

SELF-EXCITATION AND SELF-EXCITED OSCILLATIONS OF SYNCHRONOUS
MACHINES CONNECTED TO EXTRA HIGH VOLTAGE
TRANSMISSION LINE SYSTEMS

by

Suresh D. Hurry

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-ii-

To my wife

INDIRA HURRY

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Suresh Hurry

ABSTRACT

This thesis investigates the problems of self-excitation and self-excited oscillations of both conventional as well as dual-excited synchronous machines connected to series-compensated long distance EHV transmission lines. Besides, as many systems in the world are uncompensated, the problem of self-excited oscillations which are likely to occur in such systems is also examined.

Previous studies^{8-9,14-16} have indicated that self-excitation (electromagnetic instability) manifests itself in the form of undesirable electrical oscillations and can occur when synchronous machines are connected to series capacitor compensated transmission systems. Moreover, in modern systems, with the bundling of conductors, giving low series resistance, and with high series compensation to obtain a higher transmission capability, the probability of occurrence of self-excitation is increased and it becomes all the more important to investigate this problem. Analysis for self-excitation for a typical unregulated system having either conventional or dual-excited synchronous machines is carried out, in the present work, through the Routh-Hurwitz and a simpler technique, whereas self-excitation for the regulated case using different excitation control schemes is examined through the effective application of the Parameter plane technique. A comparative performance of the different excitation control schemes used for suppressing self-excitation is provided. Besides, the effect of certain system and control parameters on self-excitation is brought out. Finally, comparative performances of equivalent conventional and dual-excited synchronous machines (both hydro

and turbo) with respect to self-excitation is highlighted.

It has been indicated¹⁰⁻¹¹ that synchronous machines connected to a power system through transmission lines with a high ratio of system resistance to reactance may, under certain conditions, lose stability due to sustained low frequency self-excited oscillations (electromechanical instability) or hunting. This situation is aggravated in the presence of compensating series capacitors in the external circuit of these machines. It has been observed¹² that a synchronous machine feeding a capacitive load or supplying power to an infinite bus through a series-compensated transmission line may also experience instability due to high frequency self-excited oscillations. These oscillations are unlikely, unless the total system resistance drops below a certain value for a given capacitor compensation. Such a condition may arise in the case of transmission lines using bundled conductors.

The problem of self-excited oscillations in this thesis is examined in both uncompensated and compensated systems having either conventional or dual-excited synchronous machines. For the unregulated system, investigations are carried out through the Routh-Hurwitz technique, whereas for the regulated case using different excitation control schemes, effective application of the Parameter plane technique is demonstrated for the study of self-excited oscillations. A comparison of the different excitation control schemes used is provided and the effect of certain system and control parameters on self-excited oscillations is also discussed. Finally, a comparative performance of equivalent

conventional and dual-excited synchronous machines with respect to self-excited oscillations is brought out.

Another important contribution of the present work explores the feasibility of neglecting the transformer terms in the system dynamics with a view to simplifying the mathematical model for the study of either self-excitation or self-excited oscillations of conventional as well as dual-excited synchronous machines without practically affecting the accuracy of the results.

TABLE OF CONTENTS

	Acknowledgements	...	(iii)
	Abstract	...	(iv)
	List of Figures	...	(xiv)
	List of Principal Symbols	...	(xvi)
<u>CHAPTER 1</u>	INTRODUCTION		
1.1	Stability of Power Systems	...	1
1.2	Self-Excitation and Self-Excited Oscillations of Synchronous Machines.	...	2
1.3	State of the Art of the Problem	...	4
1.4	Scope of the Thesis	...	9
<u>CHAPTER 2</u>	SELF-EXCITATION OF CONVENTIONAL SYNCHRONOUS MACHINES		
2.1	Introduction	...	14
2.2	System Investigated	...	17
2.3	Mathematical Model	...	17
	2.3.1 Synchronous Generator	...	19
	2.3.2 Transmission System	...	21
	2.3.3 Excitation Control System	...	23
2.4	Analysis of Self-Excitation in an Unregulated System.	...	27
	2.4.1 Application of the Routh-Hurwitz Technique	...	28
	2.4.2 Application of the Simpler Technique	...	30
	2.4.3 Effect of T_{do}	...	34
	2.4.4 Effect of α	...	35

