Amoo Oluwaferanmi Mark

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Electrical Machines (EEE 326)

Assignment 3

AMOO OLUWAFERANMI MARK
ELECTRICAL ELECTRONICS ENGINEERING
18 ENG04 1077
ELECTRICAL MACHINES [EEE 326]
ASSIGNMENT 3 [TUTORIAL QUESTION]

[1(a.)] A single phase induction motor, unlike a 3 phase induction motor, does not have a self starting torque.

(b.) A single phase supply can not produce a rotating magnetic field but it produce a pulsating magnetic field which does not rotate. The double revolving field theory of a single phase induction motor states that a pulsating magnetic field is resolved into two rotating magnetic field

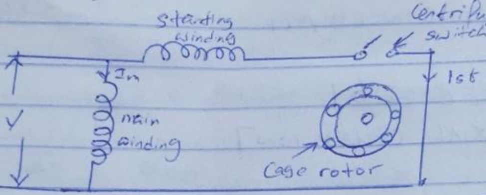
(C.) A single phase induction motor consists of a single phase winding on the stator and a cage winding on the rotor. When a 1 phase supply is connected to the stator winding, a pulsating magnetic field is produced.

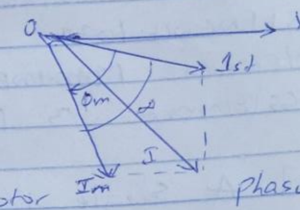
(D.) A single phase induction motor consists of a single phase winding which is mounted on the stator of the motor and a cage winding placed on the rotor.

(E.) (i) Split phase induction motor
(ii) Capacitor Start Induction Motor
(iii) Permanent Capacitor Induction Motor
(iv) Capacitor start and Capacitor Run induction Motor
(v.) shaded Pole induction motor

Split phase induction motor
This is one of the most widely used types of single Phase induction motors. The essential parts of the split phase motor include main winding, auxillary windin and a

Centrifugal switch.



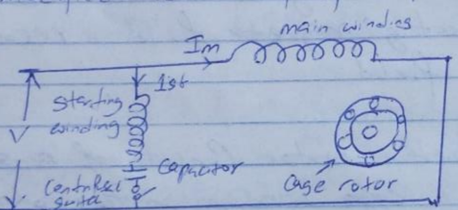


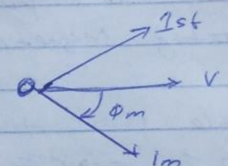
Circuit diagram of split phase motor

Phasor Diagram

Capacitor Start Induction Motor

This motor is similar to the split phase motor, but in addition a Capacitor is connected in series to auxillary winding. This is a modified version of split phase motor.





Circuit diagram of Capacitor start motor

phasor diagram

[F] The resultant of the two fields of equal magnitude rotating in opposite directions is alternating. Therefore an alternating Current can be Considered as having two Components which are of equal in magnitude and rotating in opposite directions.

2(a) A universal motor is a type of electric motor that can operate on either AC or DC power and uses an electromagnet as its stator to create its magnetic field.

Applications

(1) Power drills

(2) Washing Machines

(3) Blowers

(4.) Refrigetor
(6.) Kitchen Appliances

[2(b)] Construction of a Universal motor is Very similar to the Construction of a DC machine. It Consists of stator on which field poles are mounted. Field Coils are wound on the field poles, However, the whole magnetic path is laminated.

[2(c)] A Universal motor works on either DC or single phase AC supply. When the universal motor is fed with a DC supply, it works as a DC series motor. Hence as polarity of AC changes periodically the direction of Current in armature and field reverses at the same time

[3(a)] When the motor is excited with a three-phase supply, three-phase stator winding produces a rotating magnetic field with 120 displacements at a Constant magnitude which rotates at synchronous speed. This Changing magnetic field Cuts the rotor Conductors and induces a Current in them according to the principle of faraday's laws of electromagnetic induction.

Advantages of 3-phase Induction motor

(i) Induction motors are simple and rugged in Construction.
(ii) They are cheaper in cost due to the absence of brushes, Commutators and slip rings
(iii) They Can be operated in polutted and explosive environments as they do not have brushes which Can Cause sparks

Disadvantages of 3-phase Induction motor

(i) They have poor starting torque and high have in rush Currents.
(ii) The speed Control of induction motors are difficult
(iii) They operate under lagging power factor and during light load Conditions they operate at Very worst power factor (0.2 to 0.4 lagging).

