DRIVE FOR EXCELLENCE

The key to developing reliable electric drives is creating a best-practice workflow that incorporates model-based systems engineering and embedded software development.

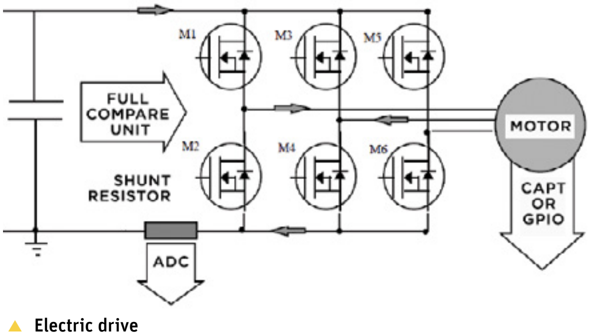
By *ANSYS Advantage* Staff

Any best practice must manage the complexities of the product development process and verify designs long before system integration and physical testing. Products that incorporate embedded software add to that complexity with their higher level of functionality and requirements — such as interactive displays and complex controls applications. The interdependent subsystems that result can benefit from model-based systems engineering solutions. Furthermore, incorporating hardware behavior (the simulated model of hardware components within the system, called the plant model) during software simulation (for fine-tuning embedded code) requires integrated multiphysics/software virtual analysis.

In designing control systems, one best practice is model-based systems and embedded software engineering workflow that relies on the ANSYS suite. The specific collection of tools — ANSYS SCADE products, ANSYS Simplorer and appropriate physics simulation software — is designed to address the needs of various engineering groups, including system architects, design engineers and validation engineers. For example, electric drive design can benefit from this model-based systems engineering and embedded software development workflow.

ELECTRIC DRIVE BEST PRACTICES

Electric drives are a key component in the power conversion chain between power sources (the grid or battery, for example) and loads (such as industrial equipment or traction motors for cars or trains). As the price of energy increases, developing reliable, efficient drives becomes more critical. A systems approach is mandatory in creating new generations of drives, as it gives designers a global view of their designs early in the development cycle.



▲ Electric drive

In the traditional development lifecycle, each discipline, system, physical component, and software control code has an independent flow. Power electronics designers focus only on semiconductors, electrical performance, EMC/EMI effects and efficiency. Software developers concentrate solely on code validation with elementary and non-realistic test cases, while mechanical and thermal engineers use approximate values as load cases and boundary conditions. Because of the silo-like workflow, no system validation is even possible until a prototype is built.

Using an ANSYS-based process for development, each design team working on the electric drive maintains standard workflows and design tools. Accuracy and investment in existing tools are not sacrificed to work within a common simulation environment. The output of system simulation benefits each discipline: Power electronics designers have realistic temperature

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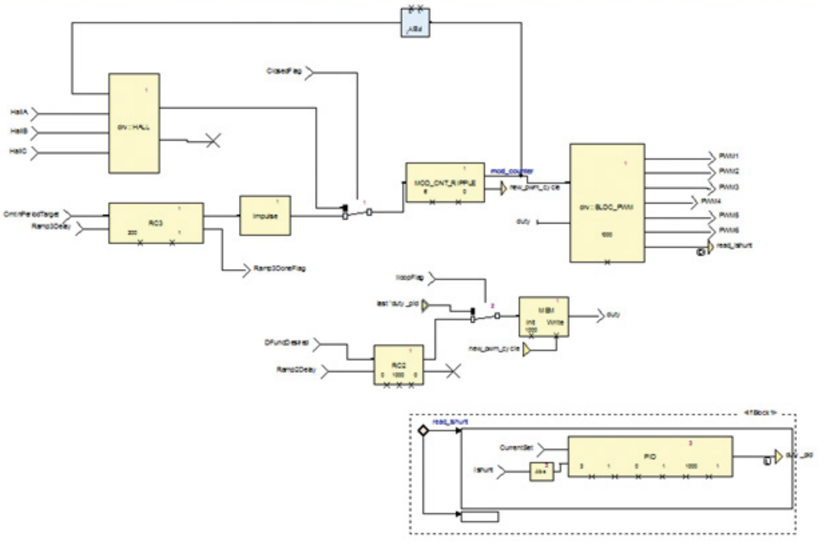
operating points, software developers can test codes with realistic hardware models early in the design cycle, and the same control models can be implemented in the electric drive. As a result, early validation is possible as systems engineers incorporate simulation models up front in the design process.