2.5.	Analysis of Self-Excitation in a Regulated System	...	35
2.5.1	Application of the Parameter Plane Technique	...	37
2.5.2	Self-Excitation in the Presence of a Voltage Regulator	...	39
2.5.2.1	Effect of T_r and X_d	...	43
2.5.2.2	Effect of T_{do}	...	43
2.5.3	Self-Excitation in the Presence of a Current Regulator	...	45
2.5.4	Self-Excitation in the Presence of an Angle Regulator	...	46
2.5.5	Self-Excitation in the Presence of a Mixed-type Regulator	...	48
2.6	Conclusions.	...	50
<u>CHAPTER 3</u>	<u>SELF-EXCITATION OF DUAL-EXCITED SYNCHRONOUS MACHINES</u>		
3.1	Introduction	...	53
3.2	System Investigated	...	55
3.3	Mathematical Model	...	57
3.3.1	Synchronous Generator	...	57
3.3.2	Transmission System	...	58
3.3.3	Excitation Control System	...	59
3.4	Analysis of Self-Excitation in an Unregulated System	...	61
3.4.1	Application of the Simpler Technique	...	65
3.4.2	Effect of T_{ro} and T_{to}	...	66
3.4.3	Effect of α	...	68
3.4.4	Comparison of instability zones of Dual-Excited and Equivalent Conventional Machines.	...	68

3.5	Analysis of Self-Excitation in a Regulated System	...	69
3.5.1	Self-Excitation in the Presence of a Rotor-Angle Regulator only	...	71
3.5.2	Self-Excitation in the Presence of a Voltage Regulator only	...	73
3.5.3	Self-Excitation in the Presence of Simultaneous control of both Reactive and Torque field Windings	...	76
3.5.3.1	Effect of K_{OV}	...	78
3.5.3.2	Effect of X_c	...	78
3.5.3.3	Effect of K_{1V} and $K_{1\delta}$	...	79
3.5.3.4	Effect of K_{2V} and $K_{2\delta}$	...	79
3.5.3.5	Effect of T_{er} , T_{ro} and T_{to}	...	79
3.5.3.6	Comparison of Performances of dual-excited and equivalent conventional machines	...	79
3.6	Conclusions.	...	82
<u>CHAPTER 4</u>	<u>SELF-EXCITED OSCILLATIONS OF CONVENTIONAL SYNCHRONOUS MACHINES</u>		
4.1	Introduction	...	84
4.2	System Investigated	...	87
4.3	Mathematical Model	...	87
4.3.1	Compensated System	...	87
4.3.2	Uncompensated System	...	89
4.3.3	Excitation Control System	...	91
4.4	Analysis of Self-Excited Oscillations in an Uncompensated Unregulated System	...	91
4.4.1	Effect of E_q/V	...	95
4.4.2	Effect of R_T	...	95
4.4.3	Effect of T_{do} and H	...	95

4.5	Analysis of Self-Excited Oscillations in an Uncompensated Regulated System	...	97
4.5.1	Self-Excited Oscillations in the Presence of a Current Regulator	...	98
4.5.1.1	Effect of δ	...	101
4.5.1.2	Effect of T_{do} and H	...	103
4.5.1.3	Effect of E_q/V and R_Σ	...	103
4.5.2	Self-Excited Oscillations in the presence of an Angle Regulator	...	103
4.5.2.1	Effect of δ	...	107
4.5.3	Self-Excited Oscillations in the presence of a Voltage Regulator	...	107
4.5.4	Comparative Performances of Excitation Control Schemes	...	112
4.6	Analysis of Self-Excited Oscillations in a Compensated Unregulated System	...	112
4.6.1	Effect of E_q/V	...	114
4.6.2	Effect of T_{do} and H	...	114
4.6.3	Effect of δ	...	116
4.7	Analysis of Self-Excited Oscillations in a Compensated Regulated System	...	116
4.7.1	Self-Excited Oscillations in the presence of a Current Regulator	...	117
4.7.1.1	Effect of δ	...	120
4.7.1.2	Effect of T_{do} and H	...	120
4.7.1.3	Effect of E_q/V and R_Σ	...	122
4.7.2	Self-Excited Oscillations in the presence of an Angle Regulator	...	122
4.7.2.1	Effect of δ	...	125
4.7.3	Self-Excited Oscillations in the presence of a Voltage Regulator	...	125

