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Research paper

High Performance Controller for 100HP Grade Agricultural Vehicles

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Abstract

Background/Objectives: In this paper, the high performance controller design which can handle all the electric components in agricultural vehicle is proposed and implemented.
Methods/Statistical analysis: To test the controller, we made the environment for testing the developed controller and monitored the responses using CAN Bus.
Findings: By introducing RTOS, simultaneous response of all 12 inputs is possible. By introducing the power management module, standby current is maintained in the unit of uA.
Improvements/Applications: It can be used for agricultural tractor for any vendor.

Keywords: *Single controller, ECU, TCU, protection circuit technology, Noise Reduction*

1. Introduction

As shown in Figure 1 below, the main controller process is becoming more complicated as more and more convenience and safety devices are added to an agricultural machine, so that a single controller which can control all the individual electrical components in agricultural vehicle is needed. So we developed the controller which can act as ECU and TCU, and handle all the electric component as shown figure 1.

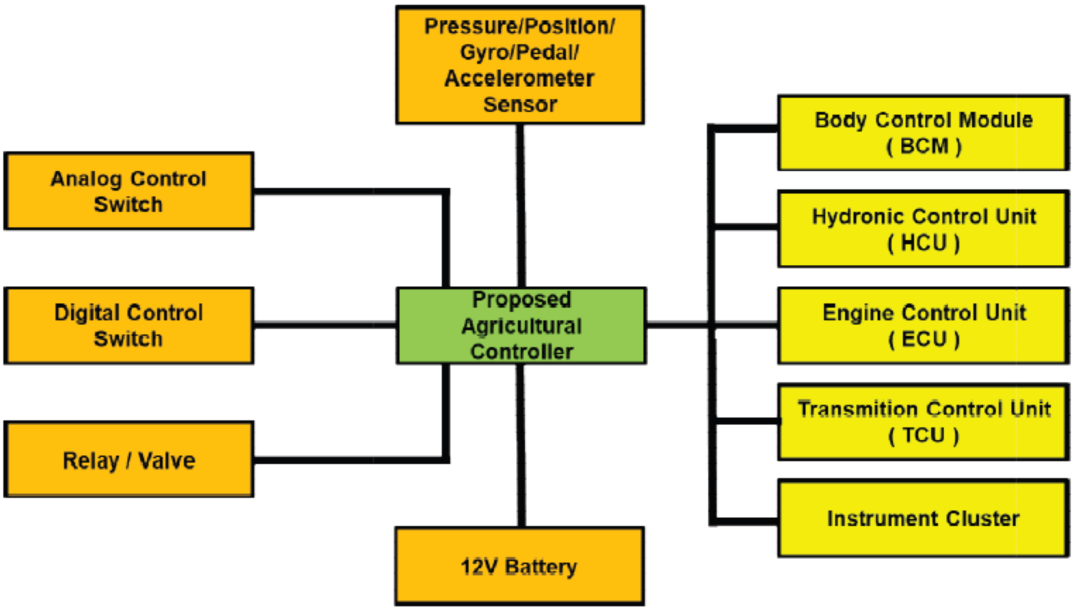


Figure 1: Agricultural tractor controller

There are several works for vehicles controller[1-8]. Model model-based diagnostic development process for automotive engine control systems is proposed[1]. This process seamlessly employs a graph-based dependency model and mathematical models for online/offline diagnosis. Multi-input and multi-out (MIMO) approach based on model predictive control (MPC) was presented for the automatic cruise system of automotive engine[2]. We adopted the MPC based MIMO approach to get the ECU control and TCU control.

2. The Proposed Design and Algorithm

2.1. Proposed Architecture

Figure 2 shows the architecture of the proposed agricultural tracker controller,which can control all the individual electrical components of tracker. All the individual components are connected with CAN Bus. Infineon 16bit SAK-XC2387A CPU is adopted for main controller. PCB is designed to accommodate the interface for connecting the all the device using CAN Bus. To reduce the standby current, power management module is introduced. Microprocessor handles the all the digital input and analog input data simultaneously using the real-time operating system.