▲ SCADE Suite model of electric drive

REQUIREMENTS MANAGEMENT AND FUNCTIONAL/ ARCHITECTURE DESIGN

Two ANSYS product families form the foundation of this best practice: SCADE and Simplorer. A number of SCADE tools play specific roles in accurately modeling and simulating the behavior of embedded software code; Simplorer's powerful technology enables analysis of all aspects of large-scale systems — in this electric drive case, electrical–electronics systems and cosimulating embedded code.

ANSYS SCADE System is a SysML-based systems design and modeling tool that has been developed specifically for use on critical systems with high dependability requirements. It provides full support of industrial systems engineering processes, such as ARP 4754A for aerospace, ISO 26262 for automotive and EN 50126 for rail.

To create the system and product requirements of the electric drive, systems engineers use SCADE System to model the functional and architectural design processes. The software uses block diagrams to represent system components and connect them through ports and connectors. Components can be either physical, such as transistors, or software, like controls for a motor.

With SCADE System, systems engineers support and structure requirements management, as well as functional and architecture design processes, to model the system requirements of the electric drive. Systems engineers start with product requirements, creating functional and architectural descriptions of the system. SCADE System software uses block diagrams to represent system components and connect them through ports and connectors.

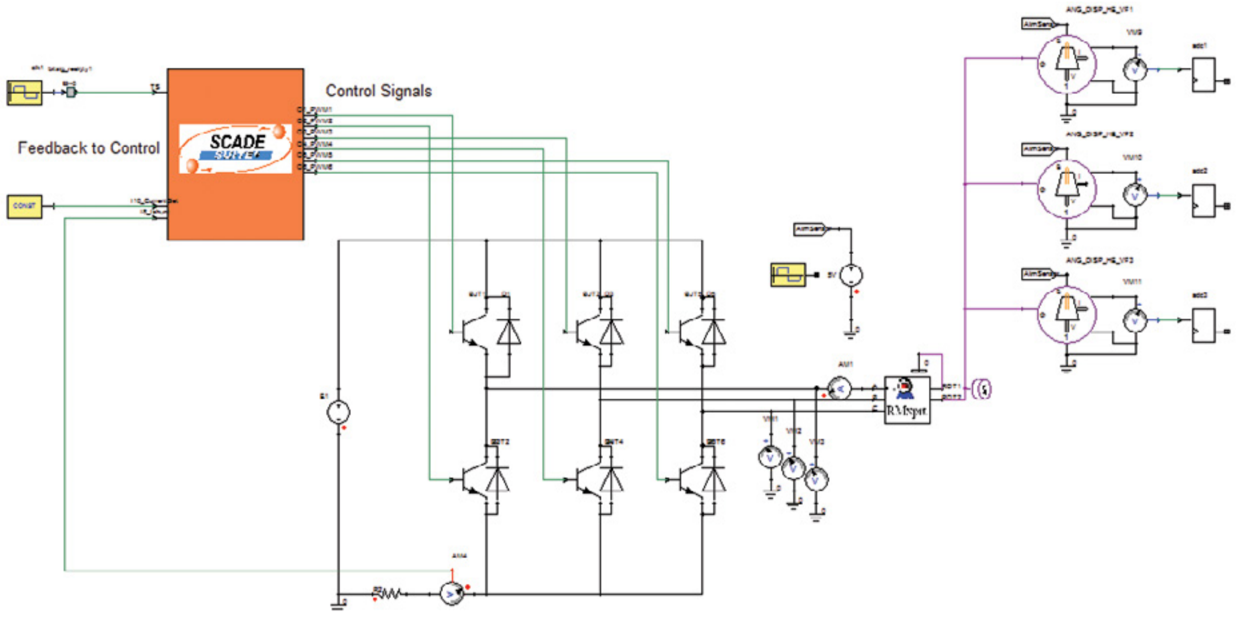
Once the system functional decomposition is available, the next step is to produce a system architectural design of the electric drive, implementing the functions in terms of physical and software blocks. This must include an explanation of how the functions and data of the initial system have been allocated to the architecture.

