Chapter I

Introduction

1.1 **Introduction** The single-phase induction motor displays less satisfactory operating characterestic than the poly phase machine, but it has achieved, nevertheless, a wide field of usefulness on application where a polyphase supply is not available. Advances in design have made the single-phase motor quite satisfactory in its smaller sizes so that millions of them are in use in the commercial and domestic field. The chief disadvantages of the single-phase induction motor, in its simplest form, are its lack of starting torque and its reduced power factor and efficiency. Scores of devices have been developed for starting single-phase induction motors. Many of these are commercially undesirable and are not used at present.

When a single-phase stator winding is connected to a source of alternating voltage, the resultant field alternates along one space axis only. Such an alternating uniaxial quantity can be represented by two oppositely rotating vectors of half magnitude. That is, a uniaxial flux with sinusoidal variation, expressed as $\phi = \phi_m \cos 2\pi ft$, is equivalent to two fluxes rotating in opposite directions, each with magnetude of $1/2\phi_m$ and an angular velocity of $2\pi f$.

When the rotor turns, the torque produced by the forward flux is greater than that of the backward flux even if the fluxes are equal.

1.2 Common starting arrangements. Because the single-phase induction motor, with only one stator winding, has no inherent starting torque, various methods have been developed for starting.

1. Shaded Pole This represents the smallest and simplest type of induction motor. It has salient poles on the stator which are excited by concentrated windings. Around one portion of each pole is wrapped by a copper strap, forming a closed circuit. This " shading coil" acts to delay the flux passing through it in time, so that the flux lags in phase that in the unshaded part. The combined action gives a sweeping action, magnetically, across the face of the pole, resulting more or less of a revolving flux. This supplies the starting torque.

2. Split Phase. From the standpoint of starting torque and commercial sizes, the split-phase motor stands second in order of motor sizes. The stator winding has two paralled circuits in which one branch has a relatively high reactance and low resistance. This represents the main or running winding of the motor. A second stator winding, displaced in space by 90 electrical degrees, has a higher resistance and a lower reactance. This represents the starting winding of the motor. Such motors are designed so that the current in starting winding and in main winding are approximately 30°

out of phase in time. It can be seen that the single-phase supply results in currents and fluxes displaced in space and time, and so yield a motor torque. The arrangement forms an imperfect two-phase motor, which, because of the difference in current magnitudes and the unlike circuit constants of the two stator windings, produces a rotating field that is not uniform in either time or space, but is sufficient for starting the motor.

Continued operation on both windings results in rapid overheating, inefficient and noisy performance. The usual design calls for a centrifugal swich on the rotor, which automatically disconnects the starting winding at about 70 percent of synchronous speed. Starting torque in ounce-feet per ampere is considerably higher than in the shaded-pole motor. Value as high as 0.8 to 0.9 are not uncommon. Commercial moter sizes are most rated from about $1/_{30}$ to $1/_3$ hp.

3. Capacitor Motors. The motor is very similar to the ordinary split-phase type, having a squirrel-cage rotor winding and two stator windings displaced 90 electrical degrees in space. One stator winding, the main winding, is fixed by the running performance required. The second, auxiliary winding, with a capacitor in series, is designed to produce a displacement in time between the current of the two windings. The condenser enables the auxiliary winding current to lead the main winding current by a much more favorable angle than could be obtained by

the use of the resistance and leakage reactance of the winding alone. This auxiliary winding is obtained opened by a centrifugal ? switch at about 70 percent of the final speed. The total starting current is the vector sum of both current in starting winding and main winding, for the same respective values, the vector sum of the currents of the capacitor motor will be less than for the ordinary split-phase machine. Also, in the starting torque formula, the torque has a function of sin of the angle between the current in starting winding and main winding. This angle may approach unity with the capacitor motor, thereby resulting in large value of starting torque, with lower starting current. As can be expected, the ounce-ft per ampere of starting current are relatively high about 3 to 3.5 on 110 volt basis. Such values are much better than can be obtained from split-phase motors. Usual ratings are $1/8$ to 1 horsepower although many manufacturers build this type of motor to 10 horsepower outputs.

Since 1930 there has been rapid development and widespread use of condenser start motor. The method was first proposed by Steinmetz. Although the principle on which the motor operates was understood approximately in 1910, the motor had to wait the development of a cheap, sturdy condenser of reduced bulk, which was required as an auxiliary device, before it could be made commercially feasible. The chief advantages of this type of motor lie in its unusually high starting torque (without excessive starting current), the versatility of its application, and its machanical simplicity.

4. Repulsion - start, induction - run motor. This type of motor has long been the most popular single-phase induction motor in terms of its starting torques. It has been manufactured in large quantities, but is gradually being replaced by the capacitor-start motor. Theoretically, the starting torque per ampere is higher on this type than on any other, being 5 to 7 ounce-feet per ampere at 110 volt. The armature of the repulsionstart motor is similar to that of the d - c machine, except that brushes are short-circuited. The brushes are shifted through a considerable angle from the position normally occupied on d - c armature. A centrifugal mechanism causes the commutator bars to be short-circuited at about two - thirds of final speed, after which the armature acts like an ordinary squirrel-cage rotor.

1.3 Purpose of this thesis. The purpose of this thesis is to study the variation of the starting torque of the capacitor/start motor as the value of the starting capacitance is varied. Practically the values of the starting capacitances for commercial motors are obtained from experimental determinations. The starting capacitance was installed for a starting torque which varied upon type of work it is designed for. The starting-capacitance obtained from calculation of the physical parameters and experimental parameters always differ from the actual measured starting torque. The various source of difference is trying to be pointed out in this thesis.