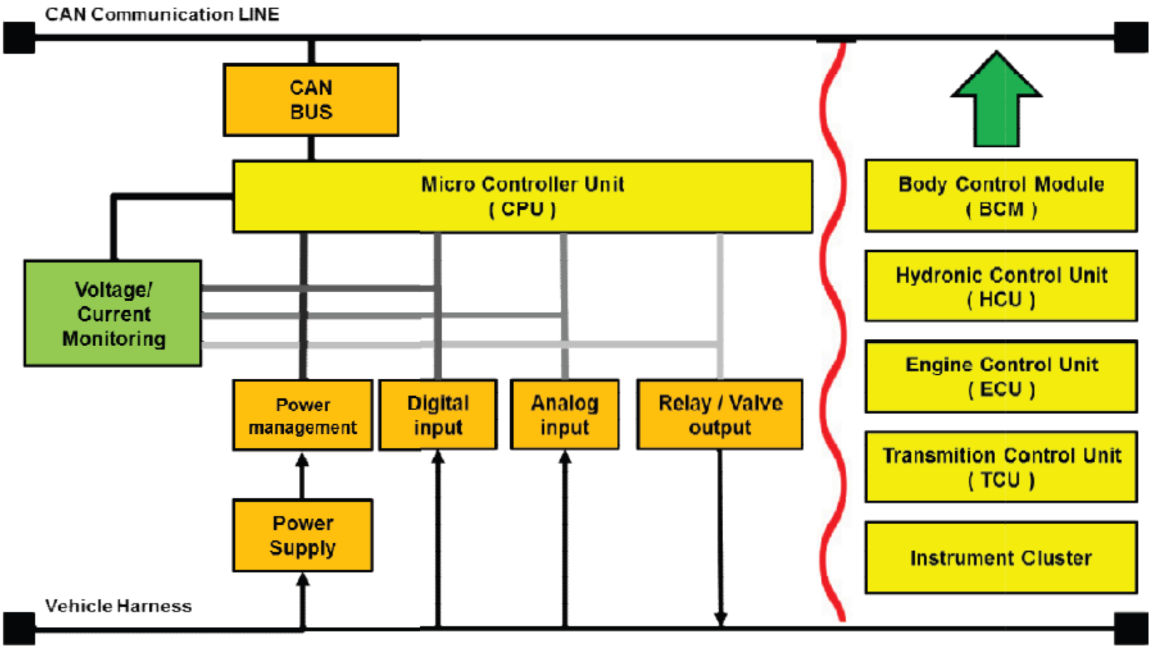


Figure 2: The architecture of the proposed agricultural tractor controller

2.1.1. Adopted Algorithms

In the proposed architecture, FreeRTOS™ is used for efficient scheduler management[9]. FreeRTOS™ is one of the real-time operating systems. It allows simplicity, excellent portability, simplicity and enables to execute several tasks at the same time. It is structured programming that does not actually perform multiple tasks at the same time. Instead, it executes multiple tasks in a very short time interval, so that it looks like the user is doing real time processing.

