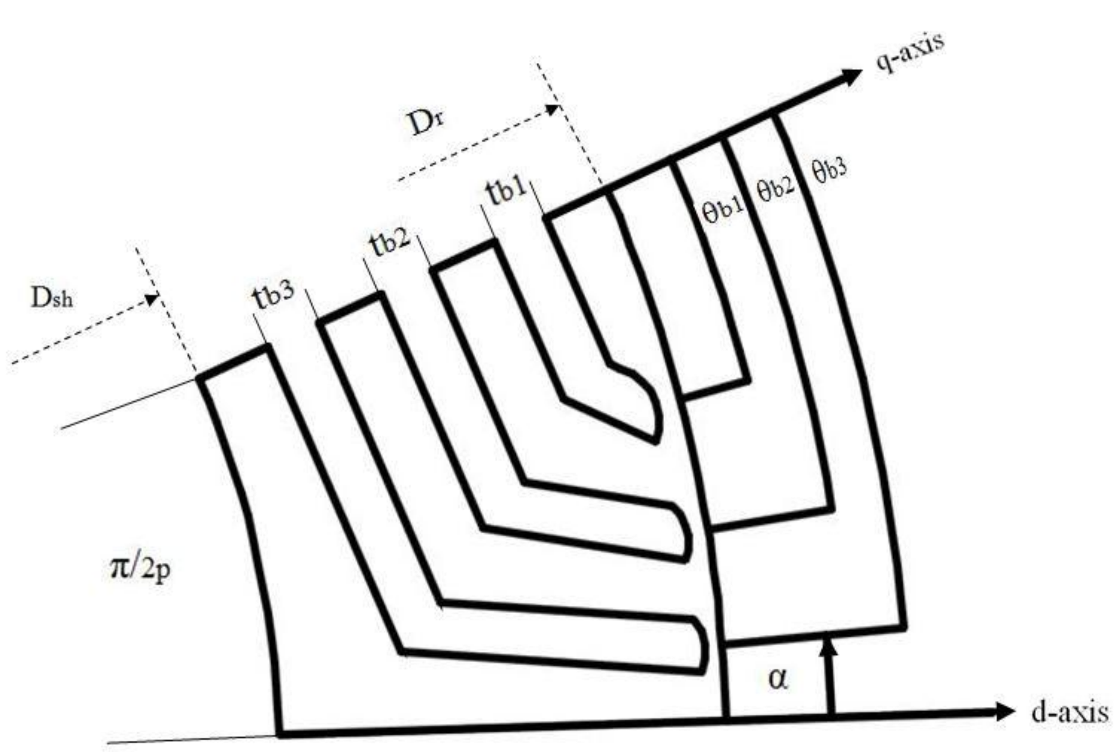
Program I.D. number: 683

2017 Aug. 29 (Tue) 13:15


## Summary

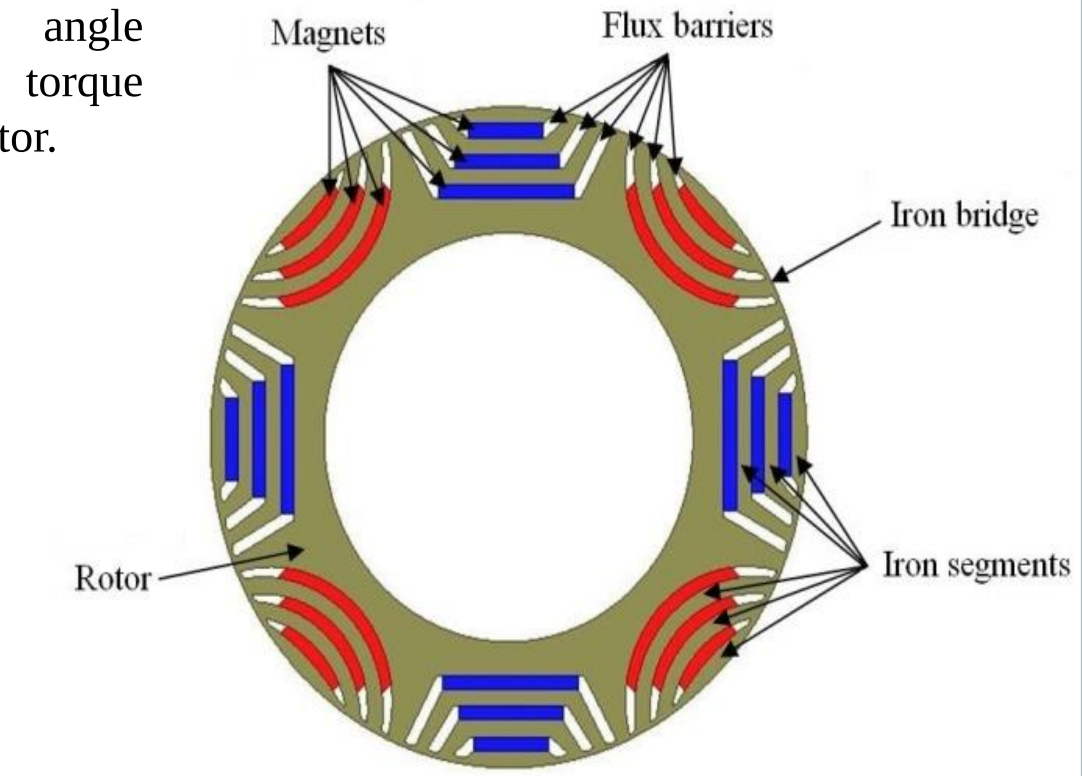

The PM-assisted Synchronous Reluctance (PMAREL) motor has been widely used in many applications due to high torque density and efficiency, especially in electric vehicles. However, it has undesirable disadvantages of high torque ripple. This paper proposes an innovative synthesis rotor geometry technique with different flux barrier rotor shapes. The proposed design appreciable changes in the torque ripple and compensate the torque harmonics with mixing the advantages of two motors. The