Feature Article

SPARC - The Common Controller Platform

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To be able to offer to our customers superior and intelligent control of rotational or linear motion machinery especially for dynamometer systems, HORIBA has developed the SPARC controller platform. This platform includes dedicated and optimized hardware and software which incorporates more than 20 years of experience in control technologies. Based on this platform HORIBA is offering a variety of control and simulation packages for engine, driveline, vehicle and brake testing. The extension of the SPARC controller platform with the STARS automation platform technology creates modern, intelligent and user friendly controller products.

Introduction

HORIBA is providing a wide range of equipment for testing of complete vehicles or various components of a vehicle like brakes, engines, transmissions or axles. All these applications have in common the need for control of speed, torque and position of one or more dynamometers to apply the required load to the unit under test. The requirements for this control function are quite similar for all application domains.

- Highly accurate and fast speed, torque and position control
- High performance interface to the dynamometer
- Remote control interface to automation systems
- Interface to programmable logic controllers (PLC) of facility
- High performance control and simulation algorithms
- Basic monitoring and safety functions

Therefore HORIBA has developed the common controller platform SPARC which is used across all product lines (engine, driveline, chassis, and brake) to share controller know-how and to guarantee superior control performance across all products.

Hardware

The SPARC hardware is designed as a robust, reliable standalone controller which operates in a harsh electrical environment and can be mounted in a console, 19" rack or directly in a drive cabinet. A SPARC unit consists of power supply board, CPU board, up to three IO boards, a CAN interface board and a spare PC104 slot (Figure 1).

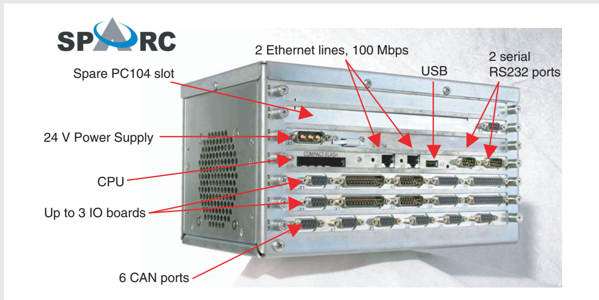

Figure 1 SPARC Box

The CPU includes a PC architecture low power CPU without enforced air cooling and hard drive. The software is stored on a removable compact flash disc for easy reconfiguration. The first Ethernet line is used as remote interface to automation systems based on a standard TCP/IP - UDP/IP protocol. The second Ethernet lines is used as a 1 kHz real-time link to connect multiple SPARC boxes e.g. for control applications where more than 3 dynamometers have to be controlled at the same time. This high speed real-time link can also be used to interface to third party hardware-in-the-loop (HIL) systems allowing users to utilize their existing simulation environment at the test rigs.

