Design and Implementation of Machine Control Systems with Modern Software Development Tools

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1 Introduction

The Agrix project studies machine control systems for agricultural implementations. The research goal is to design and implement a prototype of an open, generic and configurable implement control system. Other research topics are user interface design, positioning and navigation, telematics and fault diagnostics, wireless communications and precision farming. In the project consortium, there are four research institutions and eight companies. Most of the funding comes from TEKES³. The project consists of three phases. In the first phase, the Agrix fast prototype was developed and tested in the summer 2003.

Fig. 1. Pneumatic drill, sprayer and no-tillage drill

The development of the Agrix basic system started in the autumn 2003 and was completed with field tests in summer 2004. Two combined seed and fertilizer drills and one sprayer were modified with new control units and additional sensors. The machines are shown in Figure 1. A commercial tractor and virtual terminal together with a home-grown task controller and GPS

³ National Technology Agency of Finland
adapter were used to complete the ISO 11783 system. The control system software is developed with RTI’s Constellation software development tool. In the third phase, the results from methods research will be integrated to the basic system thus completing the Agrix advanced system which will be tested in summer 2005.

Open control systems use standardized interfaces and communication protocols so that control units from different vendors can be used in the same system. The Agrix control system is based on ISO 11783, which is an emerging communication standard for agricultural vehicles with widespread support from the industry\(^4\). Generic control systems can be used to control several different implements by changing only the control software. The hardware, the operating system and the tool chain can be reused without modifications. This greatly reduces the design cost of a new system. Configurable control systems can be easily configured using a high-level, usually graphical tool, instead of writing it with a low-level programming language. Such high-level tools are widely used in industrial automation. Most embedded systems are still programmed with assembler or C languages because of the platform limitations. However, the computational and memory limitations are becoming less important with every generation of micro-controllers.

The control functions of traditional agricultural machines have been quite simple and low-level languages have been adequate for programming these systems. But the machines are getting bigger and more complex. Large machines require more automation to keep the operator strain at an acceptable level. Emerging production methods, such as precision farming, require positioning and feedback control. Automation technology can also be used to produce more accurate farm records. To reach their full potential, separate control systems need to be connected. Creating distributed real-time embedded control systems with low-level languages is slow, error-prone and prohibitively expensive, especially if the production series are small.

2 ISO 11783

In the late 1980’s the development of communication networks between tractors and implements was started in Germany. The main parts of DIN 9684 were completed by the end of 1991. At the same time similar efforts were made in the United States, targeting the SAE J1939 standard. Both standards are based on CAN, but they are incompatible\(^8\). The development of the ISO 11783 standard was started in 1992 and it is still under development. ISO 11783 specifies the data network for control and communications on agricultural vehicles and it uses some parts of DIN 9684 and SAE J1939. The physical and data link layers are based on CAN 2.0b specification with extended identifiers\(^1\).

\(^4\) ISO 11783 is sometimes referred as ISOBUS, which is actually the name of the implementation specification of the standard.