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USING MATLAB/SIMULINK FOR MODELING COMPLEX TECHNICAL PROCESSES

The use of MATLAB/Simulink has today become one of the key tools for engineers working with complex technical processes. This environment combines mathematical models with visual block diagrams, allowing specialists to quickly build system models, analyze their behavior, and test control algorithms even before they are implemented in practice. As researchers note, "Simulink is a modeling and simulation environment for model-based engineering. It allows for the graphical design of systems by connecting blocks" (Saralegui, Sanchez, & de Castro, 2023, 7). Such an approach helps reduce risks and costs while ensuring accuracy and real-time capability. Moreover, the tight integration between MATLAB and Simulink enables iterative development—engineers can refine mathematical equations in the MATLAB script environment and immediately verify them in a block diagram context. This seamless workflow is particularly valuable when dealing with nonlinear dynamics, where analytical solutions are rarely available.

One of the most important applications is testing in hardware-in-the-loop mode. Models created in MATLAB/Simulink can be automatically converted into HDL code and executed on FPGA boards. This enables engineers to safely verify controllers without connecting them to real electronic components. The article states: "The results showed that the proposed approach delivered code that performed very close to a reference VHDL implementation, even for complex designs" (Saralegui et al., 2023, 1). In other words, efficient models can be obtained with minimal resource expenditure. From my reading of the literature, this capability significantly reduces the barrier to entry for small laboratories and academic groups that cannot afford dedicated hardware testing facilities. Instead of building costly physical prototypes, they can rely on validated semi-automatic code generation pipelines.

Another example is the modeling of microgrids, which combine solar power plants with energy storage systems. Predictive control algorithms implemented in Simulink help balance generation and consumption, thereby improving the reliability of power supply. The authors emphasize: "The EMS plays a pivotal role in coordinating the operation of generators and storage units, enhancing both efficiency and reliability of microgrid operation" (Oksenych et al., 2025, 40). This is particularly relevant for remote areas where access to centralized power systems is limited. In practice, Simulink allows engineers to incorporate real weather data and load profiles into the same environment, which makes the resulting control strategy much more robust compared to purely theoretical designs. Without such simulation tools, tuning a microgrid energy management system would require months of field experimentation.

MATLAB/Simulink is also widely used in the field of electric vehicles, particularly for modeling active balancing of lithium-ion batteries. Within this environment, various balancing strategies can be tested, both with and without external energy sources. Modeling results indicate improved efficiency of state-of-charge management and reduced balancing time, which directly contributes to enhanced safety, durability, and overall battery performance. Furthermore, researchers often extend these battery models with thermal dynamics, since temperature evolution plays a critical role in cell degradation. Simulink handles such multiphysics problems naturally: electrical, thermal, and chemical subsystems can coexist in one diagram, exchanging signals at each time step. I have noticed that many peer-reviewed papers now rely on such co-simulation approaches instead of developing separate solvers for each physical domain.

At the same time, there remains the issue of reproducibility of experiments. Many studies do not provide access to their models or tools, which makes it difficult for other researchers to replicate results. Boll and co-authors note: "only 9% of the tool evaluations presented in the examined papers can be classified to be replicable in principle" (Boll, Vieregg, & Kehrer, 2024, p. 209). This highlights the need for better practices of open access and data sharing within the scientific community. In my view, the situation is even more problematic in industry-oriented publications, where proprietary Simulink models are considered intellectual property. Nevertheless, some journals have begun encouraging authors to upload their block diagrams as supplementary material, often in anonymized form. Until such practices become standard, the field will continue to struggle with verifying published claims.

Thus, MATLAB/Simulink today is a powerful environment used in energy, electronics, and automotive engineering. Its ability to combine simulation, code generation, and real-time testing makes it indispensable for modern research and practice. At the same time, ensuring transparency and reproducibility of experiments remains an important challenge that must be addressed for the further advancement of science and technology. Looking ahead, I expect that tighter integration with version control systems and cloud-based simulation platforms will gradually improve the current situation. But for now, individual researchers still bear the responsibility of documenting their models thoroughly and sharing them whenever possible.

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