E.ON Energy Research Center
ACS | Institute for Automation of Complex Power Systems

# Bachelor-/ Master-Thesis / Diplomarbeit

## State Space Control of Constant Power Loads

**Context:**
Power electronic converters are being introduced at an increasingly rapid rate. They are now used in a broad variety of applications in land, sea, undersea, air, and space vehicles, as they allow improvements in performance, efficiency and flexibility of power and energy systems. Therefore the schematics of a possible dc distribution system may look like in Figure 1.

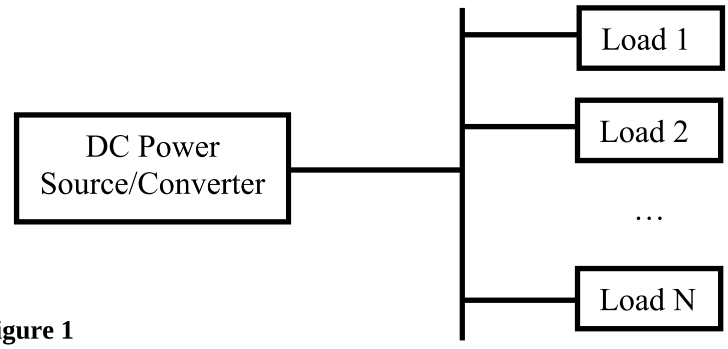



**Figure 1**

DC grid architecture relies on power electronic converters, which efficiently transform voltage levels for the interconnection of buses and loads. You can classify these converters in Line regulating converters (LRC) which convert a source voltage to a specified bus voltage and maintain said voltage in the presence of line pertubations and point-of-load (POL) converters. With the integration of LRC and POL converters in a cascaded form shown in Figure 2 a negative impedence characteristic arises.

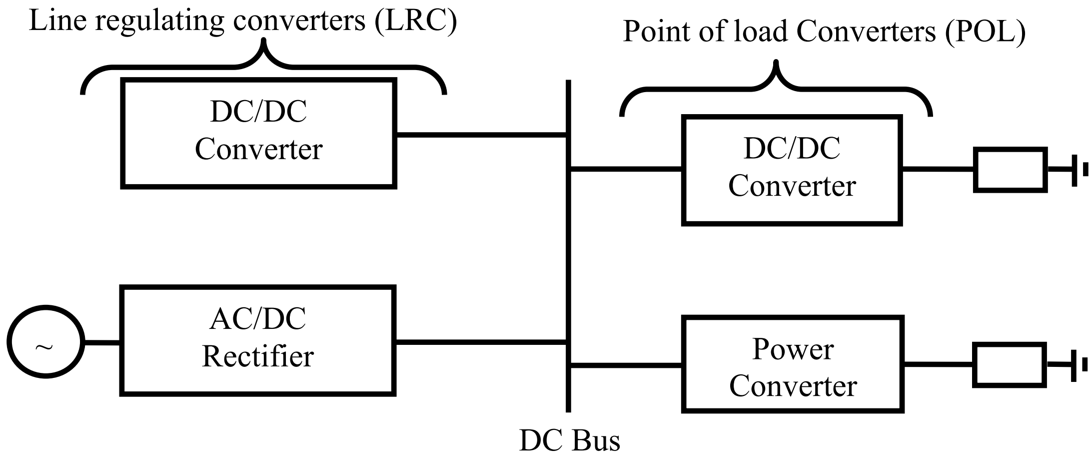
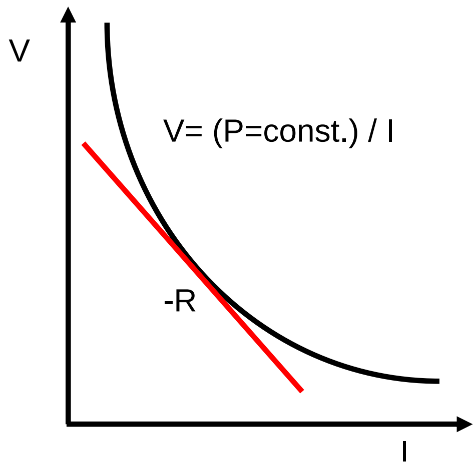
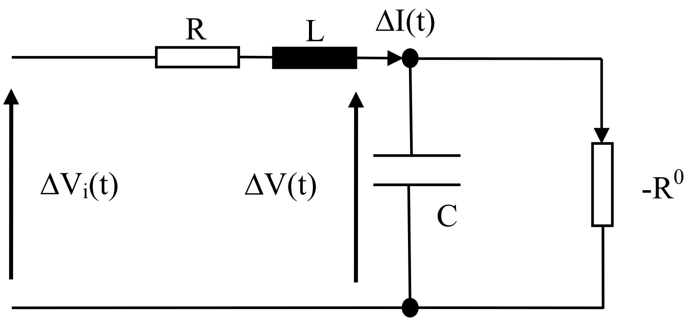



**Figure 2**

Power electronic converters are usually loaded with passive loads or combinations of passive elements and voltage and current sources. However, there are emerging system configurations where converters are loaded with other power converters. In this case a better load model is a constant power load. This converter operation appears in multi-converter applications such as future naval ships where a main converter is loaded with a set of converters operating in closed-loop, with tight output voltage regulation. This set of converters present at the input terminals a dynamic behavior similar to a constant power load (CPL) for a range of input voltages and a frequency that spans from DC up to the bandwidth of the converters.




**negative Resistance**




**Small signal equivalent circuit of the DC-link**

In general loads can be classified in two categories. One consisting of conventional loads, which have a positive incremental impedance characteristic. The other one consisting of tightly regulated loads, which appear as Constant Power Loads (CPL). These loads draw constant power from their feeding buses and hence showing a negative incremental impedance characteristic (-R), around their operating point (Small Signal Analysis). This characteristic may have a destabilizing effect on the system.

**Possible tasks for a Bachelor/Master Thesis or Studien-/Diplomarbeit could include**:

- Critical State of the Art Literature Review of damping/stabilizing control techniques for Constant Power Loads (Bachelor Thesis)
- Adaption of State of the Art proposed Control techniques for Constant Power Loads towards on a test case and their critical comparison (Bachelor/Master Thesis)
- Small Signal Extension from the single terminal/bus (one generator/one load) model to a multi- terminal/bus (multiple generators/multiple loads) (Bachelor/Master Thesis)
- State Space Model with application of a selected damping/stabilizing control technique (Master Thesis)

The topics may be adapted to the specific interests of the student, in agreement with the supervisor

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Selected References

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