While the electric drive system is being designed, the systems engineer must establish full traceability between initial system requirements and the functional and architectural designs. This can be done with the SCADE LifeCycle Requirements Management Gateway. This tool allows the user to graphically manage links between SCADE System and SCADE Suite models and other structured documents — in particular, high-level requirements and test plans.

To manage legacy data, systems engineers can use data dictionaries within SCADE System. Data can be imported from and exported to external databases using Microsoft® Excel® .csv as an intermediate format. Any piece of data can be associated to a block, port or connector in a SCADE System design.

ELECTROMECHANICAL SYSTEMS DESIGN WITH ANSYS SIMPLORER

ANSYS Simplorer assists in developing detailed 3-D and simplified 0-D simulation of the physical components. Simplorer is an intuitive, multi-domain, multi-technology tool that enables engineers to simulate complex power electronic and electrically controlled systems. Most systems are too complex for complete 3-D simulation, which requires enormous simulation time; using simplified



Importing SCADE generated code into ANSYS Simplorer

reduced-order models (ROM) and cosimulation provides a viable solution. Zero-D simulation is achieved using standard simulation languages that implement the fundamental laws of physics, such as VHDL-AMS for electrical–electronics systems and Modelica® for fluid–mechanical systems. In this way, Simplorer's powerful technology allows engineers to analyze all aspects of large-scale systems, from detailed component analysis to system performance, in a single virtual design environment. With Simplorer, engineers working in the early stages of the design cycle can identify problems that other simulation or build-and-test methods cannot detect, allowing them to maximize product performance and reduce time to market.

MODELING CONTROL SOFTWARE WITH SCADE SUITE

SCADE Suite is a model-based development environment dedicated to critical embedded software. It integrates critical applications spanning model-based design, simulation, verification, qualifiable/certified code generation, and interoperability with other development tools and platforms, including requirements traceability. By using SCADE System in conjunction with SCADE Suite, system and software engineers can work within the same framework.

With SCADE Suite, embedded software engineers model the embedded software designed to control electrical components of the electric drive. The team uses state machines and data flows to model the logic and control laws. Requirements of the embedded software can be traced through the development process to ensure that they are met. Developers can work together with the systems engineers that leveraged SCADE System to develop the system architecture. This is an important and unique feature of the ANSYS process.

Once software engineers have modeled the software design with SCADE Suite, they automatically generate the C code that will be used within the electric drive. SCADE Suite's automatic code generator is 100 percent accurate, greatly reducing the time needed for code verification and validation.

The model-based method addresses the challenges associated with developing products that incorporate increasing functionality and complexity.

COSIMULATING PHYSICAL COMPONENTS AND CONTROL SOFTWARE

ANSYS Simplorer is used for the more electrical–electronics systems cosimulating with SCADE Suite. To perform cosimulation of the physical system model designed in Simplorer and control laws designed in SCADE Suite, a .dll of the SCADE generated code that is specifically wrapped for Simplorer can be imported into Simplorer.

INTEGRATION AND VALIDATION

Integration and validation consists of assembling the final system and validating that it obeys the final requirements. Virtual integration based on models is favorable compared to laboratory testing based on prototypes. By using a virtual prototype of the system, changes can be made at any stage of the design process, reducing development effort and cost. This agile approach allows for perfecting the design before developing a physical prototype.

DESIGN OPTIMIZATION

Electric drive engineers can use the capabilities within ANSYS Optimetrics and ANSYS DesignXplorer to seamlessly optimize the overall design — for example, to design optimal controls or passenger comfort. Optimization improves the model to optimize performance.

