THEORETICAL AND EXPERIMENTAL INVESTIGATIONS

OF

Thyristor Controlled Converters

A THESIS

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BY

MOHAMED MOHAMED M. NEGM

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EXAMINERS:

Prof. Dr. Awad Ibrahim Saleh

Faculty of Engineering, Assuit University.

Prof. Dr. Elsadek A. Kandil

Faculty of Engineering, Ain Shams University.

Prof. Dr. Abdel-Fattah Kheireldin

Faculty of Engineering , Ain Shams University.

Dr. Abbas-El-Hefnawy

Faculty of Engineering , Ain Shams University.

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SUMMARY

Converter circuits are widely used for speed and current control of dc motors. This is because they are more economical than the previous methods of speed and current control. Also the development of SCR.s has opened new vistas in the field of control of d.c. motors.

The preferable converter circuit is a three-phase bridge converter because it has high reliability, high utilization factor and less harmonic content in load voltage and supply current.

The thesis deals with the most economical methods of speed and current control using three-series loops (Industrial method). The system has been built and realized experimentally.

The thesis contains seven chapters, these are as follows:
The first chapter deals with the introduction, and it gives a short summary about converter circuits. chapter two presents the analysis of the single phase half wave converter with and without the free-wheeling diode, while chapter three gives the analysis of the single phase full wave converter for continuous and discontinuous modes of operation.

The analysis of the three phase bridge converter for the case of continuous mode of operation is given in chapter four.

Chapter five introduces the three series loops-method for speed and current control of a d.c. motor. The experimental results are given in chapter six, and it contains the performance characteristics for the different modes of operation.

Chapter seven contains the conclusion and the recommendation achived during this research work

List of Symbols

$\omega = 2\pi f$	: angular frequency , rad/sec.
f	: supply frequency , HZ.
$x=\omega t$	: electrical angle.
t	: Time , sec.
I_c	: short circuit current.
Z	: Load ac impedance.
α	: firing angle.
α_c	: natural firing angle.
ϕ	: a.c. phase angle.
Id	: average d.c load current.
I_o	:perunit value of Id.
U_i	: back emf of the d.c. motor
σ	: perunit value of U_i.
i, i', i_{1r}, i_{2r}	:instantaneous load currents in per unit.
I	: per unit effective value of load current.
γ	: conduction angle.
I_1	: perunit value of the fundamental load current.
P_i	: perunit power of u_i.
P_R	: per unit power of the resistor R.
P_1	:supply power in perunit.
P_2	: Total load power in perunit.
V_d	: average d.c load voltage.
U	: per unit value of V_d.
u	:over lap angle.
X_a	:load inductive reactance.
X_σ	: inductive leakage reactance
X	: total inductive reactance.
iu	: instantaneous load current during over lap.

i'_u	: per unit value of iu.
G	: gain of the three-phase, bridge curcuit.
T_e	: electrical time constant of the d.c. motor.
K'_i	: current transducer in volt/amp.
ω_c	: cross over fraquency.
Ω	: anglular speed of the d.c. motor.
Tem	: electromechanical time constant.
J	: moment of inertia of the d.c. motor and generator set.

CONTENTS

CHAPTER (1)

INTRODUCTION

The power semiconductor devices such as diodes and thyristors are used in power applications as switching devices. Engineers concerned with the supply and utilization of electricity need to be aware of the effects which power electronics equipment have on both the supply and load. It is hoped that the present thesis will-fulfil this need.

From the historic point of view , the theory of converter circuits can be subdivided in two large sections. Circuits with controlled electronic devices, such as rectifiers and inverters will be considered as if they are continuously switched on and off. At steady state, these on and off operations are periodically repeated. The currents will be continuous or discontinuous depending on the load and on the width of each impulse.

In the classical rectifier theory, the time constants of all the circuits have been arbitrarily assumed to have an infinite value. This assumption can be achieved by neglecting all resistances on the a.c. side and by neglecting all resistances on the a.c. side and by assuming an infinite large inductance on the d.c. side . Accordingly, all oscillograms will appear as sine and cosine functions of time, and the results which are of importance to the engineer will appear in a closed form.

In the second stage, these assumptions will be modified and limited time constants are to be considered, and accordingly exponential functions of time will take place. Transcendental equations will appear and the results of importance to the engineer will no more appear in a

CHAPTER (2)

TRANSIENT AND STEADY STATE ANALYSIS OF THE SINGLE PHASE HALF WAVE RECTIFIER CIRCUIT

For a single phase rectifier circuit all the losses on the a.c. side are neglected.

The behaviour of the single phase circuit depends to a great extent on the load circuit. The firing and extinction angle are related together by a transcendental function and it is impossible to state the extinction angle in a closed form. The present chapter investigates the transient and steady state performances for a single phase thalf wave rectifier circuit without free-wheeling diode and with effect of free wheeling diode.

