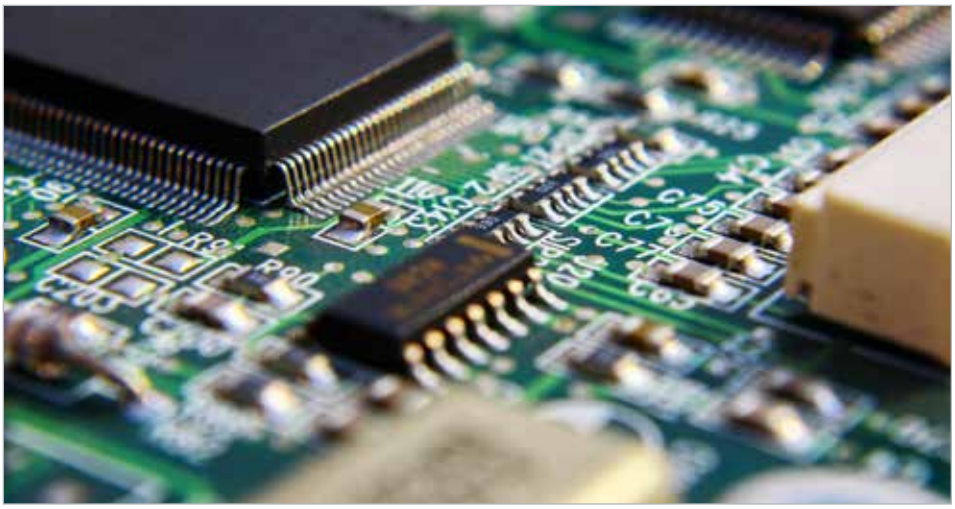
Characterization of Sensorless Motor Control Technology Using VisSim



TEXAS INSTRUMENTS

Key Highlights

Industry
Automotive, Electronics

Challenge
Characterization of TI's FAST™ observer

Altair Solution
Development of VisSim Simulation of Entire System

Benefits
- Development of technical reference manual
- Development of tool for motor controls testing

Background

In recent years, power electronics and microelectronics have seen groundbreaking advancements with the application of electric drive systems and motor control technologies, permeating almost all aspects of modern life from transistors, capacitors, washing machines, and air conditioners to elevators, motor vehicles, monorails and centrifuges. Today's Microcontroller Units (MCUs) bring great precision, efficiency and lowered costs to a wide range of applications including appliances with blowers and compressors such as washers and refrigerators, HVAC (Heating, Ventilation and air Conditioning Systems), as well as automotive control systems. Texas Instruments (TI) is a 13 billion dollar, global semiconductor design & manufacturing company. The C2000 MCU group at TI takes the best parts of Digital Signal Processing (DSP) technology and microprocessors to craft the ultimate embedded control solution. The C2000 focuses on high end processing applications like sensorless field oriented motor control.

TI recently introduced an embedded software product called InstaSPIN™, which enables designers to identify, tune, and fully control any type of three-phase, variable speed, sensorless, synchronous or asynchronous motor control system. It uses TI's new software encoder, a sensorless observer called FAST™ (Flux, Angle, Speed and Torque), which is embedded in the read-only-memory (ROM) of Piccolo devices.

Keywords: InstaSPIN™ FOC (Field oriented control), VisSim micro controller (MCU), sensorless motor solutions

Texas Instruments Success Story

“A key benefit to using VisSim for this project is its code generation capability and how quickly and fast it works. The speed of how its drivers work and being able to interface directly with our ROM code was really the key enabler for me, and that was the most important benefit in this particular project.”

