

# DESIGN OF 6 PHASE INDUCTION MOTOR & ANALYSIS BY USING 6 PHASE TRANSFORMER

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**Abstract:** This paper represents a model of 6 phase 4 pole induction motor & 6 phase transformer. The circle diagram are drawn after observing performance of motor under no load and full load condition which shows that 6 phase induction motor has more efficiency, more torque density, good reliability as compared to 3 phase induction motor. By the help of 6 phase induction motor various testing can be performed on electric vehicle, agriculture appliances and ship propulsion etc.

**Keywords:** Circle Diagram, 6 Phase 4 Pole Induction Motor, Torque, Efficiency.

## INTRODUCTION

The 6 phase induction motor works on 6 phase supply for this it is required to develop 6 phase supply by using special type of transformer connection. Transformer as regular phase shift is  $120^\circ$  but 6 phase supply is required so phase shift can be divided and after that transformer output achieve which has 6 phase and every phase has  $60^\circ$  phase shift. And to the multi winding transformer output is given to the 6 phase induction motor to drive the 6 phase induction motor.

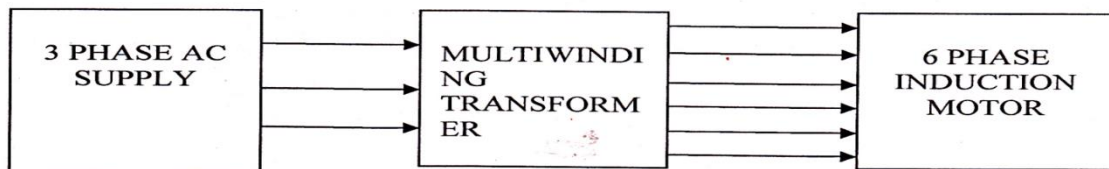


Fig.1.Block Diagram

## I. CONSTRUCTINAL DETAILS

A 6 phase induction motor consists essential of two major parts, the stator and the rotor .The construction of each one is basically a laminated core provided with slots which house windings. When one of the windings is excited with AC voltage, a rotating field is setup. This field produces an emf( Electromotive Force) in the other winding by transformer action which in turn circulates current in the later if it is short circuited. The current is flowing in the second winding interact with the field produced by the first winding there by producing a torque which is responsible for the rotation of the rotor. As shown in fig.2, 12 coils are used in the connection of motor winding. End point of first coil is connected to End of forth coil. Start point of first coil for input A1.Start point of second coil is connected to the start of fifth coil and end point of second coil for input B1.End point of third coil is connected to end of sixth coil. Start point of third coil for input C1.Start point of 3rd, 5th, 7th, 9th and end point of 4th,6th,8th coils are connected to the common Neutral. End point of 10th coil is connected to End of 7th coil.Start point of 10th coil for input A2.Start point of 11th coil is connected to the start of 8th coil and end point of 11th coil for input B2.End point of 12th coil is connected to End of 9th coil. Start point of 12th coil for input C2.

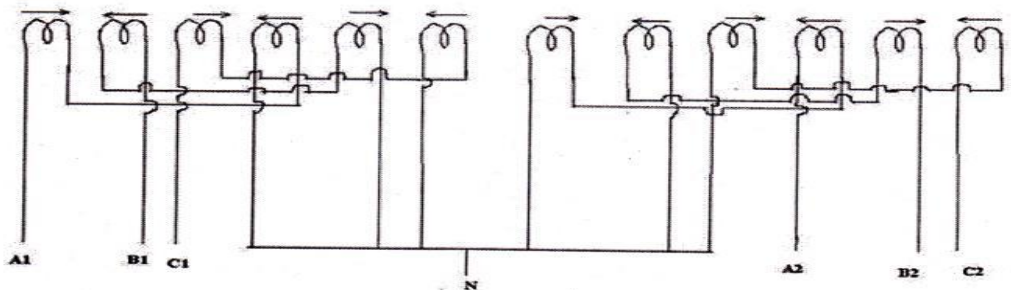


Fig.2. Winding Connection Of Transformer

## II. DESIGN CALCULATION OF 6 PHASE INDUCTION MOTOR

The designing main dimensions of 3H P(2.338KW), 200Volts, 6phase, 4pole induction motor(assuming efficiency  $\eta = 82\%$ , power factor  $\cos\Phi = 0.85$ lagging

