

Student Research Paper  
Critical clearing time of synchronous generators

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# Author's declaration

I certify that I have prepared this thesis without outside help and without using sources other than those specified, and that the thesis has not been submitted in the same or a similar form to any other examination authority and has not been accepted by them as part of an examination. All statements that have been copied verbatim or in spirit are marked as such.

Erlangen, December 13, 2023

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## **Note:**

For reasons of readability, the generic masculine is used in this seminar paper. Female and other gender identities are explicitly included where this is necessary for the statement.

# Assignment of the paper

**Topic:** Critical clearing time of synchronous generators

The critical clearing time (CCT) is an essential parameter in power system stability analysis. For example, in the case of synchronous generator (SG), the CCT determines the maximum fault-clearing time a generator can withstand without losing synchronism. This seminar will introduce the concept of CCT computing. We will discuss the factors influencing CCT, such as generator characteristics, system parameters, and fault type, and explore the methods used to calculate CCT in practical power system analysis.

The seminar research paper should contain:

- A literature research of governing equations describing the short-term dynamic behavior of SG, relevant fault types and their influence;
- an investigation of the influences from machine characteristics and system parameters on the CCT;
- a computed simulation model for numerical determination of the CCT with the equal area criterion (EAC);
- simulations of system faults and comparisons to analytical solutions.

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# 1 Introduction

Dieses Kapitel dient zur Hinführung an das Thema. Hier ist herauszuarbeiten, warum das Thema von Interesse und Bedeutung ist. Des Weiteren ist kurz der Aufbau der Arbeit anzusprechen. Der Umfang des Kapitels sollte eine oder wenige Seiten betragen.

## 2 State of the art

General sources in terms of standard literature: [1]–[4]

Relevant basics:

- dynamic behavior synchronous generators
- determination of CCT (equal area criteria)
- relevant faults, their modeling and effects
- analytic ways to calculate the CCT
- numerical methods for solving differential equations

## 3 Methods

## 4 Model simulation results



## **5 Discussion and evaluation**

## 6 Summary and outlook

In der Zusammenfassung werden die Ergebnisse der Arbeit kurz zusammengefasst. Der Umfang beträgt ca. eine Seite.

# Acronyms

<b>CCT</b>	critical clearing time
<b>EAC</b>	equal area criterion
<b>SG</b>	synchronous generator

# Bibliography

- [1] D. Oeding and B. R. Oswald, *Elektrische Kraftwerke und Netze*, 8. Auflage. Berlin [Heidelberg]: Springer Vieweg, 2016, 1107 pp., ISBN: 978-3-662-52702-3. DOI: 10.1007/978-3-662-52703-0.
- [2] J. D. Glover, T. J. Overbye, and M. S. Sarma, “Power system analysis & design,” Boston, MA, 2017.
- [3] P. S. Kundur and O. P. Malik, *Power System Stability and Control*, Second edition. New York Chicago San Francisco Athens London Madrid Mexico City Milan New Delhi Singapore Sydney Toronto: McGraw Hill, 2022, 948 pp., ISBN: 978-1-260-47354-4.
- [4] J. Machowski, Z. Lubosny, J. W. Bialek, and J. R. Bumby, *Power System Dynamics: Stability and Control*, Third edition. Hoboken, NJ, USA: John Wiley, 2020, 1 p., ISBN: 978-1-119-52636-0 978-1-119-52638-4.

# Appendix

A Anhang A

B

# A Anhang A