Controller for mobile machinery

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Introduction

Embedded systems and software technologies are enablers for innovations in the heavy machinery industry. Time to market and keeping to schedule are important for successful machine automation projects. All stakeholders have their own requirements. Sales and product management are concerned about competitive product offering. Project managers and system engineers have pressure to keep to schedule guaranteeing high quality results. For production, the supplier should keep component delivery schedules year after year and make continuous quality improvements. After-sales want to have long-term availability of components to guarantee spare parts for the entire machine life cycle. For the supplier, it is not about having micro-controllers or ICs (integrated circuits) available, the whole software ecosystem must be supported. To summarize, machine manufacturers expect a high level of commitment from their key partners.

The production batches for mobile machinery industry are typically quite small. Sometimes only a couple of machines of a certain model are produced before next modifications. Obviously, the flexibility of the machine control system is crucial for such a case. Changes are also typical for serial production models to carry out continuous improvements and implement variants for emerging customer needs. Investments towards the development of a machine control system can't be thrown aside even in a case of big changes such as introducing a new automatic gearbox system to the machine. Flexible I/O interface of control units and higher-level CAN protocols, especially CANopen and J1939, are the key technologies to open a selection of building blocks that machine manufacturers can exploit. Epec 5000 product family is designed for machine control applications in different industrial segments, such as construction machines, mining machines, agricultural applications and heavy commercial vehicles. The robust mechanical construction of the platform can tolerate harsh operating environments that expose electronics to high mechanical shocks and vibration, temperature variation, dust, water and aggressive chemicals.

The size of application software and the number of parameters per control unit has been continuously growing in the course of system development. This

Figure 1: Company's control units in use

has resulted in a need for increased performance to keep the application cycle time within specified limits. Epec 5050 control unit targets these applications by introducing a 32-bit microcontroller running at 128 MHz clock frequency. Advanced control algorithms benefit from a floating-point unit that further speeds up the program execution. Moreover, a dedicated hardware unit provides flexible signal conditioning of pulse encoders with a minimal burden to the main CPU, thus releasing processing time for the application software. The real operating environment may introduce unexpected degradation of performance if these issues are not addressed during development of embedded firmware architecture. For example, high busload on several CAN networks may lead to a dramatic growth of the application cycle time for certain approaches.

Another consequence related to large applications is the need for increased memory space. The standard application size of Epec 5050 is up to 1 MiB and can be further expanded. Non-volatile RAM (NVRAM) is a suitable solution for saving of information that needs to be retained over long power outages. Epec 5050 is equipped with a 512-KiB NVRAM for storing machine parameters or log files.

It is not enough to have sufficient hardware to make the physical implementation of the system. The tools must provide efficient means for system level design, control algorithm development, optimization and verification. The manufacturer introduced the Multitool system design and configuration tool. Due to an increased level of system distribution, the number of CAN-connected devices in machines is higher than ever. For different machine layouts and control system architectures, it may be feasible to use several CAN-segments that have dedicated protocols and bit-rates. For system integration, seamless compatibility for CANopen-protocols is a must and therefore in the center of the design. The Multitool provides interfaces to select preferred programmable control units to the system and to create CANopen object dictionaries (ODs) for these devices. Furthermore, third party CANopen devices, such as sensors, may be add- ▷

ed to the control system by importing EDS (electronic data sheet) or DCF (device configuration file) files from the device manufacturer to the Multitool project.

The Epec 5000 family was designed to meet different control system architectures and increased system distribution. Epec 5050 provides four CAN interfaces. Each of these connections can use either CANopen or J1939 protocol. The control unit is suitable for centralized and distributed system architectures. Application programming is done according to the IEC 61131-3 standard by using Codesys. The system and PLC (programmable logic controller) configurations can be exported from Multitool and used as a project-specific code template in Codesys. This saves lot of work and reduces human errors compared to having to repeat many settings manually. A manual is provided to support product-specific questions for programming the device. The control unit is equipped with an Ethernet interface to speed up program downloading. Because Ethernet can be used as a Codesys interface, online debugging of applications does not introduce any additional communication to the CAN network. On the other hand, the programming and Codesys interface are also provided via CAN network.

To enable system developers to select the best tools for access to the communication system, Multitool generates CAN databases to export data structures to third party analyzing tools. Thus the system settings can be re-used in order to analyze, optimize and verify the control system's performance.

The 5050 control unit is equipped with 65 software-configurable I/O pins that have multi-purpose functionality while the total number on pins is 105. The compact size of the enclosure with respect to the functionality has been a design requirement to address limited assembly space in machines. 28 PWM outputs, switchable 5-V and 10-V supply voltages for sensors and configurable inputs are available. The control units operate with sensors and actuators from different manufacturers, thus providing more choices for system integration.

The company has also introduced a set of function libraries in order to simplify the creation of projects. By re-using these components and the advantages provided by the complete development environment, machine manufacturers and system integrators can benefit from a faster time to market for their innovations. ◀

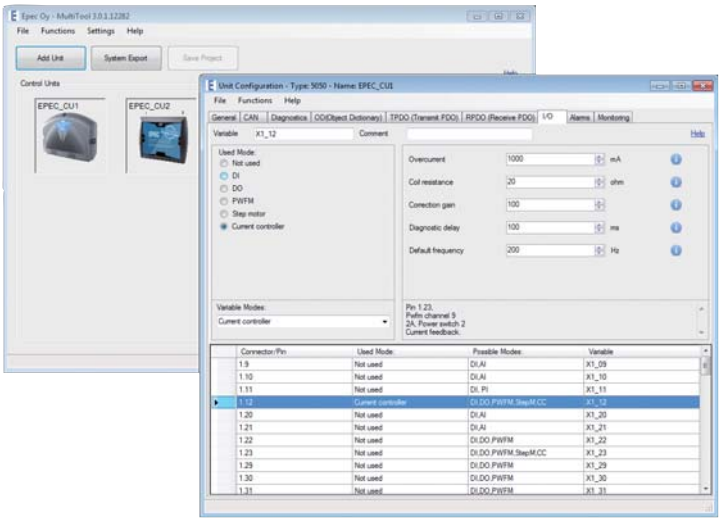

Figure 2: Multitool design and configuration tool