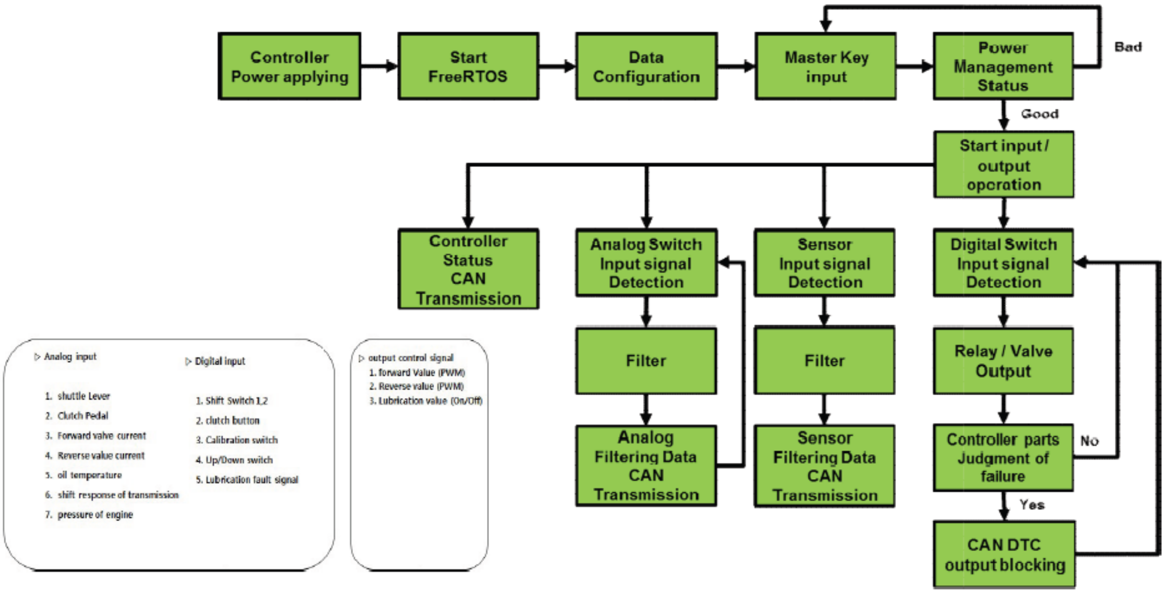


Figure 3: Parallel programing using FreeRTOS™

As shown in figure 3, seven analog inputs and five digital inputs signal are simultaneously sensed using the FreeRTOS. At the same time, the output gives the appropriate response. All input and output process are scheduled and parallelized using the RTOS. For the sensor and analog input signal, we adopted the Kalman filtering to reduce the noise generated from the engine.

2.2. Power Management and Short Circuit Protection

Unlike passenger cars, the operation and frequency of use of agricultural machinery is not used for winter season due to the characteristics of agricultural machinery. Therefore, the importance of the standby current is required, and the power management circuit as shown in figure 4 , which removes the power supply at all times according to the key input state is constructed, and the standby current is designed to manage in the unit of uA.

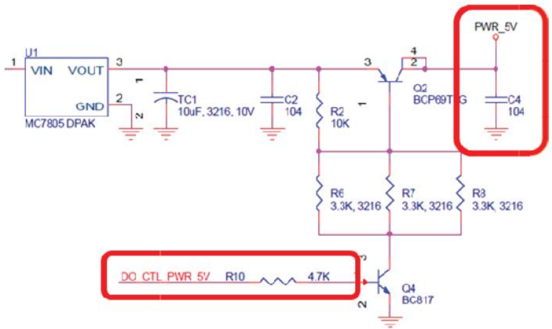


Figure 4: Power management Circuit

In case of solenoid valve and relay power supply output, short circuit protection circuit design was applied to prevent secondary failure due to short circuit of tractor as shown figure 5.

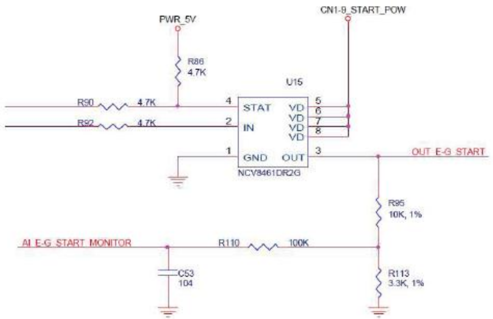
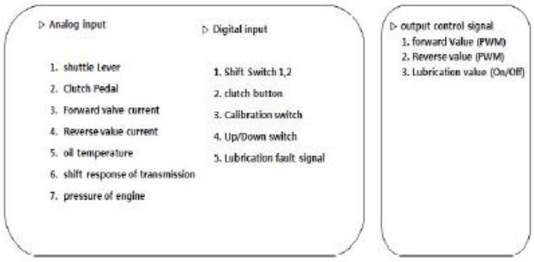