choice of the stator and rotor flux barrier thickness, together with their end angle, is a key task to obtain an optimum solution of motor. In order to evaluate the proposed motor fairly the ferrite PMs volume is kept same in all designs. In addition, as compared with original design the proposed motor average torque is increased and the torque ripple reduced effectively.


## Topologies and Principle



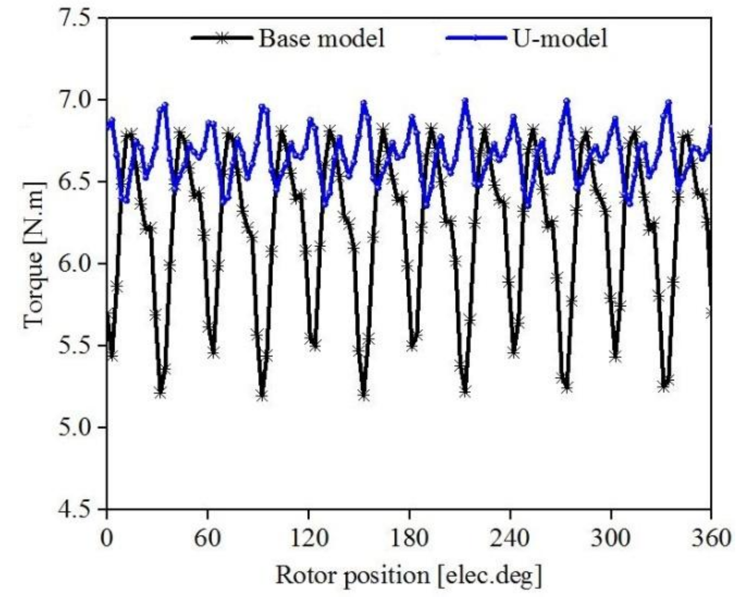

Base Rotor Geometry and Microscopic

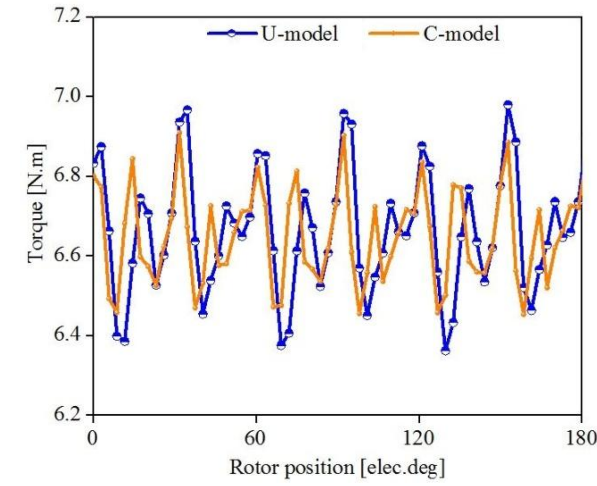
The Base model for end angle variation to compensate the torque ripple and harmonics of U+C rotor.

