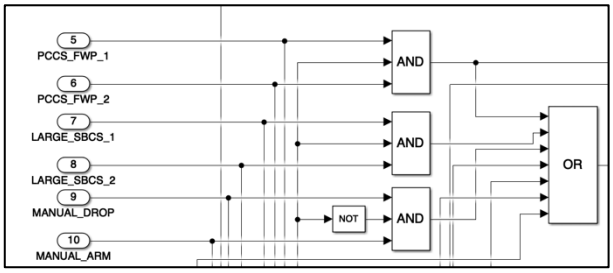

Fig. 3. Current RPCS inputs and partial logic circuit.

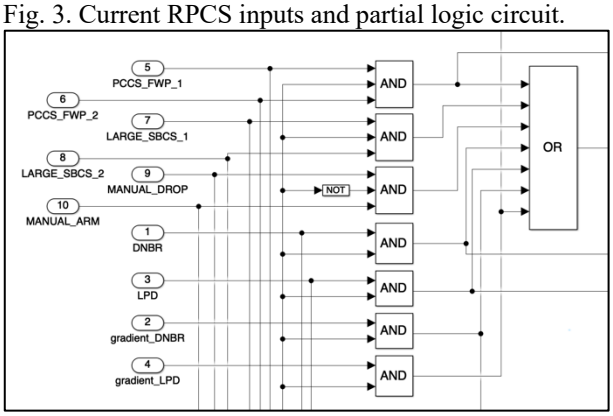

Fig. 4. Modified RPCS with DNBR and LPD inputs added.

4. Reactor Trips of the Core Protection Calculator System in Republic of Korea

The Korea Institute of Nuclear Safety publishes all events at Korean NPPs [12]. Using the data available on the website is possible to verify which events are directly or indirectly related to the core protection system.

Observing the data, the core protection system has actuated mainly because of reactor coolant pump trips, CEA signal positions and misalignment, human errors (addressable constants and operational mistakes), device and instrument failures, CEA dropping. [12]

Thus, the results and events analyzed showed that the core protection systems have done what they are designed to do. However, spurious signals and unnecessary reactor trips could be avoided. The average time NPPs took to get normal operation after the reactor trips was 10 hours and 41 minutes, with the maximum time of 23 hours and 50 minutes in the event Hanul-6-2018-05.

5. Results

The modified RPCS uses DNBR and LPD as input. For demonstrative analysis the DNBR setpoint limit is set 1.6 and DNBR absolute gradient setpoint is set to 0.3. Using a normal transient of power reduction on mode 1 from 100% to 75% power, the actuation of the system is showed in figure 5. The RPCS is active when the setpoints are reached. Therefore, instead of scram the reactor the power is drastically reduced by RPCS actuation. The same approach can be used for LPD.

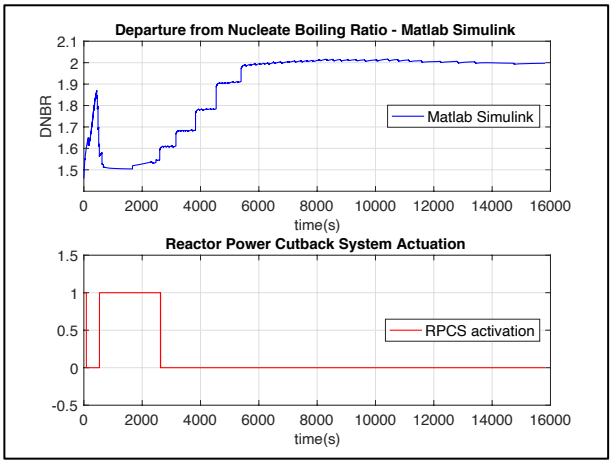

Fig. 5. RPCS actuation during a normal transient.

The RPCS system is actuated when the setpoint is reached. The figure 5 is showing the actuation of the RPCS when the value of DNBR is lower than 1.6. The best setpoint value can be investigated by using thermal hydraulics analysis and easily applied in the system.

6. Conclusion

The core protection calculator system is applied in the Matlab Simulink using the same algorithm from the functional design requirements of the current CPCS. The response of CPCS built in Matlab is dynamic, what means that a transient can be applied to the system. The validation of the modules was by comparison with the current system in KAERI facilities. All the validation files are considering single input and static calculation.

The modified RPCS is a logic circuit that has more inputs than the current system. Using a normal transient of power reduction in Barakah simulator was possible to implement the RPCS actuation by DNBR and LPD values from the CPCS, what can contribute to increase the plant availability by unnecessary reactor trips avoidance.

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