Figure 5: Short circuit protection Circuit

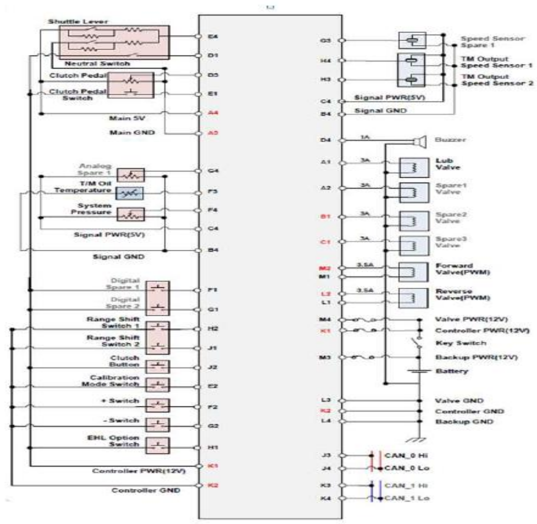
3. Results and Discussion

Figure 6 shows the interface of controller. Analog input and digital input is listed as shown in the left of figure (a), and for the output control signal, PWM control method is used. Figure 6(b) shows the implemented controller, which adopted automotive Infineon® 16bit MCU. 48-pin waterproof connector is adopted for connection and EMC proof design is applied. To meet the need of other companies, controller has spare ports and other interfaces as shown in figure 6(c).



(a) Input and output interface

(b) Implemented design



(c) Interface signal

Figure 6: Interface of controller

Figure 7 shows the Test Environment for the developed controller. We developed the Test bench circuit and monitored the response using CAN BUS and power shuttle value.

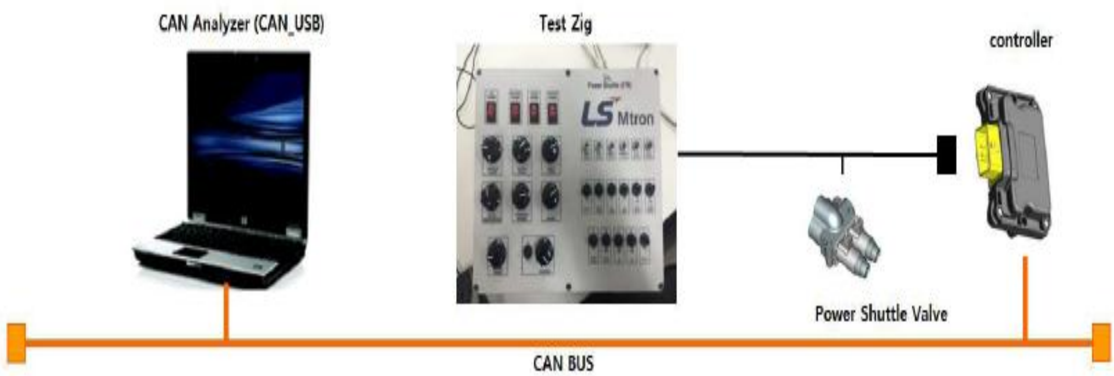


Figure 7: Test Environment

A DTC (Diagnostic Trouble Code) was sent to the parts in question to identify the problem with the part. In order to avoid the risk of breakage of the controller, it was developed to cut off the output because problems might occur in long term use. Figure 8 show the example of CAN analyzer output for DTC of ECU.

