Digital Twin Enabled Fault Diagnosis and Health Monitoring for Process Control Applications

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Abstract

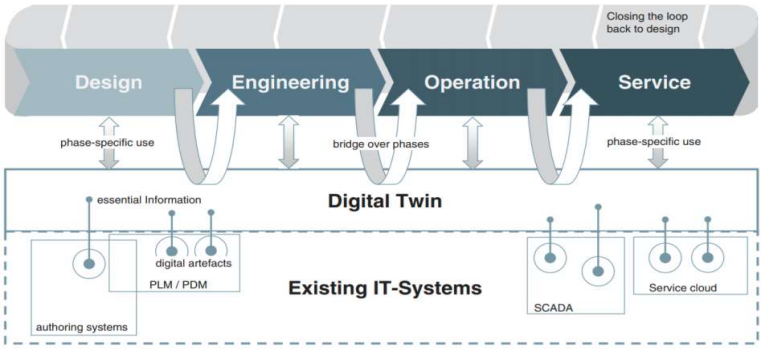
In this work a methodology for developing a behavioral matching and fault prediction for radio frequency impedance matching (RFIM) applications is presented. A RFIM system is selected as case study which is modeled following the Digital Twin development framework. A Digital Twin for a RFIM process is studied and compared to a real digital system running on an embedded environment. A model for a RFIM system is created using MATLAB/Simulink where it is running under perfect conditions. A second RFIM model is then deployed to a Raspberry Pi 4. The Digital Twin then runs in conjunction to the physical twin with the exact inputs being sent to both models. The results under these conditions will be identical, the next step is to introduce faults to the physical twin and detect them with the Digital Twin. In this configuration specific output signals are tracked to compare the health of the physical twin system. RFIM systems have application in industry such as in etching of semiconductors and the health monitoring of systems can be implemented in an edge device.

Application

Behavioral matching and fault prediction allows for the tracking of system health and prevents critical failure over time. A method to prevent catastrophic failure of machines uses preventative maintenance dictated by the Digital Twin. The applications in industry of radio frequency impedance matching are numerous from etching of semiconductor to wireless charging. Fault prediction provides a method to warn user of oncoming part degradation, process malfunction and gives a time frame and risk level to plan accordingly. This timeline allows for planning of operation interruptions to minimize the down time of a system.

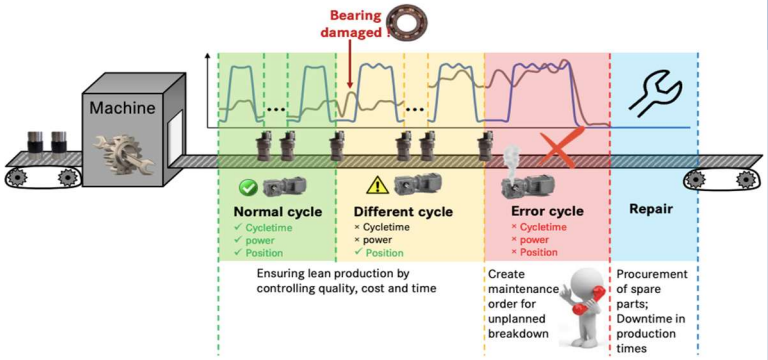
Methodology

Digital Twin Methodology



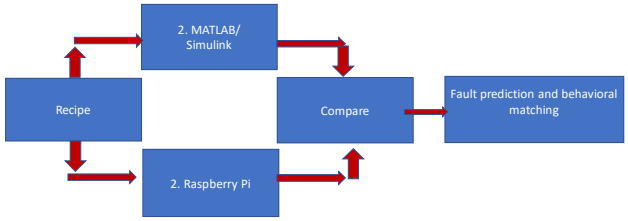
Hardware Configuration

Behavioral Matching and Fault Prediction

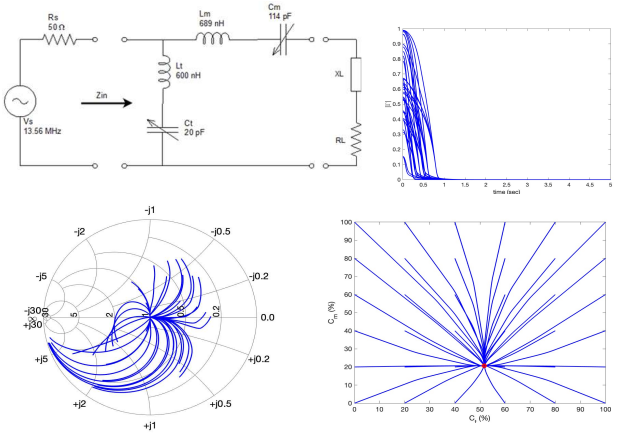


Obtained Results

Data Flow Development



Results



Conclusion

In this work a radio frequency impedance matching Digital Twin was developed and used for behavioral matching and faut prediction. The RFIM model was created in Matlab/Simulink and deployed into a Raspberry Pi 4. The results from the Digital and Physical Twin are analyzed and compared. The results show that the system output can be compared to predict faults and to match the behavior of an RLC network.

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References:
[1] Viola, J., and Chen, Y., 2020. "Digital Twin Enabled Smart Control Engineering as an Industrial AI: A New Framework and A Case Study"
[2] Guc, F., and Chen, Y., 2021. "Fault cause assignment with physics informed transfer learning". IFAC-PapersOnLine, 54(20), pp. 53–58. Modeling, Estimation and Control Conference MECC 202
[3] Rodriguez, C., Viola, J., and Chen, Y., 2021. "Data-driven modelling for a high order multivariable thermal system and control". IFAC-PapersOnLine, 54(20), pp. 753–758. Modeling, Estimation and Control Conference MECC2021