FULL-SYSTEM VIRTUAL PROTOTYPING

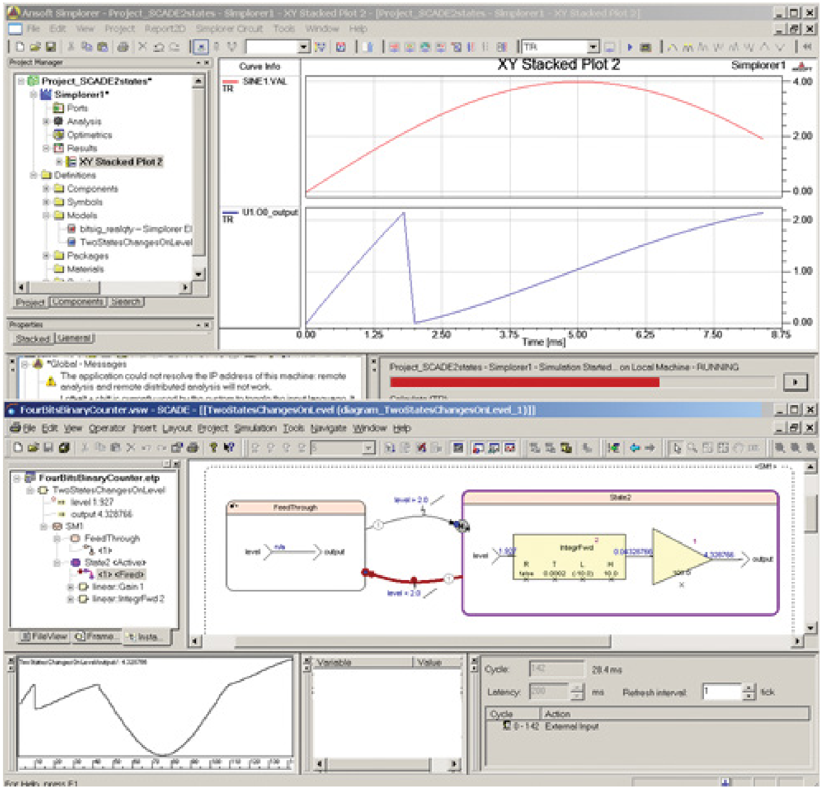
Companies looking to improve their product lifecycle development processes can benefit from best practices that embrace simulation-driven product development, such as the one described above. Integrated simulation of a number of models — high-fidelity 3-D physics, reduced-order, 0-D and accurate control software — provides an extremely effective solution.

The ANSYS systems strategy combines embedded software development with power electronics hardware design. The SCADE Suite model that is used at the simulation level is the same one that will be used to develop embedded code that controls the electric drive. The approach is extensible with more-detailed models of hardware components that are typically designed using 3-D simulations.

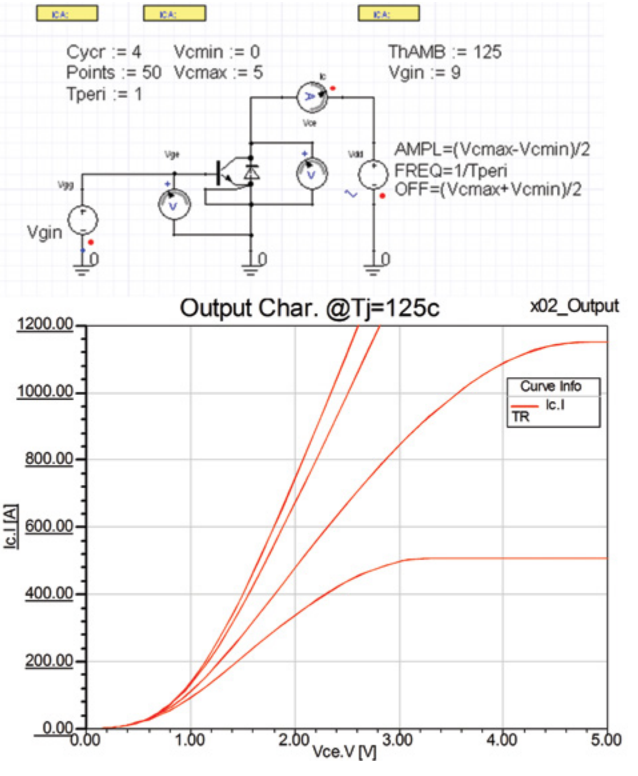
The model-based method addresses the challenges associated with developing products that incorporate increasing functionality and complexity. Managing design complexity is achieved through model-based system engineering, which reduces overall development costs, improves the optimization process and eliminates system integration failure.

ADDITIONAL RESOURCES

EMBEDDED SOFTWARE SYSTEM SIMULATION: EXAMPLE OF CONTROL SIMULATION OF AN ELECTRIC DRIVE DESIGN
esterel-technologies.com/81excellence



Cosimulation between ANSYS Simplorer and SCADE Suite



Design optimization with ANSYS Simplorer.