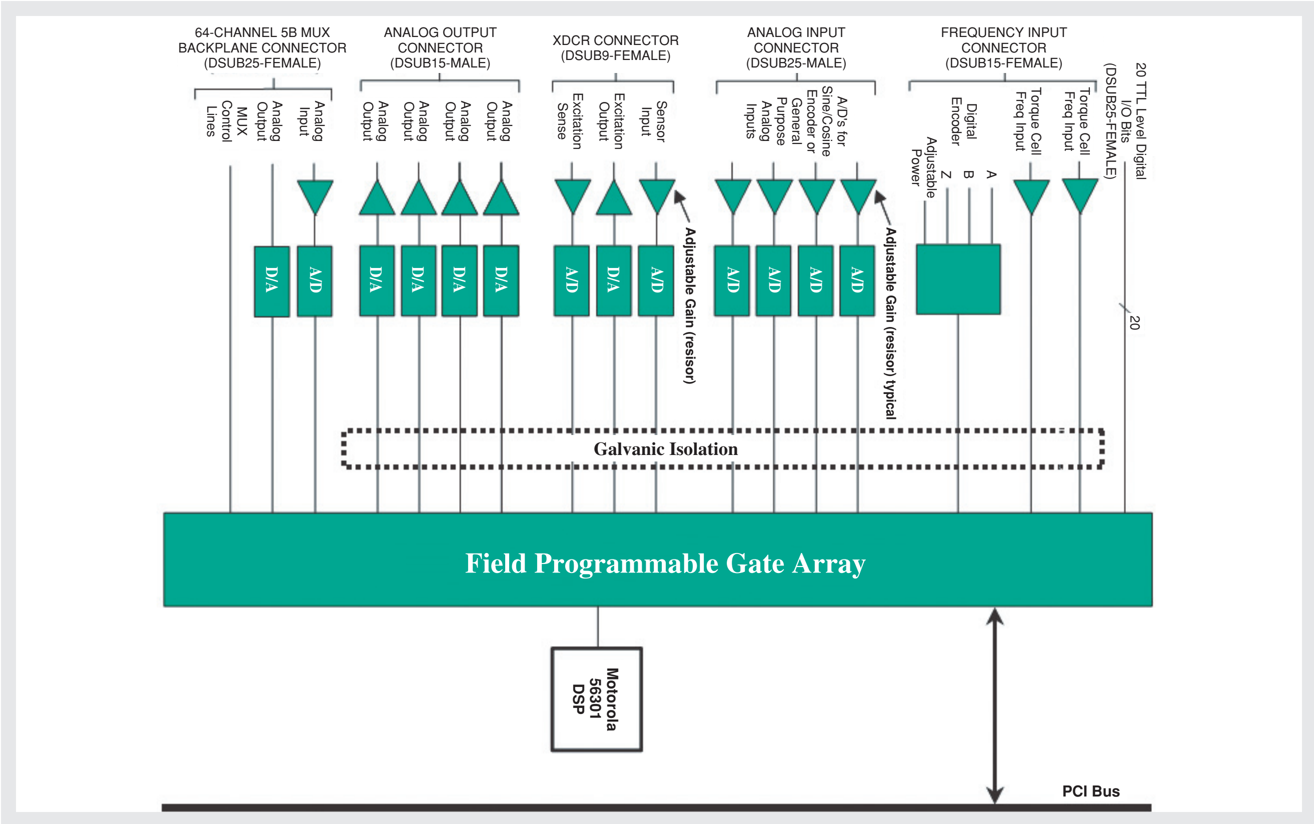

Figure 2 SPARC IO Board

The IO board (Figure 2) includes a special IO mix optimized for controlling a single dynamometer and provides outstanding performance at a reasonable price. It includes:

- 1 encoder (speed measurement with position measurement)
- 2 frequency inputs
- 4 analogue inputs with real anti-aliasing filter
- 4 analogue outputs
- 1 load cell input (AC and DC mode)
- 20 free configurable digital IO channels
- 64-channel module multiplexer
- 5 kHz sample rate on all in- and outputs

The onboard field programmable gate array (FPGA) not only controls the peripheral devices but also implements a highly sophisticated speed encoder signal evaluation. A digital signal processor (DSP) provides the computing power for fast signal pre-processing like digital anti-aliasing filters. All inputs and outputs include complete signal conditioning so actuators actors and sensors can be connected to the board directly.

SPARC comes with 6 CAN ports which are used for fast communication to the drive, for extended IO based on decentralized CAN IO modules and direct communication to specimen control units like engine control unit (ECU) or transmission control unit (TCU).

SPARC boards are connected to each other via the industry standard PC104+ bus. This allows to extend SPARC capabilities by a wide range of commercial PC104 boards like a ProfiBus interface card to connect SPARC to, for example e.g. to, a facility PLC.

Software

In common with STARS, the HORIBA automation platform, the SPARC control applications are running on top of the STARS/SPARC runtime environment which allows dynamic loading and linking of so called 'code modules'. These code modules implement predefined functionality like PID or filter algorithms. Inputs and outputs can be connected to each other to build complex control systems. The SPARC platform provides a library of common code modules' like speed and torque controllers, filters, dynamometer handlers, road load simulation or engine simulation. Based on this common library, different control applications can be developed very quickly. Using the same runtime environment for SPARC and STARS allows the sharing of code between the automation and control systems.