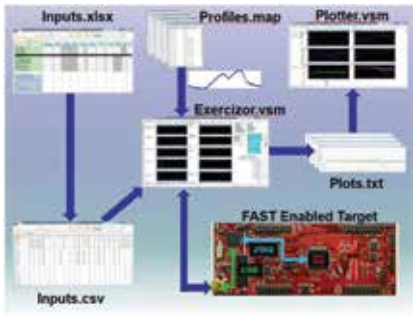
Dave Wilson,
Senior Motor Systems Engineer
C2000 Group, Texas Instruments

Characterization of TI’s FAST™ observer

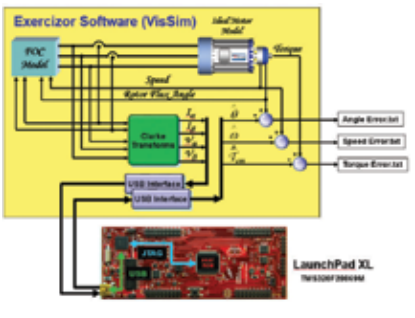
Dave Wilson, Senior Motor Systems Engineer with The C2000 Group, was recently tasked with a project to characterize the FAST™ observer and develop a datasheet for it. He tried to do this by setting up a dynamometer (dyno) system with a circuit board to control it. He intended to characterize the FAST™ observer by introducing gain and offset errors and observing its performance. This presented a challenge, as not only was it a slow and tedious process due to output variances over time and temperature changes, it also required constant recalibration. Additionally, the dyno could only measure the shaft torque, not the electromagnetic torque which is what is estimated by the FAST observer. In conclusion, the FAST software could not be properly tested since the hardware he was using was not adequately equipped to test it.

Development of VisSim Simulation of Entire System

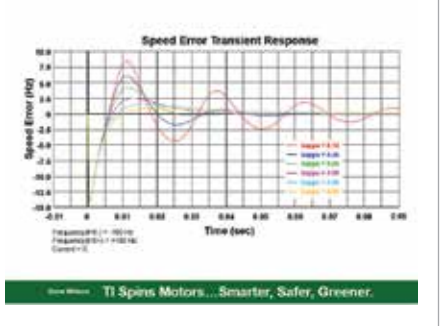
Mr. Wilson had first become familiar with VisSim while viewing a web based presentation 4 years prior. Recalling how easy it was to use, he decided to try it for his current project. VisSim provided him with the tools he needed to model fast and accurate motor analog dynamics as well as digital control. VisSim was then able to automatically create C code from the controller portion of his graphical diagram, and download the code to run on the Piccolo target. Using the VisSim JTAG Hotlink in a new synchronous mode that was released in the latest version 9 of the software, Mr. Wilson could run the motor simulation in lock step with the control running on the target in non real-time to verify the FAST outputs against the ideal values of Flux, Angle, Speed, and Torque from the VisSim model. As a result, FAST can be evaluated for ANY brushless motor, no matter