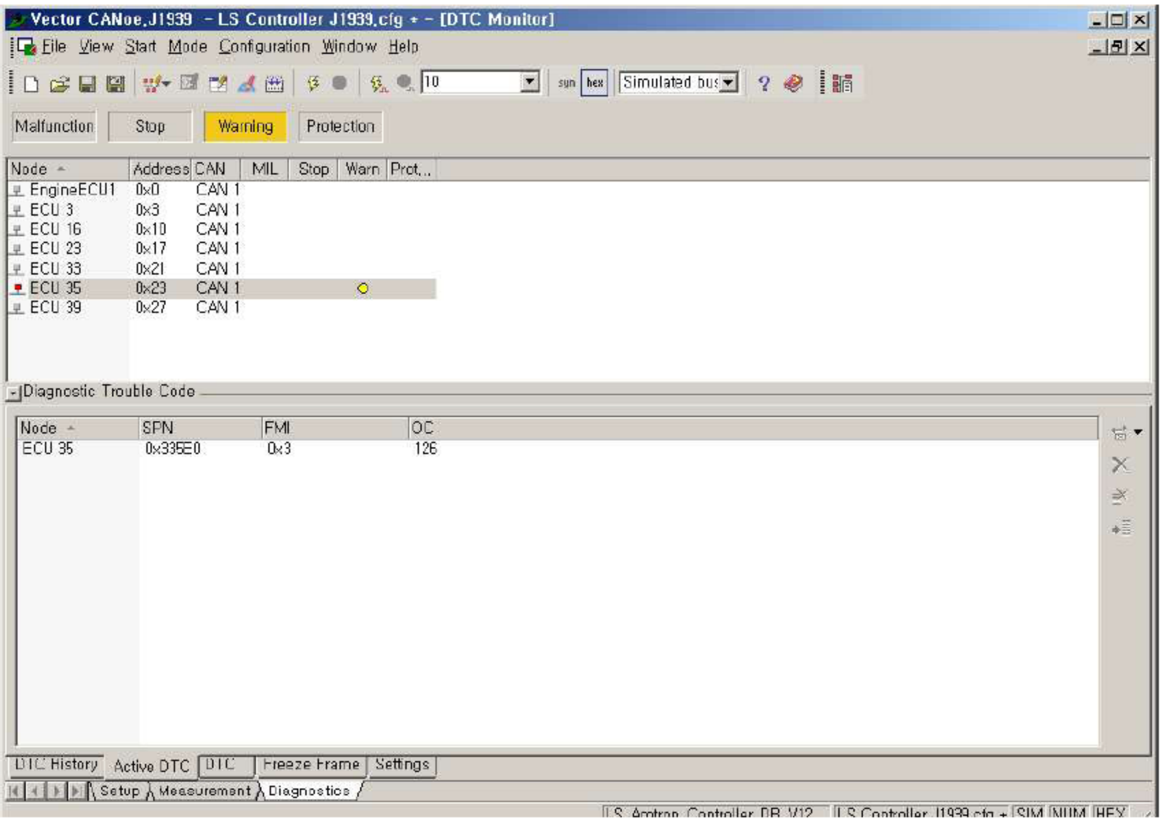


Figure 8: DTC(Diagnostic Trouble Code) Transmission using CAN BUS

The controller communicates the current state of the controller periodically to the other controller to share the data of all the controllers of the vehicle. This controller analyzes the DTC signal to recognize the danger and improves the stability by performing the prescribed treatment according to the risk factors. By parsing the data shown in figure 9, the system can determine the state of devices in the vehicle.