2.1. CASE OF SINGLE PHASE HALF WAVE RECTIFIER WITHOUT FREE WHEELING DIODE:

The single phase controlled rectifier circuit consists as shown in Fig. (2.1) of a series resistor R, a self-inductance L and of a direct voltage element U_i which can represent the rotational voltage induced in the rotor circuit of a d.c. machine or the voltage of a battery or an electrolytic cell.

The applied voltage is of the form:

$$u_1 = \sqrt{2}\, U_1 \sin \omega t = \sqrt{2}\, U_1 \sin x \qquad (2.1)$$

Neglecting the thyristor voltage drop and assuming linear circuit elements in Fig. (2.2), the following differential equation can be written:

$$\sqrt{2}\, U_1 \sin x = R\, i_1 + L \frac{di_1}{dt} \qquad (2.2)$$

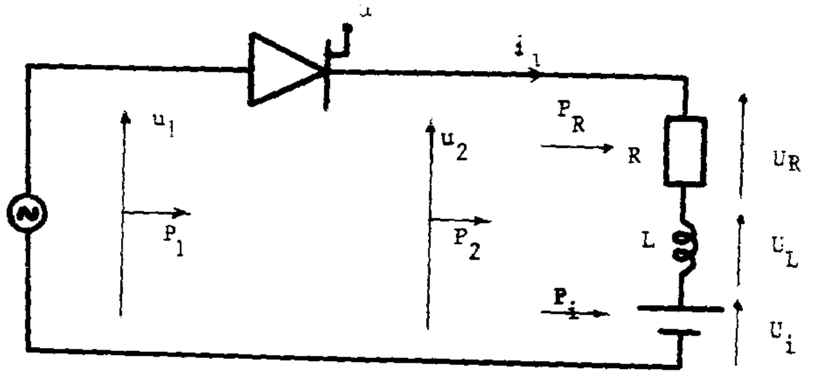

Fig.2.1. Single phase half wave circuit.

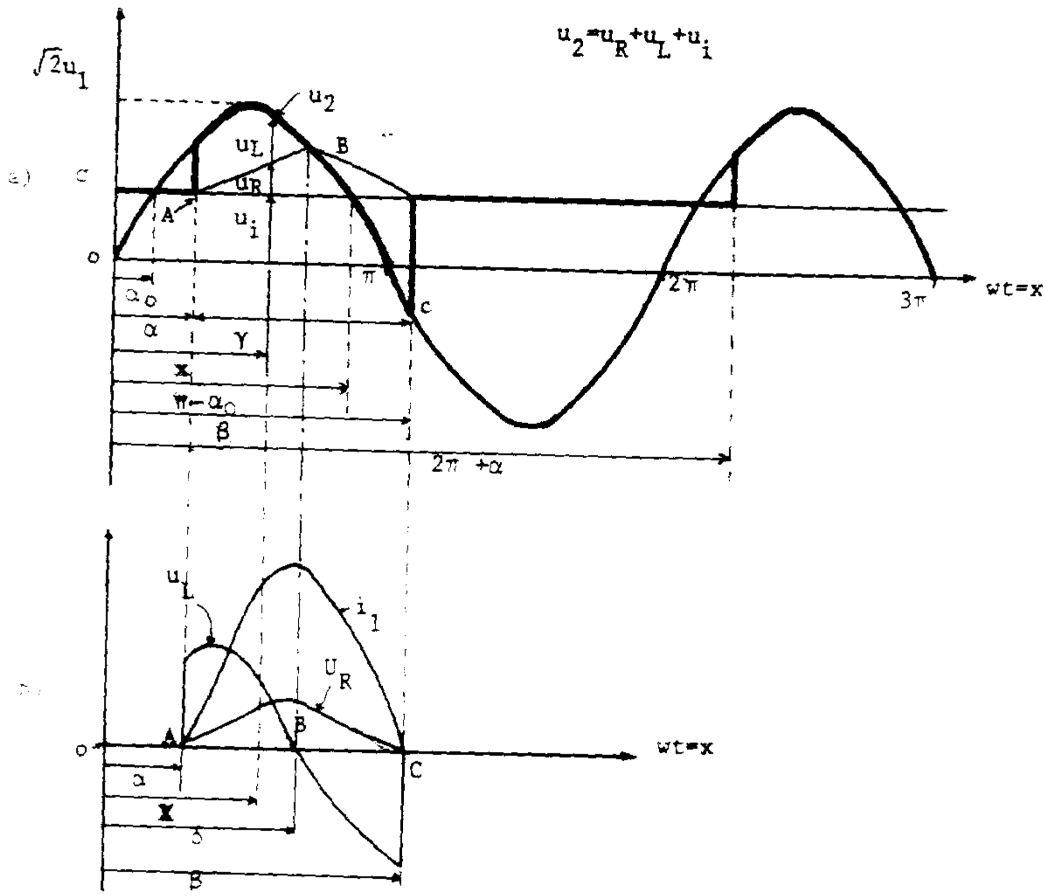

Fig.2.2. Oscillograms for the rectifier operation.

(a) Output voltage, (b) instantaneous values for load current, inductance and resistance voltages.