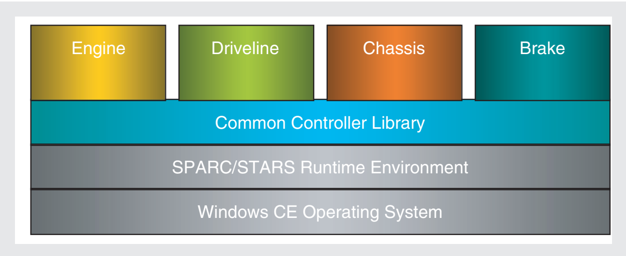

Figure 3 SPARC Software Layers

Code Modules are written in "C" or are generated out of Simulink blocks. Various code modules are connected by drawing wires in Simulink to build complex control applications (Figure 4). This graphical representation of the control structure compared to textual programming language is much easier to understand for most of the control and application engineers and supports sharing of control algorithms and sharing across different application groups.

Control Applications

A variety of control and simulation applications is available for SPARC. SPARC-Engine provides control for engine test stands like TITAN including simulation models for automatic and manual transmissions and human drivers. SPARC-Driveline includes engine torque pulse simulation (ETPS), engine inertia simulation (EIS) and service load replication (SLR).

As an example of the high SPARC performance, Figure 5 shows delta speed control in a powertrain application with active differential gear. When the input torque changes direction the differential switches from closed to open. The controller has to keep the differential speed within a 1 rpm limit. While SPARC keeps the delta speed within the required limit. A conventional controller would have a 10 times higher speed deviation.

