### SOFT STARTING OF AN INDUCTION MOTOR

# Project Report Submitted by Ioannou Yiannakis

3E1

of

In part satisfaction of the award of Diploma of Technician Engineer

in

Electrical Engineering of the Higher Technical Institute Nicosia, Cyprus

Project Supervisor: E. Michael Lecturer in Electrical Engineering H.T.I.

## AUGUST 1990

調査自由書	E PRESERVE AD
TECHNECAL.	IMILA
INSTITUTE	1742

#### SUMMARY

Advanced Motor Control Engineering introduces modern, new technology for controlling which employs methods and techniques having nothing to do with relays and generally with any mechanical logic devices, any more. Instead, power electronic devices are used. These are controlled by analogue or digital circuits which are either programmable or one function circuits. If programmable, personal computers perform their programming.

The scope of the present project it to introduce, analyze and apply a method for the starting of three phase induction motors utilizing power electronics. The method is known as "SOFT STARTING OF AN INDUCTION MOTOR".

The primary emphasis in this project is given in designing and developing the control circuit used for driving the power circuit. Together with the representation of the various parts of the control circuit, a detailed analysis of those parts is provided.

The soft starting of an induction motor, is an advanced method, which comes to substitute the previous methods where mechanical starters and relays were used. The new method is cheaper, its construction takes less space and it can be made to provide ways of protection of the motor, such as overload, phase failure. Also, the torque of the rotor and hence, of the shaft is increased smoothingly, eliminating sudden movements and large surges of current in the stator windings are avoided.

## CONTENTS

¢

#### PREFACE

ACKNOWLEDGEMENTS

## CONTENTS

INTRODUCTION

1. METHODS	OF CONTROL	1
1–1 V	arious methods of control	1
	pen-loop control systems	1
C	losed-loop control systems	1
C	losed-loop versus open-loop control systems	3
1-2 M	Nethod of control used for the soft starting	
о	of the induction motor	3
2. SPEED C	CONTROL OF ELECTRIC MACHINES	5
2–1 S	peed control of various motors	5
S	peed control of wound-field D.C motors	6
S	peed control of shunt-field D.C motors	10
S	peed control of series-field D.C motors	22
S	peed control of compound-field D.C motors	32
S	peed control of separately-excited D.C	
m	notors	33
R	everse operation of wound-field D.C motors	37
S	speed control of permanent-magnet D.C motors	38
S	peed control of brushless D.C motors	42
S	peed control of stepper motors	44
S	speed control of integral HP A.C synchronous	
m	notors	47
2-2 T	hree-phase induction motor	50
Т	hree-phase induction motor operation	51
S	Speed control of the three-phase induction	
m	notor	54
R	Regulation of the input voltage of the	
t	hree-phase induction motor	57

ii

Soft starting of the three-phase induction motor

61

3. DESIGN OF THE SOFT STARTER OF THE INDUCTION MOTOR	64
3-1 Circuit representation	64
3-2 Power circuit	67
3-3 Control circuit	69
Relaxation oscillator	69
Driving circuit	72
Ramp-rundown generator	74
Inverter	75
Power supply circuit	76
3-4 Printed circuit board	77
3-5 Possible alternations and improvements	77
4. COSTING AND APPLICATIONS	80
4-1 Costing	80
4-2 Applications	81
5. CONCLUSIONS	83
5-1 Advantages-disadvantages	83
5-2 Conclusion	83

APPENDICES

BIBLIOGRAPHY