[3(c)]

$K = 1$

$Z_s = 0.06 + j0.2 + 0.06 + j0.22$

$Z_s = 0.12 + 0.42j$

$I_2' = \frac{V_1}{Z_s} = \frac{400}{0.12+0.42j} = 251.6 - 880.5j$

$= 915.74 \angle -74.1$

$P = I_2^2 Z_s$

$P = 915.74^2 \times (0.12+0.42j)$

$P = 100629.6 + 352220.3.5j$

$= 366297.16 \angle 74.05$

$P_{mech} = 3 \times [I_2']^2 \times \frac{R_2}{K^2}\left[\frac{1-s}{s}\right]$

$= 366297.16 = 3 \times (915.74)^2 \times \frac{0.12+0.42j}{1^2}\left[\frac{1-s}{s}\right]$

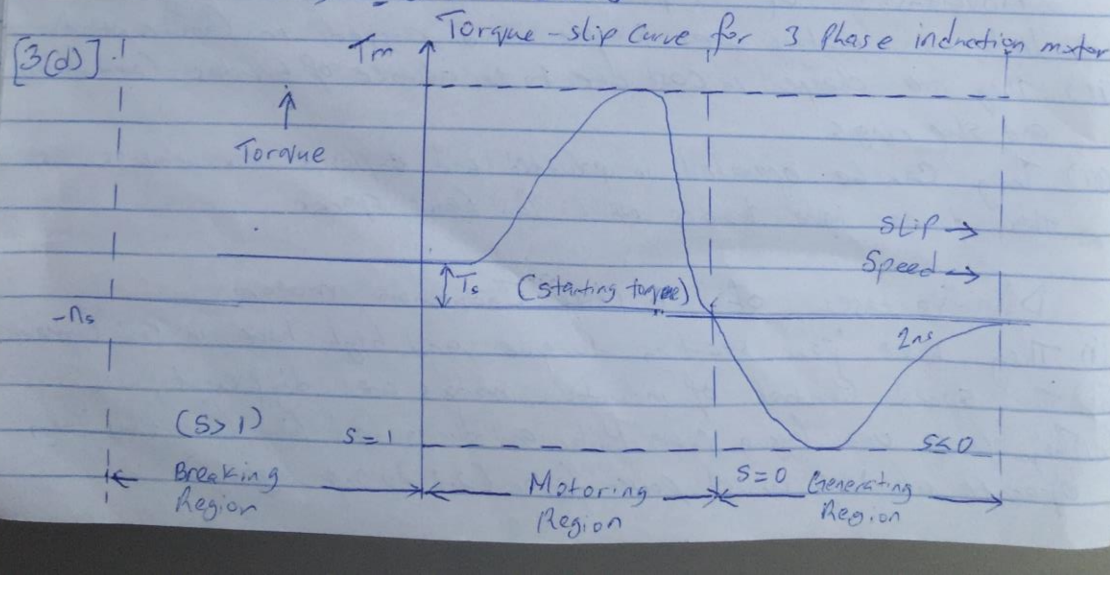
$0.09 - 0.32i = \frac{1-s}{s}$

$1-s = (0.09-0.32i)s$

$1 = 1.09 - 0.32i \cdot s$

$s = 0.84 + 0.25j$

[3(d)]



[3(e)] (i) $N_s = \frac{120f}{P}$

$P = \frac{120f}{N_s} = \frac{120 \times 60}{20}$ ~~x15~~

$\therefore P = 360$ ~~20~~ 360

(ii) $Slip = \frac{N_s - N}{N_s} \times 100 = \frac{20 - 15}{20} \times 100$

$= 25\%$

(iii) $360 = \frac{120f}{15}$

$f = 45Hz$

(iv) $N_s = \frac{120 \times 45}{360}$

$= 15rps$

(v.) $10/100 = \frac{N_s - 15}{N_s}$

~~$\frac{N_s - 15}{N_s}$~~ $= N_s - 15 = 0.1N_s$

~~15~~ $0.9N_s = 15$

$N_s = 16.67$

$16.67 = \frac{120f}{360}$

$f = 50Hz$

[4(a.)] (i) Control from stator side

(ii) Control from Rotor Side.

