Use of artificial intelligence
for optimal operation of a stand alone power plant

Student: **Øyvind August Rui**
Supervisor: **Prof. Tore Undeland**
Contact: **Amin Hajizadeh**

Problem description

To operate a stand alone power plant several things must be taken into account. On an energy management level the power produced by the renewable energy sources should be predicted to have an optimal state of charge of the battery as well as an optimal on/off strategy for the diesel engine at all time. On a level below the converters must be controlled to execute the energy flow given by the energy management algorithms and to maintain the stability in the grid at all time.

The task

Artificial intelligence is a collective term including several computing methods that can be used for modelling, estimation, prediction and control. They are based on how nature behaves, especially how the human brain reasons and take decisions. These techniques are often suitable for non-linear processes and they are quite rapid. A disadvantage is that they often have no design procedure. The parameters must be tuned based on experience and heavily depends on the rest of the system. Artificial intelligence has a variety of applications within electrical engineering. In this report the possibilities for using it for energy management and control have been investigated.

Model/ measurements

The theory behind the artificial intelligence techniques fuzzy logic, neural networks and genetic algorithms are briefly presented. The use of these techniques for energy management and control of converters are presented based on a literature study of what has been done up until now.

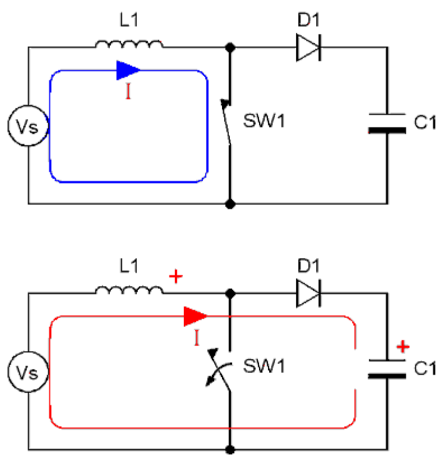

Figure 1: Boost converter

In the second part of the project simulations on a DCDC Boost converter are performed. This part will be further presented here. A boost converter (Figure 1) is a highly non-linear system and is difficult to control. In the simulations a fuzzy controller is compared with a classical PI controller. The goal is to keep the output voltage constant when the input voltage is changing. This perturbation has applications for PV panels, fuel cells and super-capacitors. A resistor on the output side models an inverter operating at constant power.

There are several topologies for fuzzy controllers. The most suitable topology for the boost converter was found by simulations and is shown in Figure 2. It is a fuzzy controller with an integrator in parallel. This controller was found in the literature; however an anti wind-up was added. This gave better response.

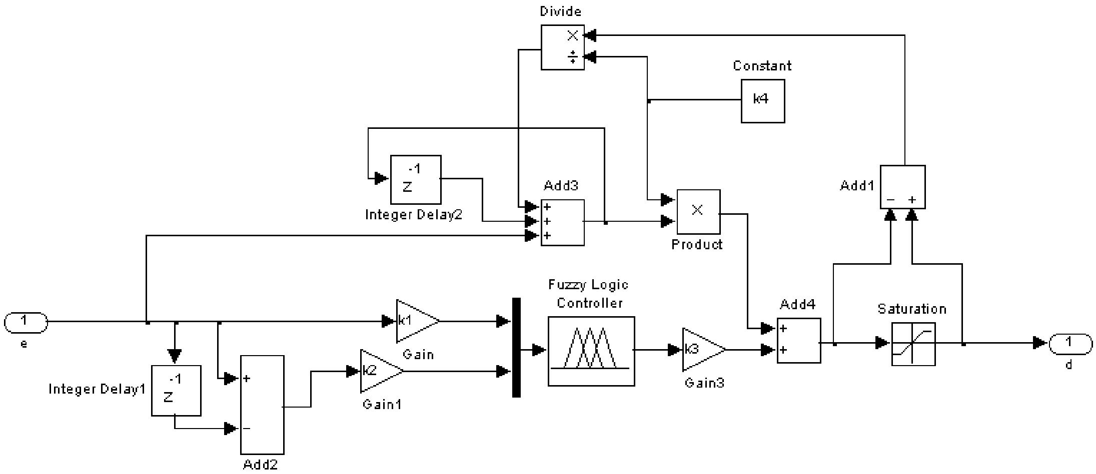

Figure 2: Fuzzy controller with integrator and anti wind-up

Calculation

The perturbation in input voltage as well as the response of both the PI and fuzzy controller with integrator is shown in Figure 3. The simulation with the fuzzy controller shows significantly less deviation from the output voltage reference (200 V).

There are oscillations in the output of the fuzzy controller. The reason for these oscillations is not understood and should be further investigated.

The fuzzy controller demands more of the DSP. Measurements with a dSPACE and a simple fuzzy controller showed that the DSP became the limit on the bandwidth of the controller and could only update the 10 kHz PWM signal every fourth period.

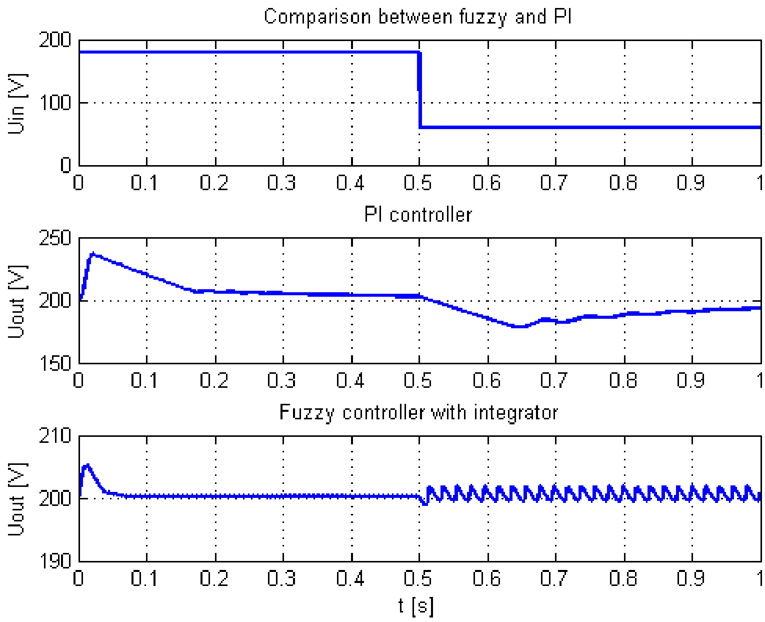

Figure 3: Excellent response of fuzzy controller

Conclusion

For prediction algorithms artificial intelligence perform as good as classical methods. The AI methods can be faster in some cases. It also often has the advantage of not being site dependent, such as for example wind power prediction based on flow modelling.

For control fuzzy logic can be very suitable for non-linear processes. AI methods demand more computing power than a classical PI and should therefore only be used when needed. An other disadvantage is that there is no design procedure for the controller.