$$Q = \frac{\text{output in KW}}{\eta \times \cos \Phi}$$

$$Q = \frac{2.338}{0.82 \times 0.85} = 3.5 \text{ KVA}$$

Also  $Q = C_0 D^2 L n_s$  And  $C_0 = 11 B_{av} a_c K_w 10^{-3}$

$K_w$  = Window space factor for 6 phase = 1

Assuming Specific magnetic loadings  $B_{av} = 0.69 \text{ wb/m}^2$  Specific electric loading  $a_c = 12000 \text{ Ampere conductors}$

$$C_0 = 11 \times 0.69 \times 12000 \times 1 \times 10^{-3} = 91.08$$

Putting the value of  $C_0$  from in We get ,  $D = 0.125 \text{ m} = 125 \text{ mm}$  , Taking overall good design condition, i.e.  $\frac{L}{T}$

$$\text{Where, } \Gamma = \text{pole pitch} = \frac{\pi D}{p}$$

$$\text{Thus } L = 0.1 \text{ m} = 100 \text{ mm}$$

Similarly turns per phase,

$$T_{ph} = \frac{E_{ph}}{4.44 \phi K_w} = 312$$

$$\text{Total conductors} = Z_{ss} = 2m T_{ph}$$

$$\text{Stator slots } S_s = 36, \text{ no. of phases } m = 6$$

$$\text{Thus Total conductor} = 3744$$

$$\text{Conductor per slot } Z_s = \frac{Z_{ss}}{S_s} = \frac{3744}{36} = 104$$

Thus the specifications of six phase induction motor areas given below:

#### **Stator Dimensions:-**

Stator Bore Diameter = 125mm

Number of Stator Slots = 36

Stack length of stator = 100mm

#### **Rotor Dimensions:-**

Rotor Outer Diameter = 125mm

Number of Rotor Slots = 28

Stack length of Rotor = 100mm

Rotor Conductor size = 22SWG

Rotor Conductors per slot = 104

No. of Turns per phase = 312

Insulation used to rotor winding = Class F

### **III. FOLLOWING ARE THE STEPS OF DESIGN TRANSFORMER**

#### **1. CONNECTION OF SIX PHASE TRANSFORMER**

As shown in fig.3 the Transformer contain total six coil. Each coil has three terminals start, tap and end. Bottom coil of each limb tapping are get connected to neutral. The top coil of each limb is start point for input supply. Top coil of each limb tap and star to fetch limb of bottom coil are output of Transformer and those are six phase input supply of six phase induction motor.