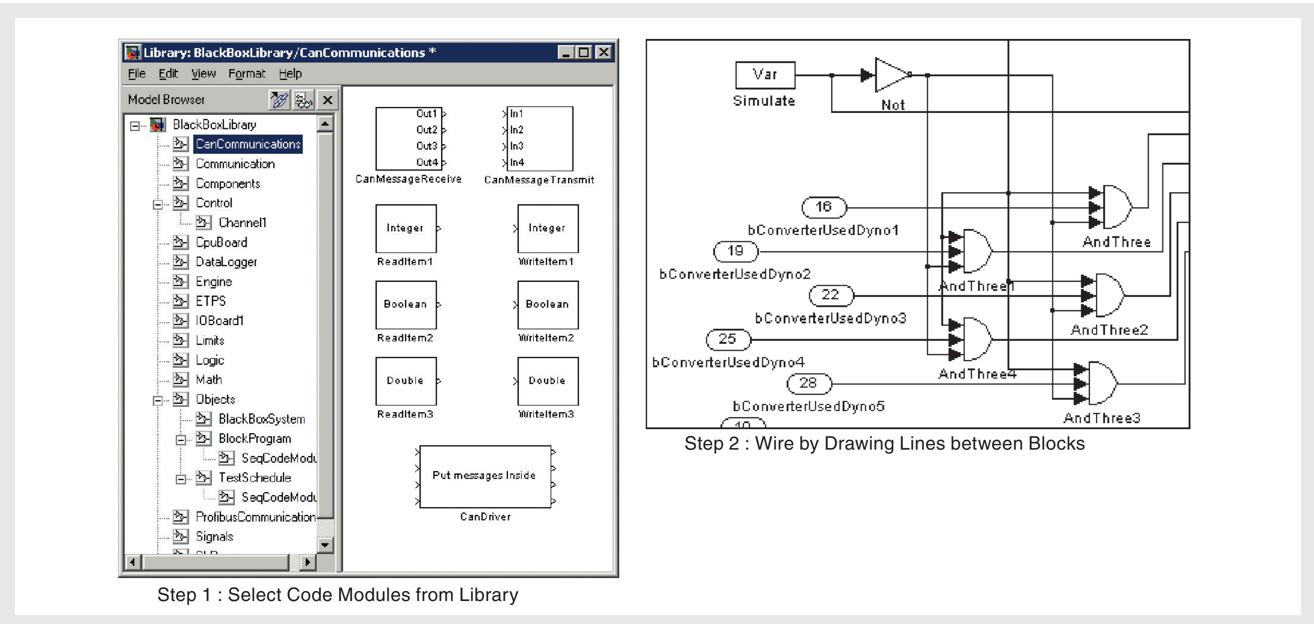

Figure 4 Wiring of Code Modules

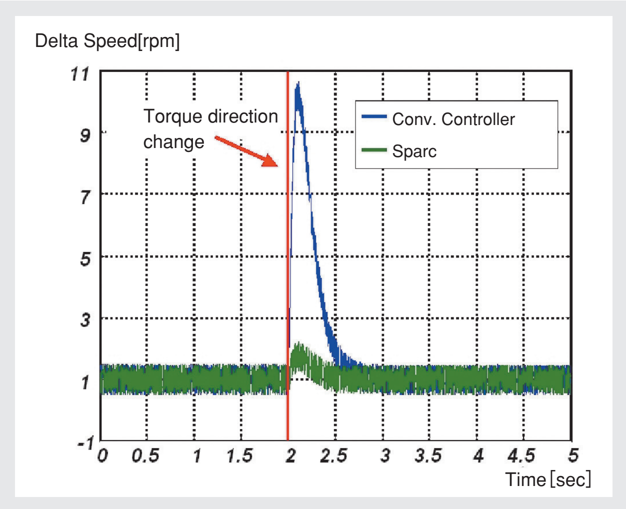

Figure 5 Delta Speed Control Performance

Smart Controller Products

Although SPARC software includes a web server which is used for basic setup and diagnostic pages, SPARC is designed as a black box for standalone controller applications without a graphical user interface (GUI). Modern controller products however require a user friendly GUI, limited data management capabilities to maintain multiple parameter sets and standard operations like quality checks to verify the overall system performance or auto tuning functions to provide an easy, fast setup on specimen change. To meet this requirement the SPARC controller platform is extended by the controller lightweight framework (CLF) which is directly derived from the STARS automation system platform. The new chassis dynamometer controller is the first HORIBA smart controller product which incorporates both STARS and SPARC technology.

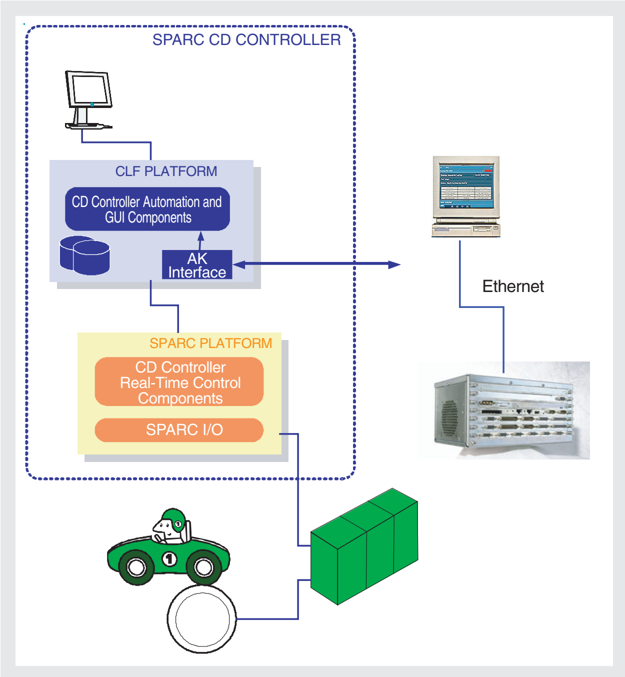

Figure 6 SPARC Chassis Dynamometer Controller

Conclusion

The SPARC common controller platform is offering a variety of control and simulation packages for engine, driveline, vehicle and brake testing. In addition, being combined with the STARS test automation platform, the SPARC can extend the application range. The SPARC controller platform has a strong possibility to be applied to various test systems in the future.

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