	4.7.4 Comparative Performances of Excitation Control Schemes.	... 127
4.8	Comparison of Performances of Uncompensated Unregulated and Compensated Unregulated systems.	... 127
4.9	Comparison of Performances of Uncompensated Regulated and Compensated Regulated systems	... 127
4.10	Conclusions	... 130
<u>CHAPTER 5</u>	<u>SELF-EXCITED OSCILLATIONS OF DUAL-EXCITED SYNCHRONOUS MACHINES</u>	
5.1	Introduction	... 133
5.2	System Investigated	... 135
5.3	Mathematical Model	... 135
	5.3.1 Excitation Control System	... 137
5.4	Analysis of Self-Excited Oscillations in an Unregulated System	... 139
	5.4.1 Effect of ϕ_L	... 140
	5.4.2 Effect of E/V , H , T_{ro} and T_{to}	... 140
	5.4.3 Comparison of Performances of Equivalent conventional and Dual-Excited Machines	... 142
5.5	Analysis of Self-Excited Oscillations in a Regulated System	... 142
	5.5.1 Self-Excited Oscillations in the presence of a Rotor-Angle Regulator only	... 143
	5.5.2 Self-Excited Oscillations in the presence of a Current Regulator only	... 146
	5.5.3 Self-Excited Oscillations in the presence of a Voltage Regulator only	... 149
	5.5.4 Discussions	... 152
	5.5.5 Self-Excited Oscillations in the presence of Simultaneous control of both reactive and torque field windings	... 153

	5.5.5.1	Effect of K_{OI} and T_{er}	... 154
	5.5.5.2	Effect of $K_{1I}, K_{2I}, K_{1\delta}$ and $K_{2\delta}$	... 156
	5.5.5.3	Effect of T_{ro}, T_{to} and H	... 156
	5.5.5.4	Effect of E/V and R_{Σ}	... 156
	5.5.6	Comparative Performances of Excitation Control Schemes	... 156
	5.5.7	Comparison of Performances of Conventional and Dual-Excited Machines	... 158
5.6		Conclusions	... 158
<u>CHAPTER 6</u>		EFFECT OF THE TRANSFORMER TERMS ON SELF-EXCITATION AND SELF-EXCITED OSCILLATIONS	.
6.1		Introduction	... 161
6.2		System Investigated	... 162
6.3		Effect of the $p\psi$ terms on Self-Excitation	... 162
	6.3.1	Unregulated system with a Conventional Synchronous Machine	... 162
	6.3.2	Regulated System with a Conventional Synchronous Machine	... 164
	6.3.3	Unregulated System with a Dual-Excited Synchronous Machine	... 169
	6.3.4	Regulated System with a Dual-Excited Synchronous Machine	... 172
6.4		Effect of the $p\psi$ terms on Self-Excited Oscillations	... 176
	6.4.1	Uncompensated Unregulated System with a Conventional Synchronous Machine	... 176
	6.4.2	Uncompensated Regulated System with a Conventional Synchronous Machine	... 177
	6.4.3	Compensated Unregulated System with a Conventional Synchronous Machine	... 180
	6.4.4	Compensated Regulated System with a Conventional Synchronous Machine	... 183

6.4.5	Unregulated System with a Dual-Excited Synchronous Machine	...	186
6.4.6	Regulated System with a Dual-Excited Synchronous Machine	...	187
6.5	Ready Reference to the effect of the $p\psi$ terms	...	190
6.6	Conclusions	...	192
<u>CHAPTER 7</u>	<u>CONCLUSIONS</u>		
7.1	Introduction	...	193
7.2	Review of the Work done	...	193
7.2.1	Self-Excitation of Conventional and Dual-Excited Synchronous Machines	...	194
7.2.2	Self-Excited Oscillations of Conventional Synchronous Machines connected to Uncompensated Transmission Systems	...	197
7.2.3	Self-Excited Oscillations of Conventional and Dual-Excited Synchronous Machines connected to Series-Compensated Transmission Systems	...	198
7.3	Future lines of Research	...	201
REFERENCES	...	...	R.1
Appendix-A	...	...	A.1
Appendix-B	...	...	A.4
Appendix-C	...	...	A.10
Appendix-D	...	...	A.19
Appendix-E	...	...	A.30
Curriculum Vitae	...	...	A.44