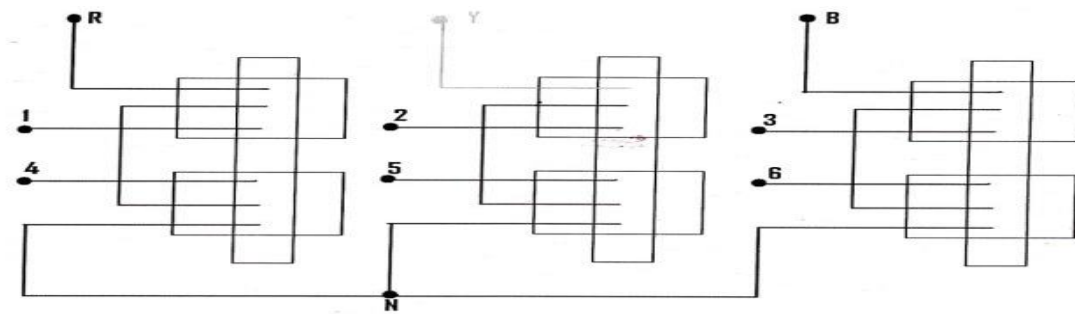


Figure 3. Connection Diagram Of Six Phase Transformer

## 2. DESIGN SPECIFICATIONS FOR TRANSFORMER CORE

| Parameter                              | Rating  | unit              |
|----------------------------------------|---------|-------------------|
| Q= transformer output                  | 5       | KVA               |
| K= constant                            | 0.4500  |                   |
| Et= voltage per turn                   | 1006    | V                 |
| Bm= Maximum flux density               | 1.2000  | wb/m <sup>2</sup> |
| Ai =net iron area                      | 0.0038  | m <sup>2</sup>    |
| D= diameter of circumscribed circle    | 0.0916  |                   |
| Agi = gross iron area                  | 0.0042  |                   |
| Kv= kilo volt                          | 1.1100  | KV                |
| Kw= window space factor                | 0.2893  |                   |
| del = current density                  | 1.5000  |                   |
| Aw= area of window                     | 15.2678 |                   |
| Wc = width of core                     | 0.0648  |                   |
| Ww= Width of window.                   | 0.070   |                   |
| D= Distance between two adjacent cores | 0.1620  |                   |
|                                        |         |                   |

## IV. PERFORMANCE CALCULATIONS

For 3 Phase Induction Motor:

V0= 417V

I0= 1.59A

W0=80W

Vc=139V

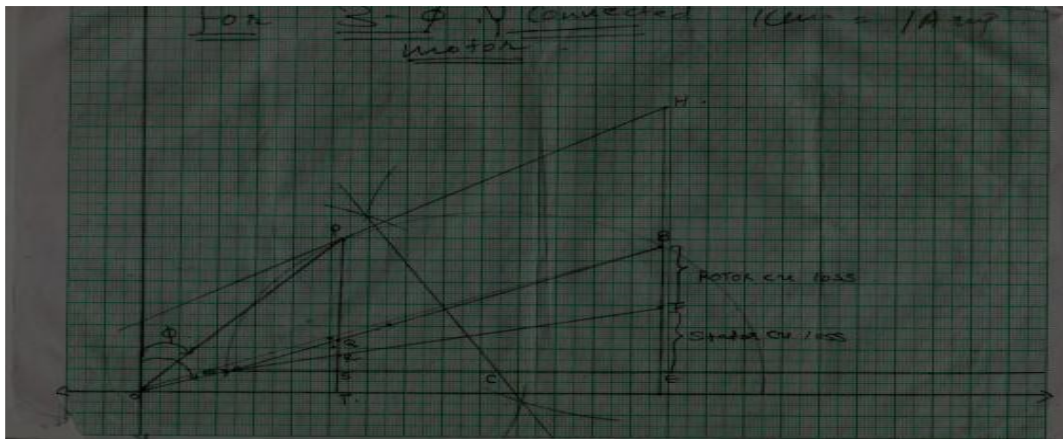


Fig.4. circle diagram

Full Load line current OP= 2.7cm

As per current scale, 1cm=2Amp

Hence full load current= 4.67Amp

$$\text{Full load } \cos \Phi = \frac{PN}{OP} = \frac{2.6}{2.9} = 0.89 \text{ lag}$$

Full load torque= Rotor input=PJ= 1.55cm

As per power scale 1 cm= 1397.984W

Hence,

Full load torque= 1.55x1397.984= 2166.87 Synchronous watts

$$\text{Full Load Efficiency} = \frac{PL}{PN} = \frac{1.55}{2.6} = 59.61\%$$

For 6 Phase Induction Motor:

$$V_0 = 207V$$

$$I_0 = 0.6A$$

$$W_0 = 120W$$

$$V_c = 107V$$

$$I_c = 4.5A$$

$$W_c = 640W$$

$$\Phi_0 = 73.800$$

$$\Phi_s = 67.430$$

Full Load line current OP = 5.35cm

As per current scale, 1cm=1Amp

Hence full load current= 5.35Amp

$$\text{Full load } \cos \Phi = \frac{NH}{OH} = \frac{4.2}{5.35} = 0.78 \text{ lag Full load torque= Rotor input=HS= 3.5cm}$$

As per power scale 1cm= 720.53W

## V. CONCLUSION

The full load torque of 6 phase induction motor 2511.75/2156.67=1.159 also efficiency of 6 phase induction motor =67.98%, while efficiency of 3 phase induction motor=58.59%.The graphical calculation using circle diagram and theoretical calculation is compared and it's clear that the torque and efficiency of 6 phase induction motor found it approximately 1.16 more than 3 phase

induction motor. The torque of 6 phase induction motor is much higher than equivalent three phase induction motor. But initial cost of 6 phase induction motor is increased due to transformer purpose as compared to 3 phase induction motor but at the same time efficiency and torque are significantly improve an obtain good performance.

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