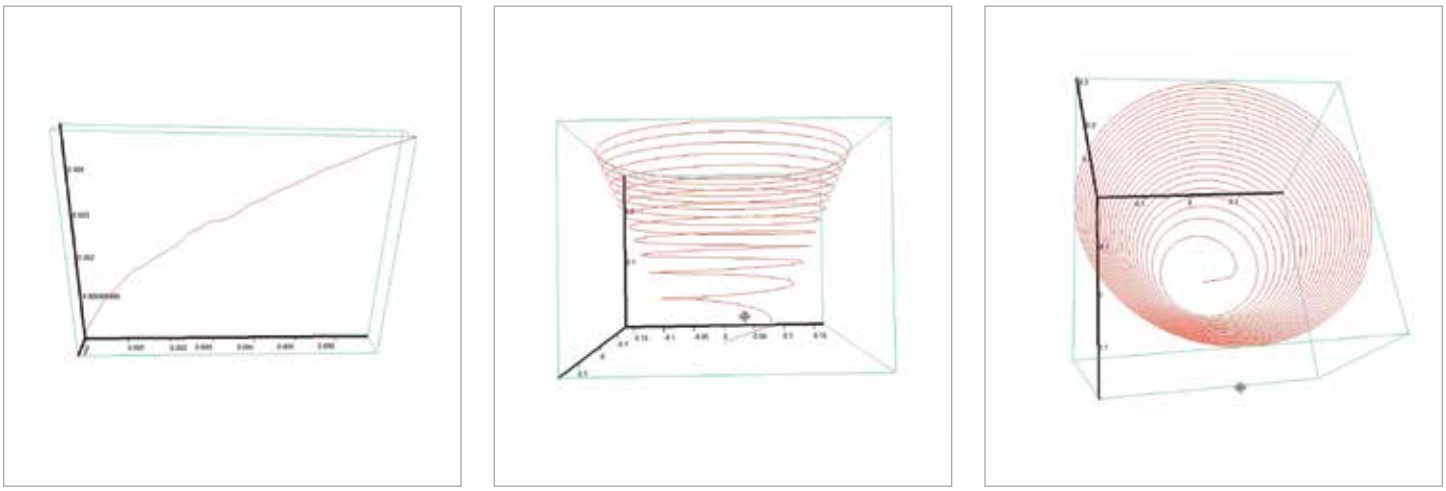
Exercizor environment



Exercizor block diagram illustrating target interface



FAST parameter sensitivity test using Exercizor

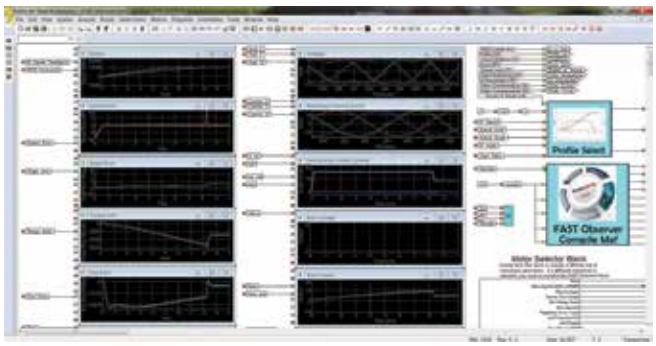


3D representations of the motor voltage space vector (x,y,t) at different values of time

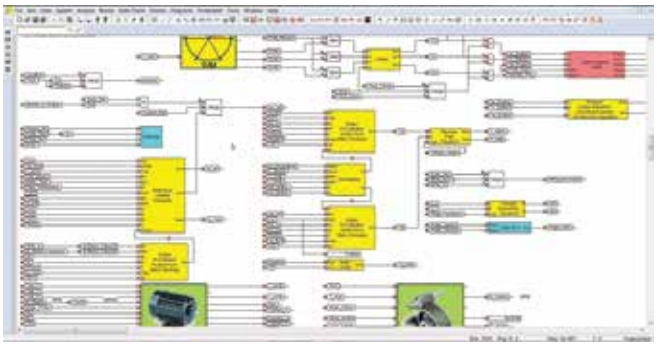
how big or small, by simply supplying the simulated voltage and current values to the FAST observer running in ROM on the target. He developed a VisSim simulation of the entire system except for the FAST™ observer. The simulation could optionally bypass the FAST observer in the feedback path, or close the control loop through the FAST observer on the target. Also, he could now set the gains and offsets to any value he liked. Different parameters like resistances, inductances, controller gains and voltage tolerances could now be controlled as well. "I could then determine what the FAST™ observer outputs in ROM would give me under identical conditions, and compare them to the ideal answers from the simulation. The bottom line is, VisSim completely solved the problem that I was running into," said Mr. Wilson, "A key benefit to using VisSim for this project is its code generation capability and how quickly it works. The speed of how its JTAG drivers work and being able to interface directly with our ROM code was really the key enabler for me, and that was the most important benefit in this particular project," he concluded.

Generation of FAST™ TRM

Deriving the solution using VisSim not only allowed generation of the FAST™ TRM (Technical Reference Manual), it also resulted in a very useful tool. This tool (called the "FAST Exercizor) can enable TI's customers to test their motor control requirements using TI's actual ROM based algorithm that they would have never before been able to do without having to hook up an actual motor system. This gives them a quick way to kick the tires on InstaSPIN™ FOC (Field Oriented Control) without having to build a whole system for it. TI plans to release the tool to its field force and customers in Q1 of 2016.



Exercizor tool using the 28069F LaunchPad board



Field Oriented Control implementation in VisSim

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