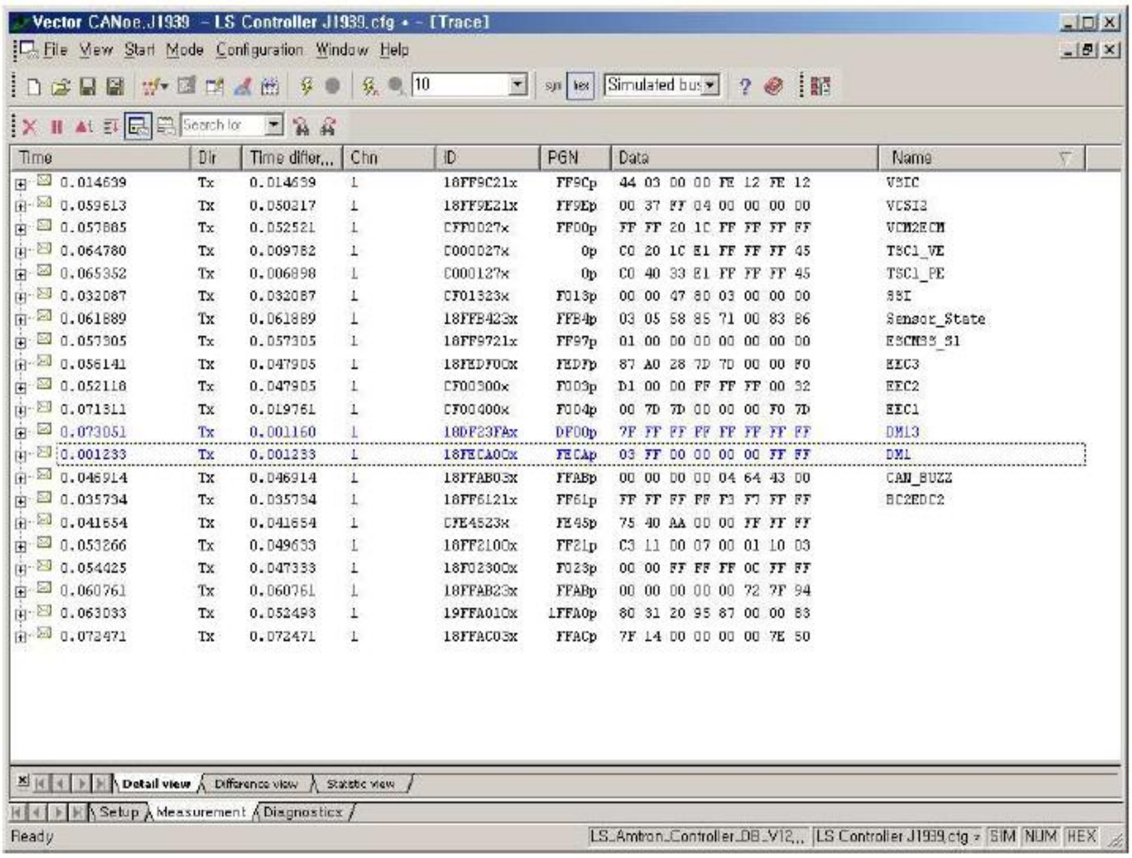


Figure 9: Detailed DTC

Figure 10: Lab Test and Test vehicle

The proposed design is tested on the Lab level and is adopted for tracker for LS MTRON, which has Tier-4 electronic engine of LS MTRON as shown in figure 10.

4. Conclusion

The high performance controller design for 100HP grade agricultural vehicles is implemented. To test the controller, we made the environment for testing the developed controller and monitored the responses. The mean absolute error (MAE) for engine speed control is 0.034, and the MAE for air fuel ratio is 0.068.

Acknowledgment

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References

[1] Jianhui Luo, K.R. Pattipati, Liu Qiao, S. Chigusa. An Integrated Diagnostic Development Process for Automotive Engine Control Systems. IEEE Transactions on Human-Machine Systems, 2007 May; 27(5): 1163-1173.

[2] Yu-jiaZhai, Yan Sun, Ke-jun Qian, Sang-hyuk Lee. A multi-input and multi-output design on automotive engine management system.science& technology of mining and metallurgy, 2015 Dec; 22(12):4687–4692.

[3] LixinZhao,Jietai Zhang,Shenglu Wang.Application of Programmable Controller in Precision Seeder,2010 International Conference on Measuring Technology and Mechatronics Automation.2010 May;1:659-662

[4] S.M. Savaresi,F.L. Taroni,F. Previdi,S. Bittanti.Control system design on a power-split CVT for high-power agricultural tractors.IEEE/ASME Transactions on Mechatronics.2004 Mar;9(3):569-597

[5] GuilhermeMarconZago, Edison Pignaton de Freitas. A Quantitative Performance Study on CAN and CAN FD Vehicular Networks. IEEE Transactions on Industrial Electronics.2018 May;65(5):4413-4422

[6] J. Baerdemaeker, A. Munack, H. Ramon, H. Speckmann. Mechatronic systems,communication, and control in precision agriculture. IEEE Control Systems Magazine. 2001 May;21(5):48-70

[7] Ali KeymasiKhalaji, S. Ali A. Moosavian. Robust Adaptive Controller for a Tractor–Trailer Mobile Robot.IEEE/ASME Transactions on Mechatronics. 2014 Mar;19(3):943-953

[8] Yongwei Tang,Maoli Wang,Xiaojie Zhao,FengqiHao. Research and application of intelligent control of agricultural machinery based on hardware and software collaborative design. IEEE 3rd Information Technology and Mechatronics Engineering Conference (ITOEC). 2017 Oct;10: 1113-1116

[9] The Free RTOS Available from : https://www.freertos.org/