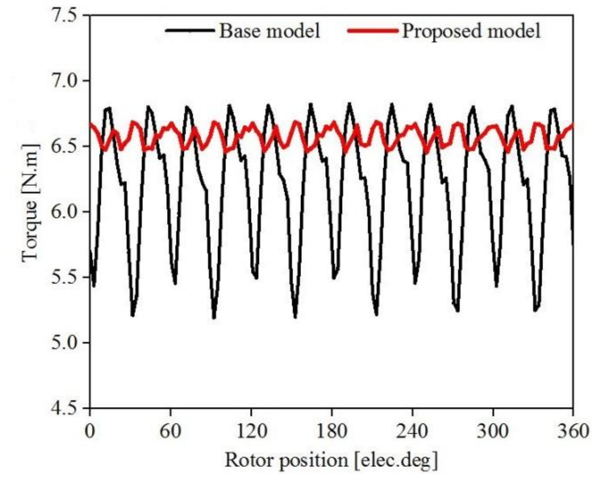



The Proposed "U+C" Rotor

## Design



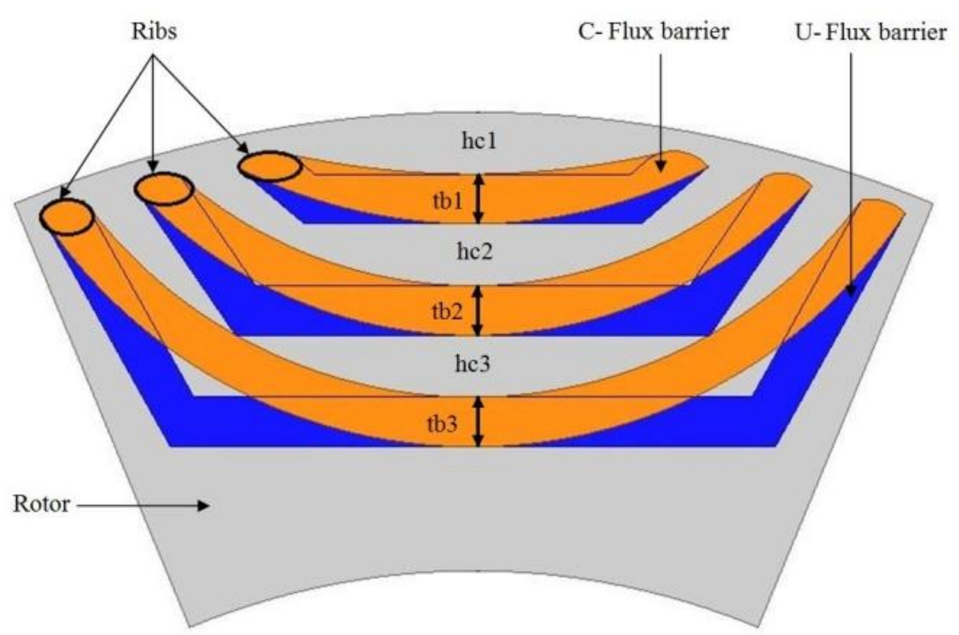




It can be seen that after Optimized the rotor and stator coefficient and the angles of the flux–barrier ends, the U motor electromagnetic torque ripple minimized as compare to base motor.