(iii) Speed Control by frequency Variation

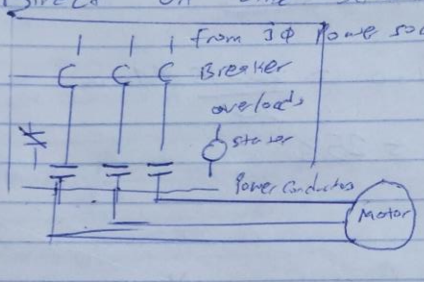
(iv) Speed Control by Varying Supply Voltage

(v) Speed Control by Varying Rotor Resistance

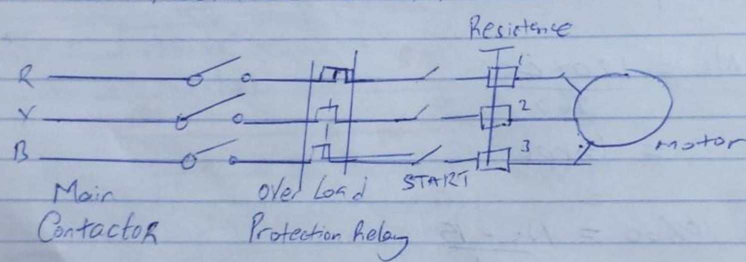
[4(b)] (i) Direct on-Line starting

(ii) Reduced - Voltage starting
(i) Soft Starter
(ii) ~~Hard starter~~ Rotor resistence Sterter

[4(c)](i) Direct on - Line Starter



(ii) Rotor Resistance Starter



[6(a)] Every equipment is tested after it's manufacturing to ensure that the equipment parameters conform to the designed parameter. The same principle is true for electrical equipment as well. The induction motor is tested. The no load test and blocked rotor test is performed on the induction motor to calculate the fixed and variable losses in an induction motor.

[6(B)] Similarities
(i) The induction motors are widely used in industries and consume maximum power
(ii) To improve its performance characteristic certain tests have been designed like no-load test and block Rotor test

Differences
(i) The test is conducted on the high - Voltage (HV) side

of the transformer where the low voltage (LV) side or the Secondary is short circuited.
(ii) A wattmeter is connected to the primary winding.

[6(c)] (i) ~~The efficiency of small moto~~

Similarity

(i) The efficiency of small motors can be determined by directly loading them and by measuring the input and output powers
(ii) It is difficult to arrange that much load for them

Differences

(i) The motor is not connected from it's load
(ii) The rated voltage at the rated frequency is applied to the stator to run the motor without a load.

[6(d)] (i) Earth Continuity and Resistance test.
(ii) Power supply test.
(iii) AC motor winding continuity test.
(iv) AC motor winding Resistance test.

Earth Continuity and Resistance Test

With a multimeter, measure the resistance between motor frame (body) and earth. A good motor should read less than 0.5 ohms.

(i) $\cos\phi = \frac{P}{VI}$

$V = IR$

$I = \frac{V}{R}$

$= \frac{645}{3.0 \times 400} = 0.5375$

$\phi = 57.5$

(i) $= I_c = I_o \cos\phi = 3 \times 0.5375$

$= 1.6125\,A \simeq 1.6\,A$

(ii) $I_m = I_o \sin\phi = 3 \times \sin 57.5$

$= 2.5A$ //

(iii) Power factor $= \cos\phi$

$= \cos 57.5$

$= 0.537$

$I_0 = \sqrt{I_m^2 + I_c^2}$

$= \sqrt{2.5^2 + 1.6^2}$

$I_0 = 2.97A$

(iv) $\therefore R_0 = \frac{P}{I_0^2} = \frac{645}{2.97^2} = 73.12\,\Omega$

(v) $X_0 = \sqrt{Z_0^2 - R_0^2}$

$Z_0 = \frac{V_1}{I_0} = \frac{400}{2.97} = 134.68$

$X_0 = \sqrt{134.68^2 - 73.12^2}$

$X_0 = 113.1\,\Omega$

(vi) $K = \frac{400}{200} = 2$

$R_2' = \frac{73.12}{2^2} = 18.28\,\Omega$

(vii) $X_2' = \frac{113.1}{2^2} = 28.26\,\Omega$

(viii) $\cos\phi = \frac{P}{V_1} = \frac{1660}{120 \times 200}$

$\cos\phi = 0.69$

(ix) $P = I^2 R$

$I = \sqrt{\frac{183}{5}} = 6.05A$ //

Connected in parallel and the method used is Called paralleling.

1 Adventeges

(i) Continuity of supply and Maintenance

(ii) Efficiency

(iii) Expansion plans

(iv) Maximize power system Reliability.