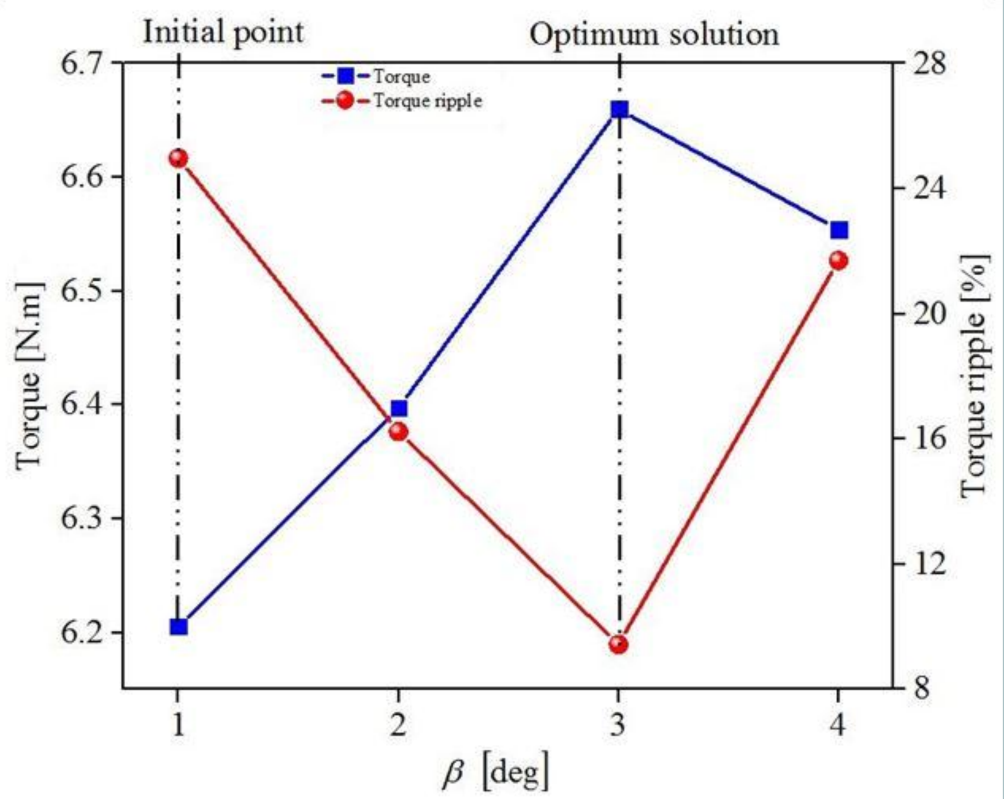
After optimization of symmetric U and C type motors, it can be seen the torque variation of symmetric design motors are almost same but In order to reduce further torque ripple the optimal geometries have been combined. In this case, an asymmetric synthesis design further effect the reduction (about 15%) of the torque ripple and a consequent increase the average torque slightly lower than U but higher than C type motor.

## Design




The C type flux barriers rotor structures design same as U type rotor methodology, to the aim of having a balanced radial force. In this case, the position of the flux-barrier ends is also gives the smooth torque at same point. The C rotor flux-barrier ends are uniformly distributed as U rotor .

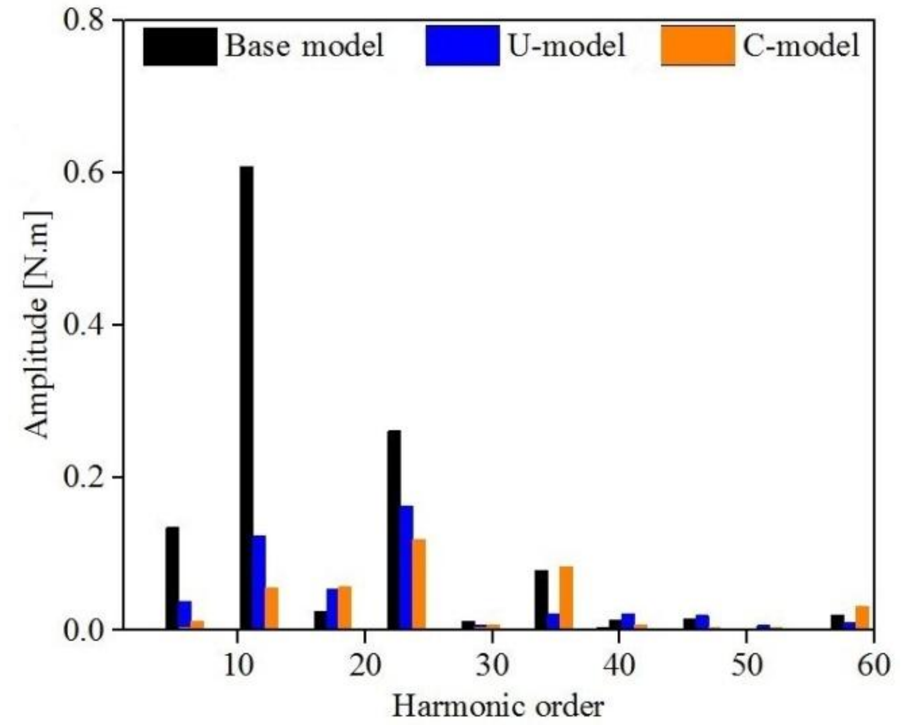
The β angle shifting significantly yield to noticeable variation of the torque ripple but as compared with original design the proposed motor average torque is increased and the torque ripple minimized effectively. It can be noticed that, while the average torque remains almost the same (the variation is less than 4%), as one degree shifting the barrier end angle can affect significantly the torque ripple. On the other hand, β angle leads to decrease the torque ripple of 78% as compare to initial point which highlighted by dash lines.

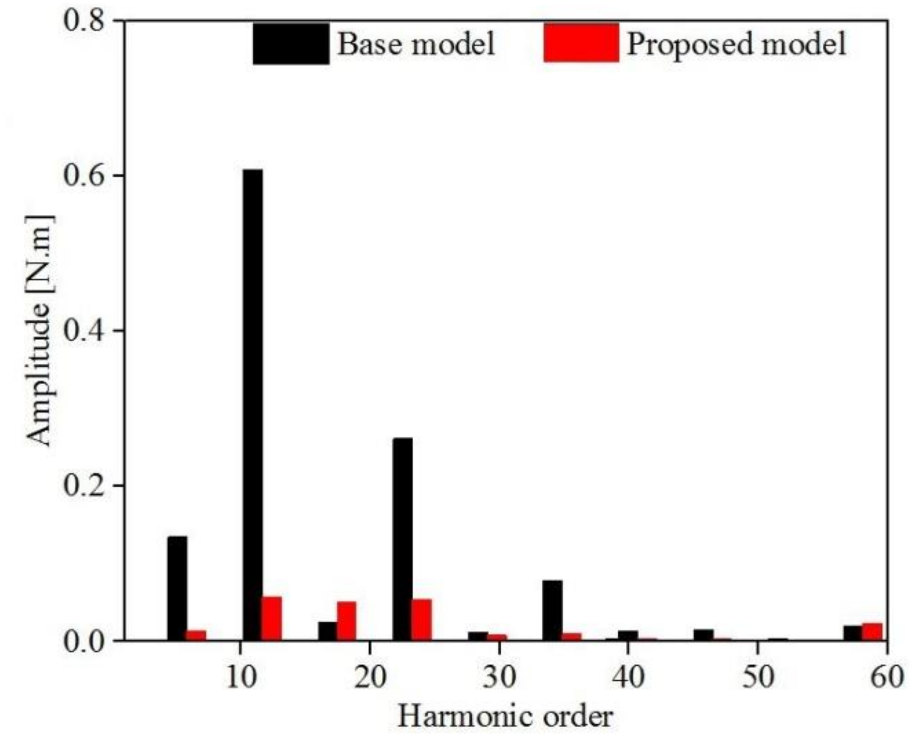



## Conclusion

In this paper, a synthesis permanent magnet assisted synchronous reluctance motor (PMAREL) has been proposed, which offers the advantages of two motors, the symmetric and asymmetric motors are compared and the results of this models allow to individuate the position of the flux–barrier ends so as to minimize the torque ripple. In addition, the proposed strategy to minimize the ripple is not only based on a suitable choice of the flux–barrier ends, but this choice is combined with the adoption of a rotor formed by two different laminations. This strategy allows an optimal compensation of the torque harmonics so that a smooth torque is achieved.

## Performance




The effect of the end angle shifting is that the torque ripple and harmonics decreases as can be seen for low order harmonics 6th , 12th, 24th and 36th. It is worth noticing that the higher torque harmonic is that of 12th order. This is due to the choice of flux barrier end angle. Moreover, the proposed synthesis asymmetric rotor design reduces significantly torque harmonics as symmetric model 0.60N.m to asymmetric model 0.07N.m., the propose motor significantly reduce the low order torque harmonic of 6th , 12th, 24th and 36th .